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DEVELOPMENT OF A SENSORY SCHEME AND PACKAGING RECOMMENDATIONS FOR SMOKE-DRIED CATFISH FOR EXPORT

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ABSTRACT

Processed African catfish, often smoke-dried, is a major export product from Nigeria. However, it is susceptible to spoilage if the packaging material and storage conditions are not ideal. Evaluation of smoke-dried catfish quality in Nigeria is based on intuition because of the lack of a sensory scheme. This study involved the development of a sensory quality scheme and assessment of packaging material for smoke-dried catfish export from Nigeria. Five approved catfish processors using a FIROR smoking kiln and five quality assurance officers from the Federal Department of Fisheries and Aquaculture were interviewed to verify current sensory evaluation procedures in quality control, used as the basis for the development of a preliminary scheme. For assessment of sensory quality, smoke-dried catfish was purchased from five processing plants (PP) and an open market (OP), a total of six sample groups for comparison of quality and a shelf-life study. Panellists were trained in the sensory evaluation of the quality of smoked-dried catfish, while the preliminary scheme was adjusted simultaneously. The quality of the smoke-dried catfish groups was determined by sensory evaluation using the sensory scheme developed and the composition of a_w and moisture content. In the shelf-life study, the best quality catfish sample (PP_4) was packed in gunny bags and vacuum packaging before storage at an accelerated temperature of 50°C for five weeks. During storage, the packed smoke-dried catfish was assessed for sensory (descriptive analysis), physicochemical (a_w and moisture content), and microbial (TVC, yeast and mould) stability. In all groups, a_w and moisture content were within CODEX limits. The quality grading scheme developed consists of sensory descriptors of appearance, colour, odour, flavour and texture, ranging from excellent (5) to unsuitable (1). The group PP4 was the best quality (overall score=5). PP1 and PP5 were of similar quality as OP (overall score=2). The shelf-life study showed that a_w decreased significantly in both packaging materials ($p=0.03$) throughout the storage period. Between packaging, there were significant differences in the a_w ($p=0.00$) and moisture content ($p=0.03$). During storage, TVC declined from 2.04 logcfu/g in week 0 to 1.03 logcfu/g in the gunny bag and 0 in the vacuum bag in week 5, while yeast and mould were not found in either packaging. The shelf-life study revealed only slight changes in odour and flavour. Vacuum packaging preserved the smoky flavour and odour better than gunny bags during storage. Vacuum packaging is proposed as a potential packaging option since it can maintain sensory, microbiological, and physicochemical quality.

Keywords: Smoke-dried catfish, quality control, quality scheme, processing plants, sensory, physicochemical, microbiological, water activity, moisture content, Nigeria

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1 INTRODUCTION

1.1 Background

Fish provides more than 3 billion people with more than 20% of their average per capita animal protein intake, reaching 50% or more in some developing countries (FAO, 2020). The increasing global population and associated demand for food are the dominant driving forces behind intensive agriculture (Olatoye & Basiru, 2013). Aquaculture has become an effective alternative to increase domestic fish production in Nigeria and globally (FAO, 2020). Nigeria's realization of a wide gap between demand and supply of animal protein in the 1990s led to heavy investment in fish production (Adeyemi, Ayeloja, Agboola, & Abdullahi, 2020). Nigeria is the second major producer of aquaculture fish in Africa after Egypt and together these two countries produce about 43% of all fish cultured in Africa (Figure 1). In 2019, the aquaculture production of Nigeria was estimated at 291,000 tonnes (FAO, 2019). Fish species cultured in Nigeria include catfish (*Clarias spp.*, *Heterobranchus spp.*), tilapia (*Hemichromis* spp. and *Oreochromis* spp.), African bony-tongue fish, oysters, marine and freshwater shrimps (Oluwatobi, Mutalib, Adeniyi, Olabode, & Adeyemi, 2017).

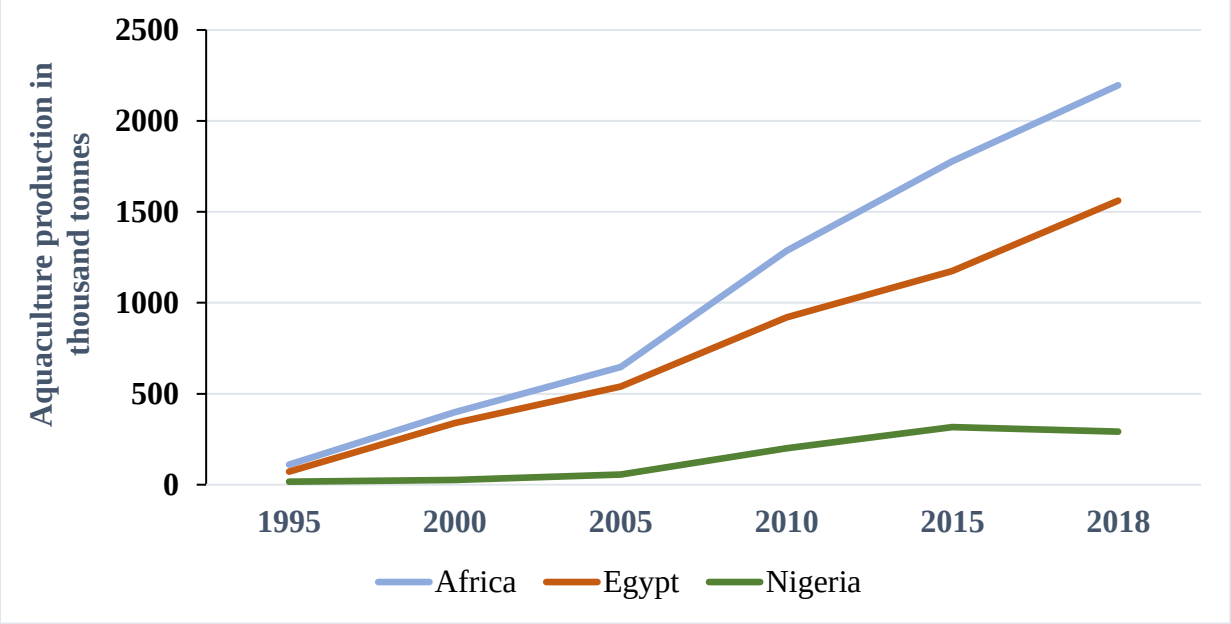

Figure 1. Aquaculture fish production in Africa showing the specific contributions of Nigeria and Egypt (in thousand tonnes) (FAO, 2019).

1.2 Production of cultured African catfish

The African catfish is in high demand as a protein source and is a globally important aquaculture species. It is easily cultured and of great economic interest particularly in Nigeria (FAO, 2017). The global production of catfish in 2019 was estimated at 235,600 tonnes of which Nigeria contributed 67% (Figure 2). Uganda, Egypt, Cuba, and the Netherlands are also among the largest producers of catfish (FAO, 2021). In Nigeria, this fish species is the most dominantly cultured fish, accounting for about 90% of total production (Nwabugo, 2021).

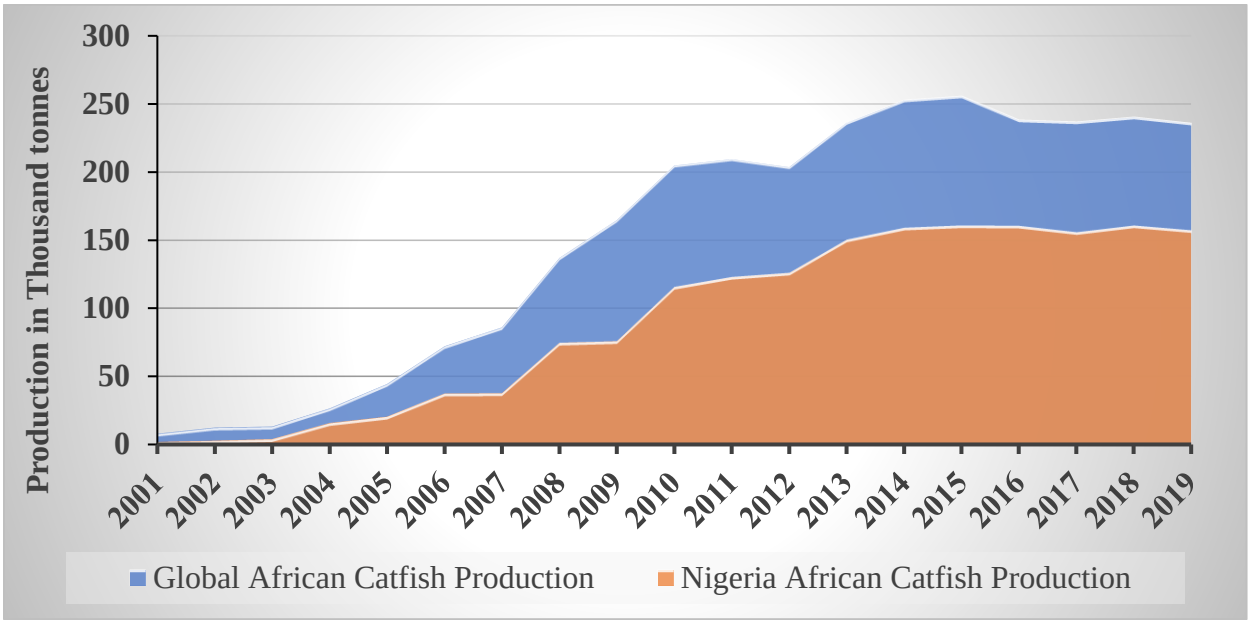

Figure 2. African catfish production in Nigeria and globally (FAO, 2021).

1.3 Processing of cultured African catfish

In Nigeria, women are the primary processors and marketers of fresh and processed fish (Babalola, Bajimi, & Isitor, 2015). Presently, smoke-drying is the most common curing method for catfish in Nigeria (Abolagba & Nuntah, 2011; Olayemi, Omodara, & Peter, 2015). Hot smoking and drying preserve quality and prolong the shelf-life of fish products. Smoke-drying is the cheapest, simplest, and most widely used fish preservation method in Nigeria (Ayeloja, 2019). This method enhances the flavour and increases the utilization, thereby increasing protein availability in the country (Kumolu Johnson, Ndimele, & Olasehinde, 2013).

1.4 Export of cultured African catfish

The international catfish trade in Nigeria is driven by demand from Africans in Europe and the United States (FAO, 2003). In 2000, about 5t of smoke-dried catfish was exported monthly to the United Kingdom via airfreight (FAO, 2003). In 2017, the total export to the United States of America and the United Kingdom was 1.42t and 0.39t respectively (FDFA, 2020). In 2018 the Food Safety Inspection Service (FSIS) of the United States Department of Agriculture (USDA) banned the import of this fish product from Nigeria. One of the key reasons was the country's inability to respond to the queries sent by the FSIS USDA concerning the production, and post-production handling of catfish. These queries included the presence of chemical residues in the products and inadequate packaging.

1.5 Post-processing losses in smoke-dried cultured African catfish

Catfish is kept live until processing, but the processed product requires proper packaging and storage to preserve the quality and minimize post-processing losses (Abolagba & Nuntah, 2011). A well-dried catfish product will spoil if not properly packaged because of its hygroscopic nature

and leaching of fat when exposed to the atmosphere (Olayemi, 2012). Some of the packaging materials commonly used for storing locally consumed and exported smoke-dried fish include nylon, jute bags, baskets, and cartons (Oluborode, Adelowo, & Unogwu, 2013). One of the reasons the country was banned from exporting its smoke-dried product to the US and EU is the improper packaging by processors and marketers.

Packaging forms an integral part of food processing because it facilitates handling during storage and distribution within the market chain (King, 2003). Packaging affects the shelf-life of a fish product. it is the end and seal to value addition and must be given necessary consideration and attention for the full development of Nigeria's fisheries sector.

1.6 Current measures to reduce post-processing losses in African catfish

The authority responsible for assessing the quality and safety of fish and fishery products (captured and farmed) intended for export or local consumption in Nigeria is the Quality Assurance Division of the Federal Department of Fisheries and Aquaculture (FDFA). Due to the ban on smoke-dried catfish exportation by USDA FSIS, the department has harmonized its working regulations with that of the European Union (EU) to ensure it follows all international regulations. Routine inspection of aquaculture farms and processing facilities has been put in place to ensure the integrity of the raw material and final product. This is done to ensure all Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP) are in place. Samples of fish from farms are also analysed and certified before sale to a processor. For further quality assurance, the department ensures a fishery inspector is on-site for every production at the processing plant to assure the processing methods and safety of the fish for human consumption.

Although these activities by the FDFA should ascertain the quality of the smoke-dried product, there is still a need to carry out a sensory evaluation of the final product as required by the EU regulation on specific hygiene rules for food of animal origin (EC) No. 853/2004**.** Therefore, sensory evaluation is necessary to assess freshness and quality in the Nigerian fisheries sector and fish inspection services (Grethe & Ditte, 2005).

1.7 Sensory assessment of quality

The quality of a product is one of the determinants of the value placed on it by a consumer. Sensory characteristics such as appearance, colour, taste, odour, and texture are parameters that drive consumers' acceptance or rejection of a product. In recent decades, consumers' concern for quality and safe food has increased, instigating a call for safe handling throughout the production chain (Ko, 2010).

Assessment of the quality of smoke-dried catfish in Nigeria is conducted based on inspectors' intuition without carefully defined criteria. However, sensory evaluation based on defined criteria is critical for assessing the quality of fish. It ensures the processed product meets the buyers' and regulatory agencies' expectations.

1.8 Problem statement

Smoke-dried African catfish from Nigeria has suffered rejection from international markets. Large consignments have been seized, destroyed, and returned to Nigeria from countries in the EU, USA, and others due to mould and insect infestation because of improper packaging (FCWC, 2018). Processed catfish are currently sorted and packaged in low-quality materials such as nylon (polyethylene), baskets, and paper cartons that have previously been used for cigarettes and biscuits, jute, or polypropylene sacks used for rice or sugar, wrapped in newspapers, or re-used computer and television boxes which are in poor condition. These packaging methods are mostly unhygienic and contaminate the fish (Olayemi, 2012; Ayeloja, 2019).

Consequently, smoke-dried catfish (and other types of smoked fish) from Nigeria are susceptible to rapid deterioration as they are exposed to high ambient temperatures, poor post-harvest handling, and inappropriate packaging materials.

Smoke-dried catfish is a ready-to-eat product, and it is essential to assess its sensory quality. Several studies on the quality of smoke-dried catfish have been carried out in Nigeria. Umar, Su, Faruk, & Ibrahim, (2018) studied the sensory evaluation of catfish smoked using different types of fuel and Ayeloja (2019) studied the sensory quality of spiced smoked *Clarias gariepinus* as affected by packaging methods. However, neither gave a detailed description of the sensory quality scales used. There is currently, no defined scheme for evaluating the quality of smoke-dried catfish in use in the fisheries industry.

1.9 Rationale

Presently, the Nigerian government is making deliberate efforts to increase the involvement of youth, women, and investors in the agricultural sector. In its bid to increase foreign exchange, the government has encouraged farmers, processors, and investors to increase catfish production (Oladosu, 2021). However, increasing production without market expansion will lead to a glut and inevitable low pricing. The bulk of the smoke-dried catfish is sold locally because of various bottlenecks limiting access into international markets (Oladosu, 2021).

Due to the rejection of Nigeria's smoke-dried catfish by the international market, Nigeria lost an estimated 2 billion dollars in potential revenue between 2015 and 2018 (FCWC, 2018). Many farmers, processors, and investors have left the industry, leaving the processing plants and facilities un-operational. This rejection has restricted the market for catfish products to local markets, which has led to excess supply, low pricing resulting from market forces of supply and demand, loss of profit, and low returns on investment, the exit of investors, loss of employment, and other socio-economic problems (Areola, Oladosu, Williams, & Uhweraka, 2018; Muktar, 2020; Oladosu, 2021).

The Federal Department of Fisheries and Aquaculture (FDFA) the inspection service and fish processors in Nigeria, lacks a standardized scheme to determine the quality of smoke-dried fish from the beginning of processing through packaging until the point of storage which ascertains the quality of the fish. Therefore, there is a need to develop a quality scheme, and train the quality assurance inspectors and quality control managers of processing plants to apply during sensory evaluation. Also, there is a need to determine an appropriate packaging material that will prevent

mould growth and exposure to moisture and insects as highlighted by the international market. This study aims to contribute to increasing foreign exchange, the involvement of youth and women, encourage the return of processors, farmers, and investors back into the industry, and provide market opportunity for value-added products by proposing possible packaging material for export and a scheme for evaluating the quality of smoke-dried catfish.

1.10 Goal

This project aims to reduce post-processing losses and address two of the main problems of the exportation of Nigeria's smoke-dried catfish, that is, inadequate sensory quality control and inadequate packaging.

1.10.1 Objectives

To achieve the above goal, the following specific objectives were set:

- To map and identify current procedures of sensory assessment, and the descriptors currently applied for the quality inspection of smoke-dried catfish in Nigeria.
- To develop a sensory quality grading scheme for smoke-dried catfish in Nigeria.
- To explore suitable packaging materials for improved market potential and self-life of smoke-dried catfish products from Nigeria.
- To assess the influence of improved packaging material on the physicochemical, microbial, and sensory quality of smoke-dried catfish.
- To design a plan for implementation of standardized sensory evaluation methods for smoke-dried catfish in Nigeria.

2 BACKGROUND OF STUDY

2.1 African catfish

The African catfish (*Clarias gariepinus*) is an important freshwater aquaculture fish species belonging to the family Clariidae. It is reared in earthen and concrete ponds, mobile tanks (fiberglass, collapsible, tarpaulin, etc.), and cages and pens at various levels of intensification (FAO, 2022; Anetekhai, 2013). African catfish is cultured in thirty pan-African and fifteen European countries, Asia, and America (FAO, 2021; Binohlan & Musschoot, 2021).

The African catfish has a high feed conversion efficiency and a fast growth rate (Olayemi, 2012; Williams, Kareem, & Ojolowo, 2012). The growth rate is directly related to temperature (Zerihun, 2015). It is relatively resistant to infectious diseases and can tolerate a wide range of water quality conditions (Olayemi, 2012; Njieassam, 2016). African catfish can also tolerate deficient oxygen levels because it utilizes oxygen from the atmosphere with an accessory cauliflower-like breathing organ (Ochimana, 2016). Due to its rugged characteristics, it is the preferred species for culture in Nigeria as it can be transported long distance. This species can stay alive for many days out of water if their skin remains wet (FAO, 2022), which is incredibly beneficial in Nigeria, where in many areas electrical supply is not dependable.

African catfish has a highly nutritious white meat rich in vitamins and minerals. It is lean but a good source of polyunsaturated omega 3 and 6 fatty acids (Nkrumah & Akwetey, 2021; Michael, 2020; USDA, 2019). It has a high protein content and is low in calories. Consumers highly appreciate African catfish due to its excellent meat quality (Sikoki & Ibim, 2014). Over two hundred thousand tonnes of African catfish are cultured each year globally; a bulk of it is sold fresh, frozen, smoked, or smoke-dried (Williams, Kareem, & Ojolowo, 2012).

2.1.1 Smoke-drying

Smoke-drying is one of the oldest methods of fish preservation (Akwuobu, Antiev, & Ofukwu, 2019). It is the commonest, easiest, and cheapest processing method in developing countries (Essien, Cia, Akwasi, & Adele, 2019; Assogba, et al., 2019). Smoke-drying leads to the deposition of antimicrobial and antioxidant compounds, such as aldehydes, carboxylic acid, and phenols, which delays microbial growth and rancidity development (Mahmud, et al., 2018; Essien, Cia, Akwasi, & Adele, 2019).

This processing method ensures long term preservation and enhances the flavour, taste, and texture of fish (Omoruyi, Okpeva, & Abdullahi, 2017). Smoke-drying decreases the water holding capacity of the muscle, which results in loss of muscle tenderness (Dhanapal, et al., 2013). Maillard reaction between carbonyl amino group and caramelization of fish flesh from smoke-drying and lipid oxidation gives the characteristic colour and odour (Leksono, Suprayitno, Purnomo, & Hardoko, 2014; Arason, Nguyen, Thorarinsdottir, & Thorkelsson, 2014). Carbonyl compounds produced during smoking contribute to the colour, texture, and odour (Mahmud, et al., 2018). The flavour is from the absorption of volatile compounds (guaiacol and syringol) produced from smoke (Jónsdóttir, Ólafsdóttir, Chanie, & Haugen, 2008). Lipid oxidation can also lead to changes in the flavour (Arason, Nguyen, Thorarinsdottir, & Thorkelsson, 2014). During smoke-drying, the elevated temperature leads to lipid leaching from the fish muscles (Arason, Nguyen, Thorarinsdottir, & Thorkelsson, 2014). Smoke-drying affects the nutritional composition of fish, it concentrates the crude protein, fat, and crude fibre of fresh fish due to moisture loss (Samuel, et al., 2017; Oyedokun, 2020). The pH in the fish muscle decreases during smoking resulting from acid absorption from smoke, dehydration, and the reaction of phenols, polyphenols, and carbonyl compounds with protein and its constituents (Arason, Nguyen, Thorarinsdottir, & Thorkelsson, 2014).

The raw material for smoke-drying in Nigeria is live fish. The live catfish is transported to the processing plant in a bowl, bucket, or keg containing clean water. At the processing plant, the water in the bowl is drained, salt is poured over the fish and left for 30 minutes at a typical fish to salt ratio 20kg:150-200g to kill the fish and remove slime for easy de-gutting as catfish is slimy. Then gutting and thorough washing are carried out, the fish is rewashed in clean water to remove blood and dirt. The fish is immersed in brine solution for 10-15minutes; a typical fish to salt ratio is 20kg:50g in 15 to 20 litres of water. Then the fish is put on racks to dry for at least 15 minutes. Once dry, the fish trays are put into the smoking kiln (metal drums, mud ovens, or improved smoking kilns produced by Federal Institute of Industrial Research Oshodi (FIIRO), Nigerian Stored Products Research Institute (NSPRI), and the Nigerian Institute for Oceanography and Marine Research (NIOMR) kiln (Omotayo & Olaoye, 2006; Omodara, et al., 2016)) and allowed to smoke at a temperature between 100°C and 140°C for a period of 4-5 hours

after which it is dried at 26°C for 24hours (Ajani, Akinwole, & Ayodele, 2011). For export purpose only FIIRO, NSPRI, and NIOMR kilns are approved for use by the FDFA.

Smoke-drying should achieve a moisture content of 10% or less (water activity of 0.75% or less) to control bacterial and fungal spoilage during storage and transportation without refrigeration (CODEX, 2018).

2.2 Packaging

The primary purpose of packaging is to maintain food products' physical, chemical, and microbial quality (Olayemi, Omodara, & Peter, 2015; Margarita, Avelina, & Jung, 2014). Packaging ensures the safe delivery of high-quality food to the market (Emblem, 2000), making it an essential aspect of the food industry. Effective packaging material must reduce the rate of oxidation, dehydration, bacterial, and chemical spoilage, prevent odour absorption, and protect the product from physical damage (Olayemi, Omodara, & Peter, 2015). Packaging must prevent insect access and prevent rehydration, which leads to microbial spoilage (John, 2006). Understanding the functionality of packaging and the environment where it is used is key to optimizing packaging material that is durable and cost-efficient. Due to high external temperature and moisture in the tropics, the packaging material to be used must have good insulating qualities.

2.2.1 Vacuum packaging

Vacuum packaging is a proven technology for the shelf-life extension of various food products (Patil, et al., 2020). Primarily, vacuum packaging eliminates oxygen from within the packaging before hermetically sealing (Kerry & Tyuftin, 2017; Dominguez, Bohrer, Pateiro, Paulo, & Sajid, 2021). The removal of air slows the rate of oxidative reactions such as lipid and protein oxidation and subsequently inhibits the growth of aerobic bacteria and fungi during storage (Zeki, 2018; Dominguez, Bohrer, Pateiro, Paulo, & Sajid, 2021). Vacuum packaging also acts as a barrier for oxygen and vapour, and resistance against oil and chemical (Patil, et al., 2020).

Materials for vacuum packing must be strong, flexible, and have a specific level of heat sensitivity (Dominguez, Bohrer, Pateiro, Paulo, & Sajid, 2021). A significant challenge with vacuum packaging is the requirement of synthetic packaging materials such as plastics, as very few biodegradable and bio-based materials can undergo vacuum packaging (Patil, et al., 2020). The shelf-life of vacuum-packed fish and fishery products is influenced by factors such as the species, raw material quality, handling and processing, packaging material and storage temperature.

2.3 Shelf-life

The shelf-life of a product is the duration over which a product remains safe and suitable for use after manufacturing and packaging (Haouet, et al., 2019). The shelf-life of a product begins from the time the product has been processed and packaged. The product must retain its acceptable chemical, physical, microbiological, and sensory characteristics during this period. There are two main types of tests to establish shelf-life: Real-time stability and accelerated shelf-life testing.

In real-time stability testing, a product is stored at recommended storage conditions and monitored until it fails the specification (Haouet, et al., 2019). A real-time stability test can be time-consuming and expensive.

Before a product launch, it is rarely feasible to carry out complete shelf-life evaluations for long shelf-life products. Therefore, an accelerated shelf-life test is recommended. Accelerated shelf-life testing involves storing a food product in a controlled environment to accelerate its deterioration without inducing new changes (Bouillé & Beeren, 2016). The accelerated shelf-life principle increases the aging rate of a product, with the most common accelerated factors being temperature, humidity, and light (Hough, 2010). Temperature is the most common factor used for chemicals, pharmaceuticals, and biological products because of its relationship with the degradation rate (Haouet, et al., 2019). Accelerated shelf-life study is tailored to a specific product as every product has a distinct mode of spoilage (e.g., rancidity, moisture loss/gain, sensory changes).

2.4 Spoilage of smoke-dried catfish

Smoke-dried catfish is a product of long shelf-life. Smoke's antibacterial components are likely to exert more antimicrobial effects on bacteria than fungal microflora (Fasuan, Akin-Obasola, & Borisade, 2021). Spoilage in smoke-dried fish is mainly associated with xerophytic fungi, particularly moulds. Moulds grow best at water activity higher than 0.7, relative humidity at 75%, and temperatures of 30 - 35 °C (Fasuan, Akin-Obasola, & Borisade, 2021). Moulds are adaptable to growth, sporulation, and toxin production under favourable interacting environmental factors (Hassan, Azza, & Heba, 2011). Spoilage moulds in smoke-dried fish are predominantly xeromorphs or halotolerant species when the processing stages include brine treatments. Drying fish to a safe water activity level may be most effective in preventing spoilage by fungi (Fasuan, Akin-Obasola, & Borisade, 2021).

2.5 Sensory evaluation

The most important attributes of fish and fishery products to consumers are the sensory characteristics of texture, odour, appearance, and colour. Sensory evaluation evokes, measures, analyses, and interprets human response to characteristics of products perceived through the senses of sight, smell, taste, touch, and hearing (Stone H., 2018). Sensory evaluation utilizes trained human panellists to measure the sensory characteristics and acceptability of fish and fishery products (Singh & Maharaj, 2014).

Sensory evaluation is pertinent in various areas such as inspection of raw materials, product development, product improvement, quality control, selection of packaging material, shelf-life/storage studies, and establishing relationship between measurable attributes and sensory perception. Sensory evaluation is performed daily on products in the fishery industry and on each production batch for sale, by quality control officers and government inspection officials. There is a need to follow a guideline and a defined scheme for inspection to avoid error and bias and ensure consistence over time and among inspectors.

Sensory evaluation gives an objective and reliable result when done under controlled conditions. There are different methods for evaluating the quality of fish and fishery products. The commonly used are the scaling and grading methods such as the EU scheme, Quality Index Methods (QIM),

Torry scale, raw fillets grading method, and Quantitative Descriptive Analysis (QDA) (Martinsdottir, Schelvis-Smit, Hyldig, & Sveinsdottir, 2009; Esteves & Anibal, 2021)

2.5.1 Grading scale for raw fillets

The grading scheme for the quality of raw fish fillets is widely used in the fishery industry to describe sensory attributes such as appearance, odour, colour, and texture. Some attributes are related to freshness and others to handling. Defects such as bruises and blood spots can be measured, counted, and compared to standards. The grading scale for fillets was first reported by Learson & Ronisvalli (1969). The scores were from 5 to 0, each score for all attributes is described. A score of 5 (Excellent) denotes very fresh fish, while a score of 0 (unsuitable) means spoiled. Each grade describes all attributes as one i.e., a grade is allocated to description of the fish's appearance, texture, and odour (Appendix 1).

2.5.2 Descriptive Analysis (DA)

Descriptive analysis (DA) is based on the ability of a trained panellist to detect and describe quantitative sensory attributes under the guidance of a panel leader (Stone & Sidel, 2004). The popularly uses descriptive analysis is the Qualitative Descriptive Analysis (QDA). This sensory method has been used to give a detailed description of the sensory profile and determine the maximum shelf life of seafood (Martinsdóttir, 2010). An unstructured 15 cm linear scale (0-100%) from left to right by panellists to indicate the attributes' relative intensity by marking on the line (Stone & Sidel, 2004). Terminologies for sensory evaluation are developed in an interactive session guided by the panel leader. However, the panel leader only facilitates the communication process but does not participate in the terminology development. The panellists are trained to familiarize themselves with the sensory intensities for each attribute using the linear scale (Xi, 2017). Finally, sensory evaluation is carried out by the panellist in separate booths to reduce distraction and panellist interactions.

The success of QDA in sensory evaluation depends on the panellist’s commitment and motivation through individual interviews (Xi, 2017). The application of QDA is not restricted only to shelf-life studies but also in monitoring competition of products, product development, and relating instrumental and sensory analysis methods (Stone & Sidel, 2004).

Generic descriptive analysis (GDA) is based on a modification of QDA to suit the goals of any project (Lawless & Heymann, 2010). It does not require evaluating too many sensory attributes but rather those of interest following the principles of QDA. An accurate characterization of sensory properties of a selected sample effectively emphasizes the qualitative evaluation of sensory characteristics using their intensity values in the order of perception (Lawless & Heymann, 2010). The quality of results depends on the number of assessors and their skills to describe their perceptions.

3 MATERIALS AND METHODS

3.1 Sample selection

The purposive sampling technique was used to select processing plants for samples and qualitative data collection. The FDFA has approved fourteen processing plants in Lagos, and five of those were selected. The selected processing plants are in the Ifako-ijaye, Alimosho, Ojo, Surulere, and Eti-osa local government areas of Lagos, Nigeria (Figure 3). All selected processing plants used the FIIRO smoking kiln.

Three kilograms of freshly smoke-dried whole catfish were purchased from the five processing plants (sample groups PP_1-PP_5). In addition, one kilogram of smoked catfish was purchased from an open market for comparison (sample group OM). The total weight of smoked catfish samples collected was sixteen kilograms. All samples were purchased on the 14th of December 2021, transported to Matis in Reykjavik, Iceland via airfreight, and arrived on the 17th of December 2021. Sensory scheme development and shelf-life study of whole smoke-dried catfish were carried out in Matis, Iceland.

Figure 3. Location of the processing plants sampled, alongside the Federal Department of Fisheries and Aquaculture (FDFA) Quality Assurance Division in Lagos, Nigeria.

3.2 Experimental design

3.2.1 Development of quality scheme and training of panellists

An interview administered questionnaire was used to obtain information on current procedures for evaluating sensory attributes and quality of smoke-dried catfish, attributes of interest, and its

description in quality control. Interviews were conducted during phone calls to quality control managers of the selected processing plants and five representatives of the fish inspection service in Nigeria's Federal Department of Fisheries and Aquaculture (FDFA). The resulting responses of the questionnaire were used as input into designing the preliminary sensory quality scheme. The questionnaire is shown in Appendix 2.

Eight trained sensory panellists participated in the further development of the sensory quality scheme for smoke-dried catfish (Figure 4). They were first trained on scoring each sensory attribute such as the odour, colour, appearance, texture, and flavour using the preliminary scheme and smoke-dried catfish samples at the sensory laboratory. The preliminary scheme was modified during the training using the panellist's comments.

Figure 4. Training of panellists and modification of preliminary scheme for smoke-dried catfish.

3.2.2 Sensory quality of smoke-dried catfish

Sensory evaluation was conducted in the Matis sensory laboratory to determine the quality of smoke-dried catfish. On a clear table, samples were arranged and labelled with codes (PP_1, PP_2, PP_3, PP_4, PP_5, and OM) (Table 1). The smoke-dried catfish was evaluated by four trained and one untrained panellist using the final scheme as a basis for evaluation (Figure 5). The attributes evaluated were appearance, colour, odour, and flavour and texture. This sensory evaluation was carried out once.

Figure 5. Sensory evaluation of smoke-dried catfish by panellists using the final scheme.

3.2.3 Analysis and sampling period for shelf-life study

The six groups of smoke-dried catfish were analysed at arrival for baseline composition (water activity and moisture content) and quality (sensory evaluation). Based on the sensory evaluation, only the sample group with the best quality was used for the shelf-life study. The sample was divided into two parts for packaging in different materials; gunny bags and vacuum packed in plastic. Following this, the samples were stored at ≈50℃ in a storage chamber at the Matis laboratory for up to five weeks. Samples were collected for sensory evaluation, physicochemical and microbiological analysis after 0, 2, 4, and 5 weeks of storage to determine the quality, safety, shelf-life, and stability of the smoke-dried catfish in the packaging materials (Figure 6 and Table 1). The relative humidity was monitored using a humidity logger.

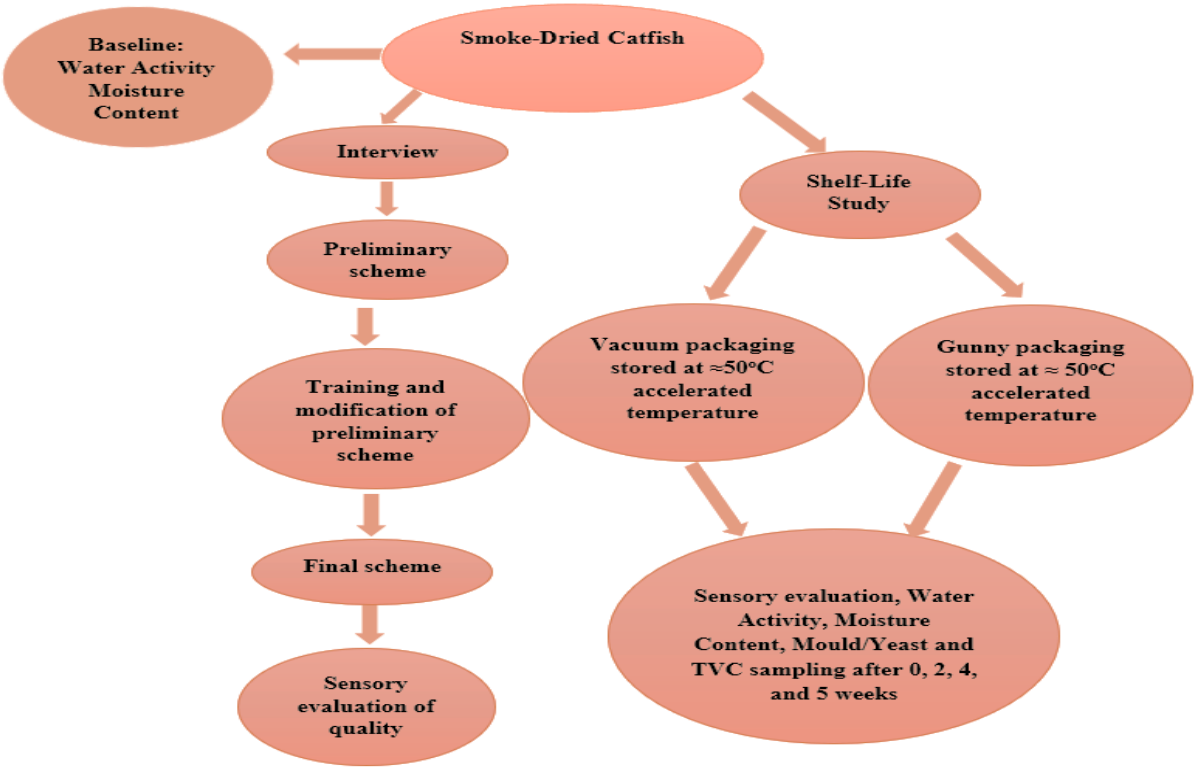

Figure 6. Process flow of development of the quality scheme, experimental design, and sample analysis for shelf-life studies of smoke-dried catfish.

3.3 Packaging methods

The selected best quality smoke-dried catfish was packed in 300 x 500 mm vacuum bags which contain Polyethylene (PE) and Polyamide (PA), with 90-micron thickness. The vacuum bag was evacuated, packed with 500g of smoke-dried catfish, and automatically heat-sealed (Figure 7a). Gunny bags containing 500g of best-selected quality whole smoke-dried catfish were tightened using the bag string (Figure 7b). All packaging was then transferred to the storage cabinet (Figure 8).

Figure 7. Smoke-dried catfish sample stored in two different packaging materials (a(left): Vacuum packaging (VP) and b(right): Gunny bag (GB).

3.4 Storage temperature

The temperature 50℃ of storage was calculated using the accelerated aging time (Patent No. WO/2015/122864, 2015) (Appendix 3). The storage temperature was monitored with a i-button temperature and humidity logger (DS1923-F5#Hygrochron).

$$AAT = \frac{RT}{Q_{10}\{(T_{AA} - T_{RT})/10\}}$$

Where:

AAT=Accelerated Aging Time
RT= Desired Real-Time
TAA= Accelerated Aging Time
TRT= Ambient Temperature
Q10= Aging Factor

Figure 8. Storage cabinet of samples for shelf-life study at ≈50℃.

3.5 Sensory evaluation

3.5.1 Generic Descriptive Analysis (GDA)

Generic Descriptive Analysis (Lawless & Heymann, 2010) was used to evaluate the sensory changes in smoked-dried catfish stored at 50℃ in gunny bags and vacuum packaging for five weeks. The samples were packed in small aluminium containers (Figure 9), coded, and evaluated in duplicate by five trained panellists. Sensory evaluations were carried out in weeks (0, 2, 4, and 5). The sensory sessions were conducted in the Matis sensory laboratory under light with each panellist using an individual booth in compliance with ISO 8589:2007 (Figure 10). Sensory

changes were evaluated on a 15 cm unstructured line scale (from “none” to “much”), which was converted to numbers from 0 to 100. Sensory attributes and definitions are shown in Table 2.

Table 1. Generic Descriptive Analysis evaluation form (Lawless & Heymann, 2010). Each attribute was rated on a scale of 0-100.

	Sensory attributes	Scale	Definition
Odour			
	Rancidity	none‖much	Rancid fish oil
	Smoke	none‖much	Odour of smoke
	Spoilage	none‖much	Spoilage odour
Flavour			
	Rancidity	none‖much	Rancid flavour
	Smoke	none‖much	Smoky flavour
	Spoilage	none‖much	Spoilage flavour
	Salty	none‖much	Salty flavour

Figure 9. Smoke-dried catfish samples prepared for sensory evaluation.

Figure 10. Individual cabin for sensory evaluation.

3.6 Physicochemical analysis

3.6.1 Moisture content

Moisture content was determined as the percentage of weight lost during drying at 102.4°C, according to ISO 6496 (1999). Moisture content was measured in smoke-dried catfish at arrival and after storage for 0, 2, 4, and 5 weeks. Approximately 5g of each sample with skin were crushed, placed in a crucible, and allowed to dry in a preheated oven for four hours at 102.4°C. Afterwards, the dish was placed in a desiccator for about 15 minutes to cool to ambient temperature. As shown in equation 2, the moisture content of the fish sample was calculated by dividing the final weight by the initial weight of the sample and subtracting from 1. This analysis was performed in duplicate. The data were expressed as a mean±standard deviation.

$$\%\ Moisture\ Content = 1 - \left(\frac{weight\ of\ dry\ matter}{weight\ of\ sample}\right) x\ 100$$

Where:
Dry matter = weight of sample and bowl after drying - weight of bowl alone
Sample = weight of sample and bowl before drying - weight of bowl alone

3.6.2 Water activity

Water activity (a_w) was measured using an Aqua Lab, 4TE, dew point water activity meter. The water activity in smoke-dried catfish at arrival and after storage in gunny and vacuum bags at 50°C was measured. Approximately 2g of homogenised samples were placed in a clean and dry measurement plate (no more than half full) and placed in the instrument. The a_w was automatically measured after the program started. The catfish's head, body, and tail were analysed separately in duplicate. The data was expressed as a mean ±standard deviation.

3.7 Microbial analysis

3.7.1 Total viable count (TVC)

The total viable count at 30°C was determined using the method described by Downes & Ito (2001) and European Pharmacopoeia, (2020). The counts of all colonies were expressed as a logarithm of the number of colony-forming units per gram (Log cfu/g).

3.7.2 Mould and yeast count

Mould and yeast count were carried out using a standard method described by Downes & Ito (2001) and NMKL 98 (2005). A total of 20g of blended smoke-dried fish samples were weighed in a stomacher bag, and 180ml of dilution buffer (Maximum Recovery Diluent) was added and allowed to homogenize for 2 minutes in a stomacher. Successive 10-fold dilutions were done as required. Samples were serially diluted up to $10^{-4,}$ 0.1ml of each dilution was inoculated in duplicate into a Dichloran Rose Bengal Chloramphenicol agar plate and spread over the surface using a sterile L-shaped glass rod (hockey stick). The plates were incubated at 22°C for 5 days. The quantity of yeast and mould was counted separately, and the number per gram of samples was calculated from the number of colonies counted on selected plates. Results were expressed as a logarithm of the number of colony-forming units per gram.

3.8 Data handling and analysis

The statistical analysis was carried out using the Microsoft Excel statistical tool pack 2016, Statistical Package for Social Sciences (SPSS) version 20.0, and the general linear model. One-way analysis of variance (ANOVA) and student T-test was used to test for significant differences between samples. P-values less than 0.05 were considered significant for all analyses. Duncan's post hoc test was used to analyse statistical differences between the sample groups, or storage time and packaging type. Regression was used to analyse the correlation between laboratory parameters, and packaging type.

4 RESULTS

4.1 Current use of sensory evaluation in QC

According to the responses in interviews with five quality control managers of processing plants and five inspection service representatives in Nigeria, sensory evaluation is currently used within quality control protocols of smoke-dried catfish production. However, none have a sensory scheme for evaluating sensory quality of the smoke-dried catfish. Four out of five of the respondents from the inspection service reported that they evaluate the texture, colour, odour, and appearance of products, while one reported that they consider other attributes only (raw material quality and storage conditions). Three of the five quality control managers evaluate the texture, colour, odour, and appearance and two evaluate the texture, colour, and appearance (Table 2). All respondents considered these sensory attributes essential to determine the quality of the product.

Table 2. Results of the questionnaire administered to quality control officers of five processing plants and five representatives of FDFA.

Quality Control Managers (n=5)	
Items	Frequency
Scheme	0
No scheme	5
Carry out sensory evaluation	5
Do not carry our sensory evaluation	0
Attributes	
Texture, colour, odour, and appearance	3
Texture, colour, and appearance	2
Representatives of Regulatory body (n=5)	
Items	Frequency
Scheme	0
No scheme	5
Carry out sensory evaluation	5
Do not carry our sensory evaluation	0
Attributes	
Texture, colour, odour, and appearance	4
Other attributes (raw material, storage conditions)	1

4.2 Development of sensory quality scheme for smoke-dried catfish

The preliminary scheme developed based on responses from the administered questionnaire is shown in Appendix 4. This preliminary scheme for smoke-dried catfish was a five-category grading scale. Each category included a description of appearance, colour, texture, flavour, and odour based on different product quality ranging from excellent (grade=5) to unsuitable (grade=1). Several modifications were made to the preliminary scheme during the training of panellists. The final scheme (Table 4 and Figures 11-14) described four quality parameters (overall appearance, colour of the belly-side, overall odour, and flavour and texture during tasting) using a five-category grading scale, ranging from excellent (grade=5) to unsuitable (grade=1).

Table 3. Final quality scheme for smoke-dried catfish showing the grades, description, and scores.

ATTRIBUTE	DESCRIPTION	Sample code					
APPEARANCE (overall)							
Excellent-5	Characteristic of the product, dry, shiny, smooth surface, whole intact pieces. Firm						
Good-4	Dry, but slightly less shiny, less smooth surface, mostly intact						
Average-3	Slightly oily, dull, slightly broken. A rather rough surface.						
Questionable-2	Very oily, and/or grey/black soot, a little burned, somewhat broken. Rough surface						
Unsuitable-1	Not characteristic of the product, burnt, maggot growth, mouldy, unclean, very broken/in pieces. Very rough surface						
COLOUR (belly side)							
Excellent-5	Golden yellow						
Good-4	Light brown						
Average-3	Dark brown						
Questionable-2	Dark, discoloured						
Unsuitable-1	Black, very dark, very discoloured						
ODOUR (overall)							
Excellent-5	Sweet, smoked, characteristic of the product						
Good-4	Less sweet, less characteristic of the product						
Average-3	Slight off-odour, slightly burnt						
Questionable-2	Off-odour is apparent, somewhat burnt						
Unsuitable-1	Burnt, strong off-odour, rotten, spoilage odour						
FLAVOUR and TEXTURE (during tasting)							
Excellent-5	Sweet, slightly salty, slightly oily, smoky flavour. Crispy						
Good-4	Rather sweet, smoky flavour. Somewhat crispy						
Average-3	Lightly smoky, slightly burnt. Not crispy, a bit rubbery						
Questionable-2	Somewhat burnt, bitter, sour taste, overwhelmingly salty, rather rubbery, soft						
Unsuitable-1	Off-flavour, burnt, rancid, very bitter, putrid. Very rubbery, very soft						

VARYING QUALITY OF SMOKE-DRIED CATFISH

Figure 11. Excellent-5 visual quality. Belly side (left), back side (right). Appearance (overall): Characteristic of the product, dry, shiny, smooth surface, firm, and whole intact pieces, Colour (belly side): Golden yellow.

Figure 12. Good – 4 visual qualities. Belly side (left), back side (right). Appearance (overall): Dry, but slightly less shiny, less smooth surface, and mostly intact. Colour (belly side): Golden yellow/lightly brown.

Figure 13. Questionable- 2 visual quality. Belly side (left), back side (right). Appearance (overall): Very oily and broken. Colour (belly side): Dark.

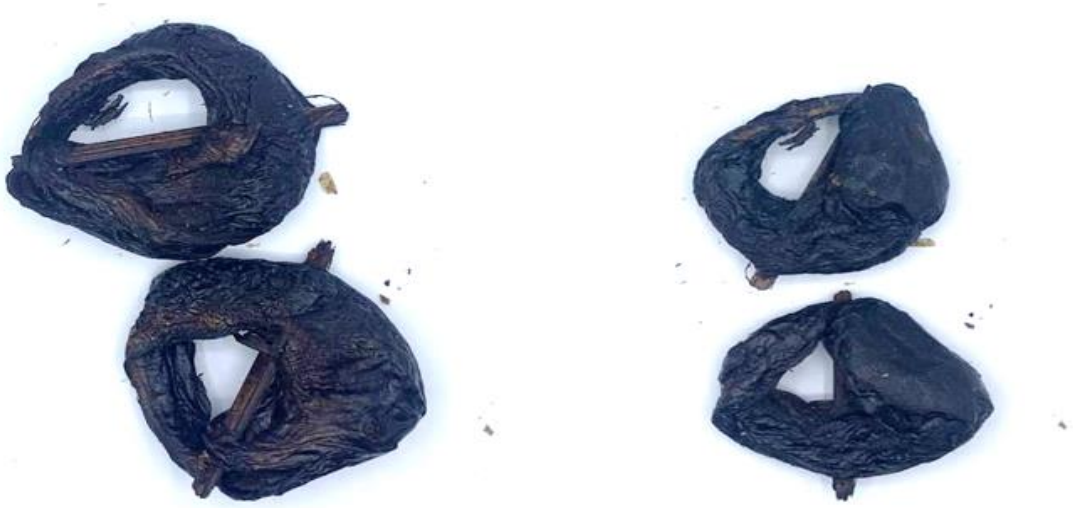

Figure 14. Unsuitable- 1 visual quality. Belly side (left), back side (right). Appearance (overall): Not characteristic of the product, burnt, grey/black soot, and rough surface. Colour (belly side): Very dark.

Figure 15. Smoke-dried catfish from PP1 Belly side (left), back side (right).

Figure 16. Smoke-dried catfish from PP2. Belly side (left), back side (right).

Figure 17. Smoke-dried catfish from PP3. Belly side (left), back side (right).

Figure 18. Smoke-dried catfish from PP4. Belly side (left), back side (right).

Figure 19. Smoke-dried catfish OM sample. Belly side (left), back side (right).

4.3 Panellist performance during training

Eight panellists participated in the training sessions of sensory evaluation of smoke-dried catfish. As shown in Appendix 5a, there was variation in scores for the quality parameters in all samples. The panel's lowest score was for samples from the open market, and the highest was from processing plant 4, which indicated that panellist agreed when evaluating both samples. However, there was some degree of disagreement in the panellists' scores for each attribute, with panellist 1 and 6 deviating the most from average scores. Panellists 2 and 8 had a lot of missing data.

4.4 Quality attributes of smoke-dried catfish at arrival

4.4.1 Sensory quality of smoke-dried catfish

Five panellists evaluated the six groups of smoke-dried catfish using the sensory grading scheme developed (Table 3). The sensory scores of smoke-dried catfish graded during sensory evaluation are presented in Table 4 and the visual description in Figures 13-18. A significant difference was found in scores of individual sensory attributes (appearance, colour, odour, and flavour and

texture) between sample groups ($p<0.05$). The scores for sensory attributes were generally not different with each sample, with the exception of sample from processing plant 3 (PP_3) where a significant difference was found in scores for appearance and colour.

Table 4. Sensory scores (Mean ± Standard deviation) of smoke-dried catfish during the development of the scheme, number of assessors= 5. Similar superscript indicates significant difference among means in the same row (upper case) and columns (lower case) at $p \leq 0.05$.

S/N	SAMPLES	APPEARANCE	COLOUR	FLAVOUR&TEXTURE	ODOUR	p-values
1	PP_1	2.4 ± 1.5^{a}	2.2 ± 1.3^{a}	2.2 ± 1.3^{a}	2.5 ± 1.3^{a}	0.98
2	PP_2	2.6 ± 1.5^{a}	3.6 ± 0.9^{b}	3.9 ± 0.2^{ab}	3.8 ± 0.8	0.18
3	PP_3	2.9 ± 1.2^{A}	4.6 ± 0.5^{acA}	3.5 ± 1.0	4.2 ± 0.4	0.03
4	PP_4	5.0 ± 0.0^{ab}	4.8 ± 0.4^{ad}	4.6 ± 0.9^{ac}	4.6 ± 0.9^{ab}	0.75
5	PP_5	2.5 ± 1.4^{b}	2.3 ± 0.9^{cd}	3.2 ± 0.4	3.4 ± 0.9	0.31
6	OM	2.2 ± 1.1^{b}	1.8 ± 0.8^{bcd}	2.0 ± 0.7^{bc}	2.4 ± 1.1^{b}	0.78
p-values		0.02	0.00	0.00	0.01	

The smoke-dried catfish samples from processing plants were rated to be of excellent to questionable quality in all attributes (Figure 16-20), while those from the open market were rated questionable. This result shows that samples, when arranged in order of quality in terms of appearance, colour, and odour from highest to lowest quality: $PP_4 > PP_3 > PP_2 > PP_5 > PP_1 >$ OM. However, in terms of texture and flavour the sample from PP_2 was better quality than PP_3.

4.5 Panellist performance during sensory evaluation

Five panellists participated during the sensory session; all panellists except one (panellist 5) took part in the training session. The scores for the quality parameters varied in all samples (Appendix 5b). All panellist allocated the lowest score to the catfish from the open market and the highest to samples from processing plant 4. However, there was some degree of disagreement in the panellists' scores for each attribute. Panellist 5, who did not attend the training, had the most deviation from the average, while panellists 2 and 3 had the least deviation from the mean. Panellist 1 had the most missing data.

Excluding panellist 5 from the data analysis, the scores for the quality parameters were not significantly different (Appendix 5c). Panellist 4 alone deviated from the group the most. Excluding panellist 4, all panellists agreed on attributes of all sample groups except the appearance of sample from Processing plant 5.

4.5.1 Water activity (a_w)

There was a significant difference between the water activity of smoke-dried catfish samples ($p=0.00$). However, there was no significant difference between the head and belly water activity of samples from processing plants and open market except for the tail where there were differences ($p=0.01$). Water activity ranged from 0.29 to 0.58 in all samples.

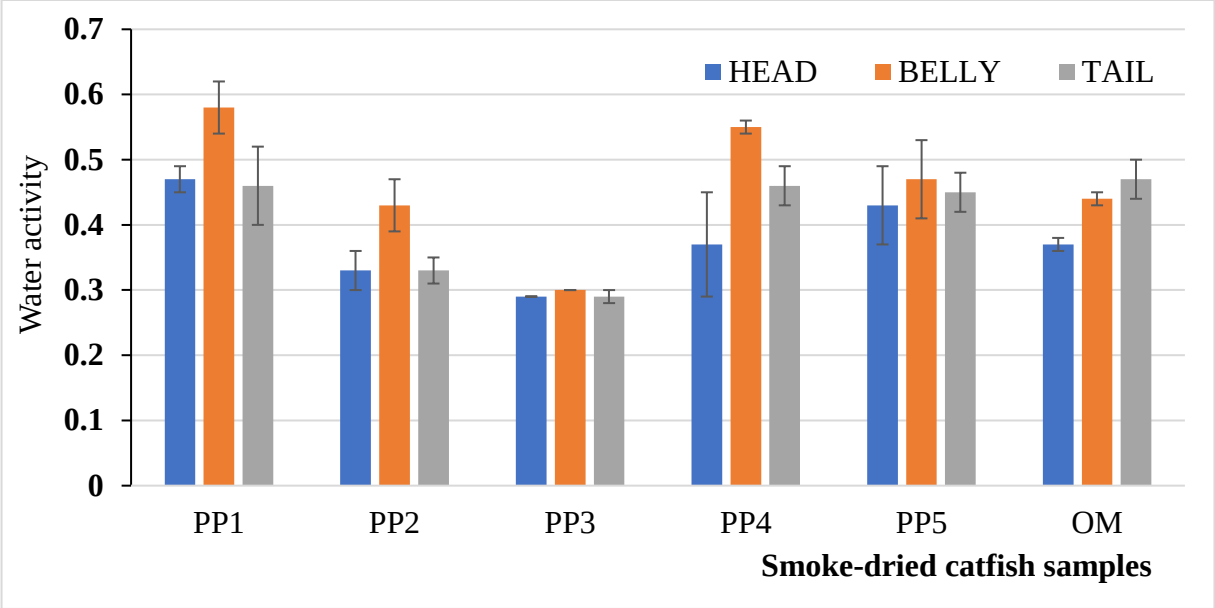

Figure 20. Water activity (aw) of the head, belly, and tail of smoke-dried catfish at arrival.

4.5.2 Moisture content (%)

Smoke-dried samples had moisture content from 4.28 to 10.21%. There was a significant difference in the moisture content of the smoke-dried fish from the different sources (p=0.03). There were no significant differences between the moisture content of the processing plant samples and OM. The highest moisture content was seen in samples from processor one and the lowest from processor two.

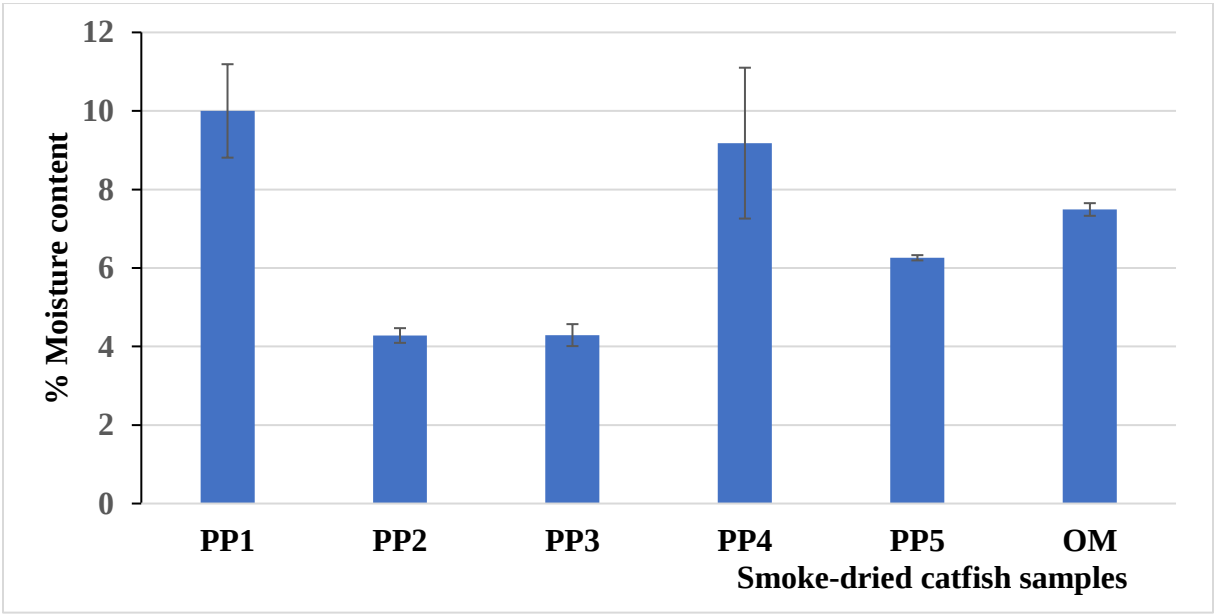

Figure 21. Moisture content (%) of smoke-dried catfish at arrival.

4.6 Temperature and relative humidity profile during storage

The disparity in the temperature and relative humidity within the storage chamber throughout the five weeks storage period is shown in Appendix 6. The temperature was approximately 50°C, while the relative humidity was 1.0 %.

4.7 Storage stability of smoke-dried catfish under different packaging material

4.7.1 Physical changes

There was evidence of oiliness in samples stored in both packaging materials as the storage time increased (Figure 22). The oil appeared noticeable on the first week of storage in vacuum and the fourth week in gunny bag.

4.7.2 Sensory evaluation

There were only minor differences in the flavour and odour of smoke-dried catfish samples stored in gunny sacks and vacuum packaging over the five weeks (Figure 23). The smoky odour decreased significantly faster in smoke-dried catfish stored in gunny bags in comparison to vacuum packs during weeks 2 and 4 ($p=0.02$ and 0.01). After four and five weeks in gunny bags, smoke-dried catfish lost more of their smoky flavour, which was still detectable in vacuum packed samples, but the difference was not significant. Only minor (below the score 20) rancid and spoilage odours and flavour were detected, which did not increase significantly with storage time in either packaging. The salty flavour was detectable but weak during storage in both packaging methods.

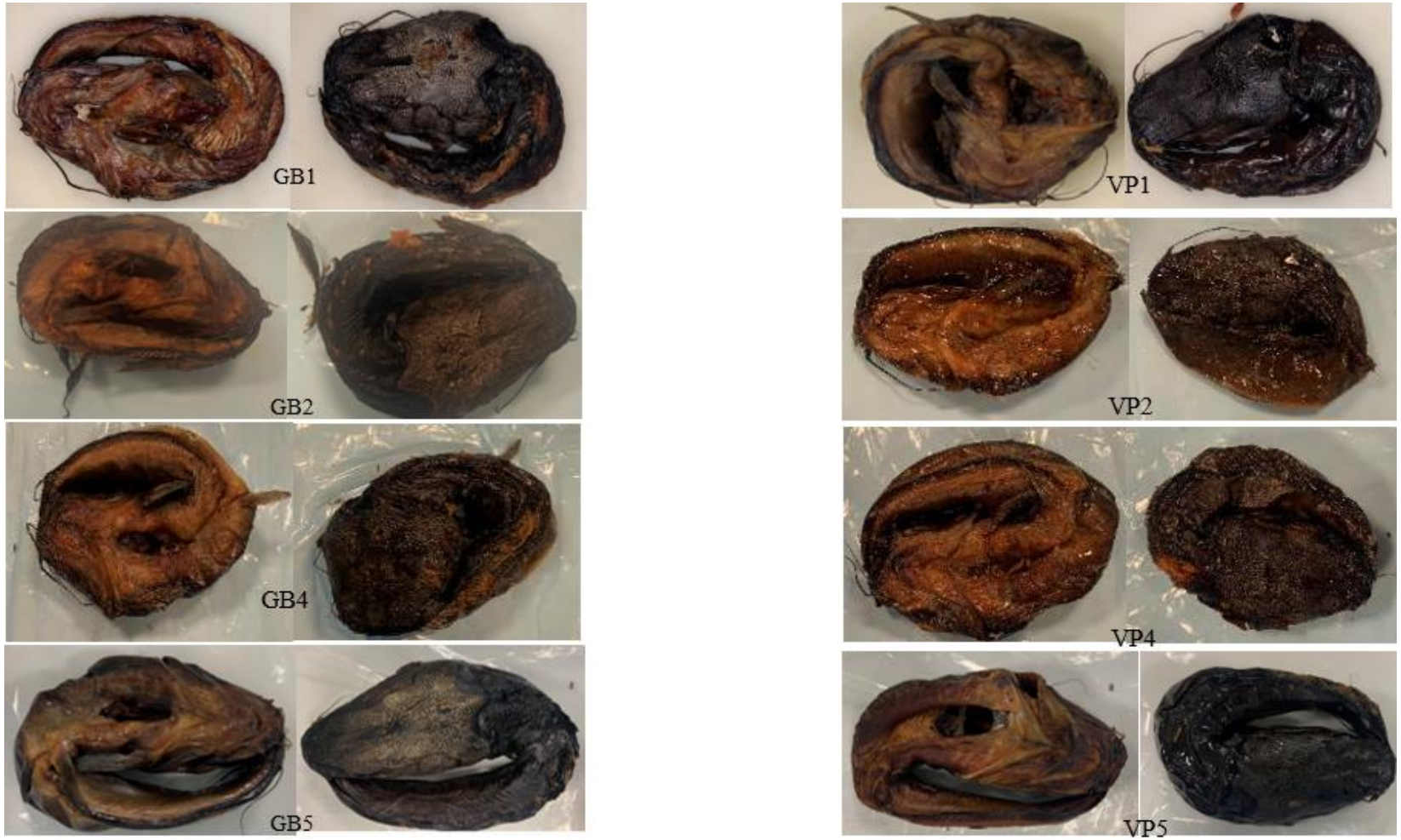

Figure 22. Smoke-dried catfish in gunny bag and vacuum pack. Belly-side (left), back-side (right). GB1, GB2, GB4, and GB5: smoke-dried catfish stored in gunny bag week 1-5. VP1, VP2, VP4 and VP5: smoke-dried catfish stored in vacuum packaging week 1-5.

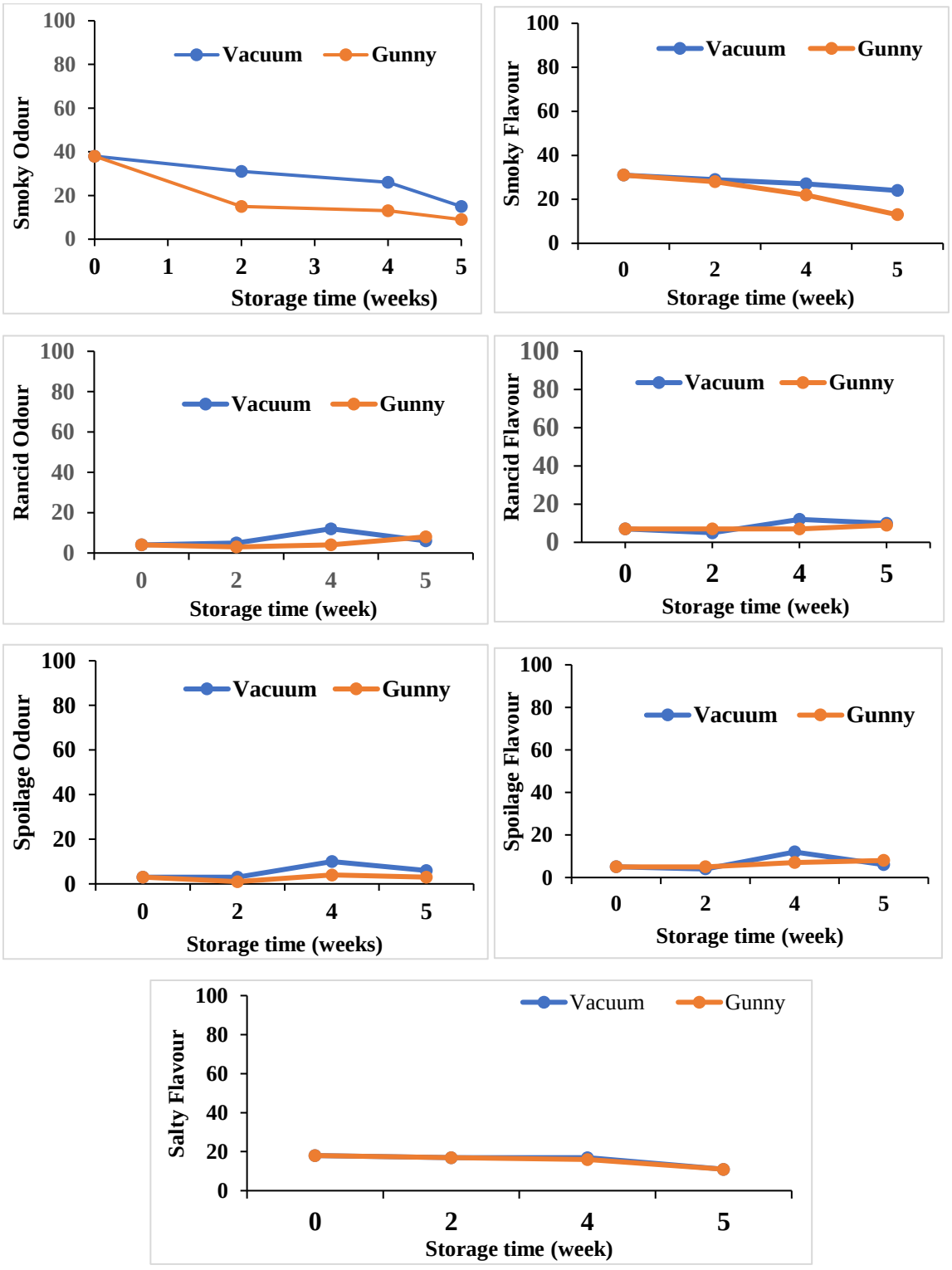

Figure 23. Sensory profile of smoke-dried catfish during storage in gunny bag and vacuum packaging at ≈50oC as evaluated by a trained sensory panel using descriptive analysis (scale 0-100) (O-Odour; F-Flavour).

4.7.3 Water activity

Water activity decreased significantly during storage in both gunny bags and vacuum packaging (p=0.01) (Figure 24). Water activity decreased significantly faster during storage in gunny bags in comparison to vacuum packaging (p=0.00).

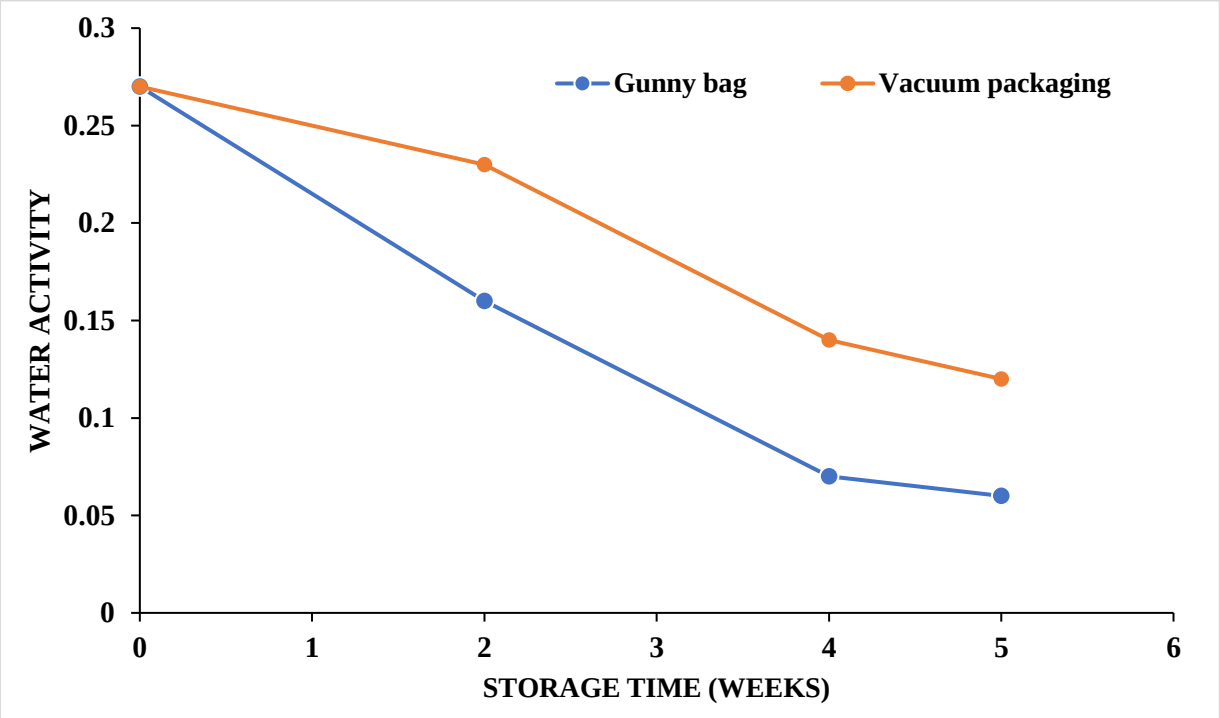

Figure 24. Evolution of water activity (aw) in smoke-dried catfish during storage in gunny bag and vacuum packaging at ≈50C.

4.7.4 Moisture content

The moisture content decreased during storage in gunny and vacuum packaging but was not significant (Figure 25). The moisture content decreased significantly faster in gunny bags in comparison to vacuum packed samples (p=0.03).

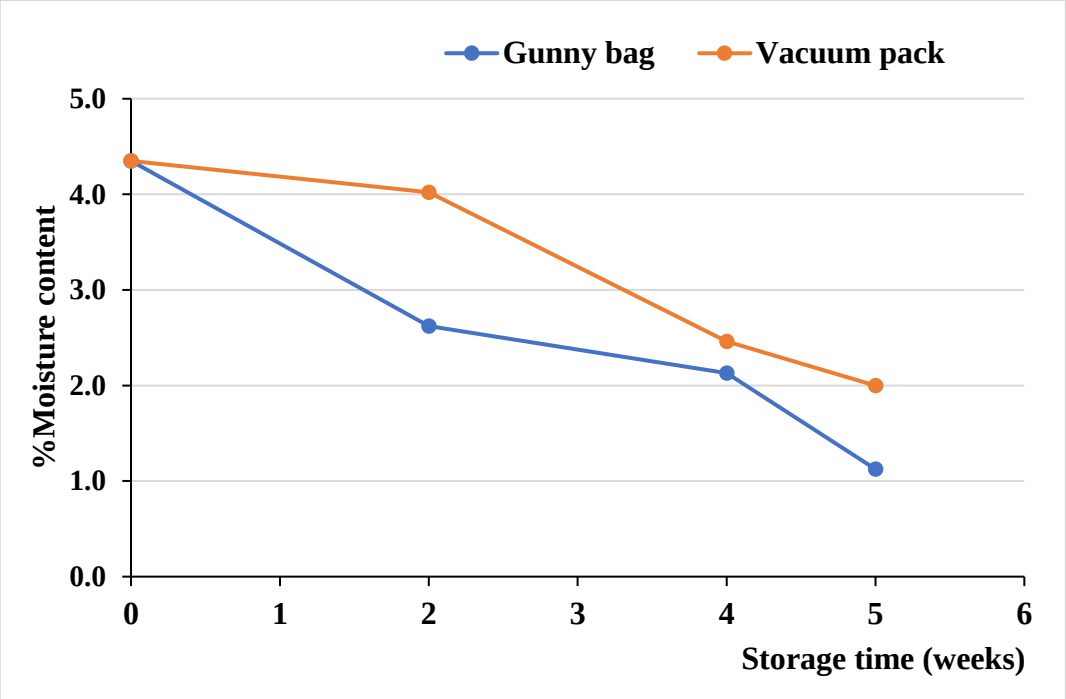

Figure 25. Moisture content of smoke-dried catfish during 5 weeks of storage using gunny bag and vacuum packaging at ≈ 50C.

4.7.5 Microbiological Stability

Total Viable Count (TVC) in smoke-dried catfish samples decreased throughout the storage period in both vacuum packaging and gunny bags but the decrease was not significant (Table 5). There was no significant difference in the TVC between VP and GB (p=0.17). There was no detected yeast or mould in either treatment throughout the storage period.

Table 5. TVC, mould and yeast in smoke-dried catfish samples packed in vacuum packaging and gunny bag during 5 weeks of storage at ≈ 50°C.

Storage time (in weeks)	TVC		Mould		Yeast	
	GB	VP	GB	VP	GB	VP
0	2.04	2.04	ND	ND	ND	ND
2	2.58	ND	ND	ND	ND	ND
4	1.60	1.30	ND	ND	ND	ND
5	1.30	ND	ND	ND	ND	ND

ND: Not Detectable GB: Gunny Bag; VP: Vacuum Pack

5 DISCUSSION

5.1 Development of quality scheme for smoke-dried catfish

Mapping and identification of the current procedures of sensory assessment and descriptors currently applied within the inspection of smoke-dried catfish in Nigeria revealed that the quality control officers of the processing plants and the regulatory body do carry out sensory evaluation. However, not all inspectors use the same criteria for sensory quality assessment, nor is there any

description or scheme for evaluating the product's sensory quality. This emphasises the importance of this research to implement protocols and sensory scheme for evaluating the sensory quality of smoke-dried catfish in Nigeria.

The preliminary scheme developed from the administered questionnaire alongside the sensory scheme for fish fillets that was first reported by Learson & Ronisvalli, (1969) served as a reference in developing the final quality scheme for smoke-dried catfish, with some changes being made during the training sessions. Parameters in the preliminary scheme were considered and modified into a detailed and more suitable description of how to evaluate each sensory attribute. The word “overall” was included in the appearance, and odour, “belly-side” was added to colour, and flavour and texture were combined, and “during tasting” was also added. In evaluating the colour of the fish, it is important to check the belly side as the backside of catfish is usually greyish black before smoking and black after smoke-drying. A sensory scheme considers specific aspects of each species, or product, assessing the quality by sensory analysis of a set of attributes considered relevant. The sensory scheme for fish fillets describes all attributes for each grade together, but the scheme developed adapted to smoke-dried catfish provided an individual and detailed description and grading of each attribute. It is essential to grade each attribute separately, making it easy and suitable for teaching, training, comprehension, and assessment coordination. The scheme considers the specific aspect of the product assessing the quality of the fish by sensory analysis of a set of relevant attributes.

Like the sensory grading scheme for fish fillets, the quality of the product is determined by the score given by the assessors, and the lowest score determines the product's quality (Matis, 2014; Martinsdóttir, 2010). If any attribute of smoke-dried catfish is graded unsuitable, the product should be deemed unacceptable.

5.2 Quality of smoke-dried catfish at arrival

The overall quality of smoke-dried catfish from processing plants at arrival was between excellent to questionable, while those from the open market were questionable. Smoke-dried catfish from processor 4 was the best quality, and the open market was the lowest. According to Alabi, et al., (2020), the use of an improved processing kiln produces a higher quality product. However, the smoke-dried catfish from processing plants 1 and 5 were of similar quality as those from the open market. This further emphasises the importance of evaluating the quality of products produced by approved processing plants and the importance of a quality scheme to ensure uniformity of evaluation.

Smoke-dried catfish from processing plants were of varying qualities, although they were processed using the same make of processing kiln. Many factors may lead to this varying quality, and these include the difference in pre-processing conditions and treatment (Olayemi, Omodara, & Peter, 2015), processing techniques e.g., the length of smoking and drying time (Chen, Huang, Tsai, & Mujumdar, 2008) and post-processing conditions and handling (Puke & Galoburda, 2020). Unsuitable drying conditions may have significant effects on the product quality, such as texture and colour, and the process yield of the product (Arason, Nguyen, Thorarinsdottir, & Thorkelsson, 2014).

Sensory evaluation measures intrinsic sensory attributes through analytical sensory perception by human assessors (CODEX, 1999). For assessors to objectively conduct sensory evaluation, they must be carefully selected and trained using the required testing methods and monitored for their ability to perform the sensory task (ISO 8586, 2012; CODEX, 1999)). During the evaluation of smoke-dried catfish from the processing plants and open market, the panellist without training gave high scores to samples with low-quality, showing the importance of training in sensory evaluation. Colour was the only attribute the majority of the panellists were able to evaluate without variations. There was some degree of disagreement when panellists were evaluating attributes of some samples, which could indicate a need for repeated training sessions focusing on panellists deviating from the group and the attributes of the deviations to ensure clarity. It could also indicate a need for modification of the scheme.

At arrival, the water activity of smoke-dried catfish was low and within the recommended limit (0.75) (CODEX, 2018). The moisture content of samples at arrival was also within limits (6 - 12 %) for smoke-dried fish recommended by Olayemi, Omodara & Peter, (2015) and the CODEX standard (2018). Low water content is of great importance in preventing spoilage during storage. This observation agrees with the findings of Oyedokun (2020), Ceasar & Constance (2019), Mosarrat, Dr. Gulshan, Dr. Shubhash, Farzana, & Mohajira (2017), Olayemi, Omodara & Peter, (2015) and Kumolu-Johnson, Aladetohun, & Ndimele (2010). They all reported that spoilage of fish resulting from the action of enzymes and bacteria could be slowed down by a reduction in moisture through sun drying or smoke-drying.

5.3 Storage stability of smoke-dried catfish using different packaging material

5.3.1 Physical changes

The oiliness observed on the smoke-dried catfish in vacuum packaging and gunny bags is probably related to low moisture content due to accelerated temperature, which supports the findings of Tinyiro, (2016) and Ayodeji, Wasiu, Adetayo, & Adam, (2020), who reported a negative correlation between moisture and fat content during storage. The delay in the visibility of oil on the smoke-dried catfish stored in gunny bags likely resulted from the oil absorption by the gunny bag as oil was observed at the bottom of the bag on the fourth week of storage.

5.3.2 Sensory evaluation

The assessed quality attributes, including rancidity and spoilage odour/flavours were not significantly affected during the five-week storage at 50^{o}C. The samples maintained their sensory properties. This finding agrees with Famurewa, Akise, & Ogunbodede, (2017) who reported that smoked fish stored at an accelerated temperature of 40^{o}C had less reduction in quality. From the lack of spoilage and rancidity found in smoke-dried catfish, it is also evident that the shelf-life of smoke dried catfish was not reached in these 5 weeks. While rancidity and spoilage odour and flavour increased with storage time, they were hardly detected in either packaging method. The smoky flavour and the odour decreased over time in both packaging types, but the decrease in the vacuum pack was much slower. This agrees with Angela, Mentang, & Sanger, (2015) and Eliazer & Junianto, (2021). They both concluded that vacuum packaging slows down the decline of the odour and flavour of smoked fish during storage.

5.3.3 Physicochemical stability

Moisture content is an important quality indicator of dried fish (Chowdhury, Rahman, Jahan, Flowra, & Islam, 2020). Water activity and temperature are some of the functions that describe the growth and activity of spoilage microorganisms (Gram, et al., 2002). Smoke-drying eliminates water, inhibiting spoilage microorganisms' growth and decreasing many deteriorative reactions controlled by water (Chowdhury, Rahman, Jahan, Flowra, & Islam, 2020).

The changes in the moisture content and water activity of smoke-dried catfish under vacuum and gunny packaging methods were highly correlated (r=0.92 Appendix 7) throughout the storage period. This result is similar to the findings of Tinyiro (2016) who reported a strong correlation (r=0.95) between water activity and moisture content of dried capelin during storage. The accelerated temperature significantly decreased moisture content and water activity of smoke-dried catfish in both packaging trails. The decrease observed in the water activity and moisture content may be attributed to the increase in solubility of non-polar solids such as fat in water at high temperature, resulting in lower water vapour pressure due to more significant interaction between water and fat molecules (Roopesh, et al., 2016). The decrease is similar to the findings of Costa (2016) who reported a decline in moisture content and water activity of smoked redfish during storage. The decrease in water activity and moisture content observed in vacuum-packed smoked-dried catfish during storage was slightly slower than in the gunny bag. The porous and ventilated nature of the gunny bag resulted in a quick decline. The diffusion of moisture in and out of a food product is dependent on the vapour pressure, composition, and temperature (Andrade, Lemus, & Pérez, 2011). Water vapour diffusion at high temperature is faster, resulting in dried food achieving quick water activity equilibrium (Roopesh, et al., 2016). The relative humidity was low at the high temperatures, resulting in moisture migration up the vapour pressure and out of the smoke-dried fish stored in the gunny bag. The final water activity and moisture content values in this study were 0.06, 0.12 and 1.12% and 2.0% in gunny and vacuum packaging, respectively, which was below 0.8 and 10% set standard of CODEX, (2018). All packaging methods maintained a safe moisture content and water activity level throughout the storage time in this study.

5.3.4 Microbial stability

Total viable count gives a quantitative estimate of microorganisms in food (Chowdhury, Rahman, Jahan, Flowra, & Islam, 2020). Dehydration and low moisture content prevent the growth of spoilage microbes (Kilic, 2009). The growth of microbes in smoke-dried catfish during storage is dependent on the water activity, storage temperature, handling, packaging method and storage environment (Fasuan, Akin-Obasola, & Borisade, 2021) which corroborated with the positive correlation between TVC and water activity for gunny bag and vacuum pack (r=0.8 and 0.6 respectively) during storage. At high storage temperature, TVC was reduced in both packaging methods throughout the storage period. The initial TVC before storage was 2.03 Log cfu/g which reduced to zero in vacuum and 1.03 Log cfu/g in gunny bag. The packaging method influenced microbial development in smoke-dried catfish. The lowest total viable counts (TVC) were observed in vacuum packaging. This can be attributed to air elimination, which retards the growth of microbes in the vacuum packaging as the growth of microbes in food is dependent on

the availability of oxygen, and the redox potential of the food, which will affect the quality and safety of the product (Chowdhury, Rahman, Jahan, Flowra, & Islam, 2020).

Yeast and mould were generally not detected during storage which is associated with the low moisture content due to processing conditions and storage temperature. The growth and production of fungi toxins in smoke-dried fish are dependent on water activity (Fasuan, Akin-Obasola, & Borisade, 2021). According to Fasuan, Akin-Obasola, & Borisade, (2021), the water activity of <0.7 should be maintained to prevent the growth of fungi. Reduction in the water activity during processing, sealing, and vacuum packaging reduced contamination by aerobic microbes such as yeast and mould. The results indicate that vacuum-packed smoke-dried catfish were microbiologically stable during storage.

6 CONCLUSION

Smoke-dried catfish is susceptible to spoilage if the packaging material and storage conditions are not ideal. A well-defined sensory scheme is a practical method of assessing the quality of processed fish. The development and implementation of a standardised sensory scheme will help ensure quality from the producers and ensure only acceptable products get to consumers.

The quality grading scheme developed proved to be an important tool for determining the quality of smoke-dried catfish. Despite using similar processing machinery, smoke-dried catfish from processing plants were of varying quality, and some were comparable to products from the open market which was of lesser quality.

In the shelf-life study, packaging and accelerated storage temperatures contributed to the decreased sensory, physicochemical, and microbial parameters in smoked-dried catfish throughout storage. As indicated by the smaller TVC in smoke-dried catfish packaged with vacuum packaging, the microbial quality of the catfish was protected. The moisture content and water activity were within acceptable limits in both packaging. However, vacuum packaging protected the smoke-dried catfish from losing too much moisture content and water activity throughout the storage.

Vacuum packaging protected the sensory quality, microbial and physicochemical properties of smoke-dried catfish throughout the storage period. Smoke-dried catfish remained safe and did not exceed the shelf-life after five weeks of storage at ≈50^{o}C, equivalent to six months of storage at 28^{o}C.

In general, the excellent quality of smoke-dried catfish utilised in this study was crucial in ensuring that most quality indicators of smoke-dried catfish remained within acceptable limits throughout storage. The implementation guidelines for training quality control officers in Nigeria (Appendix 8) were developed using the experiences and knowledge acquired during the development of the quality scheme.

7 RECOMMENDATIONS

- The FDA should coordinate with processors to achieve uniform smoke-dried catfish quality.
- The developed quality assessment scheme should be adopted for quality control and management in Nigeria.
- Additional long-term shelf-life studies should be conducted to investigate the use of alternative packaging materials, such as packaging in plastic with and without vacuum and at traditional storage temperatures.
- Studies should be conducted to assess the characteristics and reduce the oily appearance in smoke-dried catfish during storage.

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APPENDICES

Appendix 1. Grading scale for raw fillet (Learson & Ronisvalli, 1969)

Description	Grade
The colour is characteristic of the species. No unusual hue because of blood, insufficient washing, or storage. The fish flesh is firm and not ruptured. Odour is fresh (marine)	**EXCELLENT-5**
The colour is characteristic except for small colour changes in fillet (just noticeable). The fish flesh is firm and not ruptured	**GOOD-4**
Small colour changes. Reddish colour in the flesh (not a strong blood colour) and small blood spots visible in some fillets and in minor parts of them. Fish odour is weak but not abnormal odour	**AVERAGE-3**
Fillets and part of fillets have lost their characteristic colour. Grey-yellow and brown shades are visible in some fillets. Reddish hue and other colour changes caused by blood are visible. This raw material is definitely old. Flesh is soft and torn. No fresh odour but abnormal odour is apparent in some fillets (TMA or defrosted odour).	**QUESTIONABLE-2**
The appearance and texture are unsuitable for fish. Spoilage odour is obvious (strong TMA, sour and putrefaction)	**UNSUITABLE-1**

Appendix 2. Administered Questionnaires

Questionnaire For Fish Processors in Nigeria

This questionnaire is to develop a sensory scheme for smoke-dried catfish. A Sensory scheme gives a detailed interpretation, explanation, and grading of a product. It tells when to consider a product good or bad quality.

Please answer the following questions.

1. Name of Processing Plant:
2. Do you carry out sensory evaluations on smoke-dried catfish? Yes/No
   If yes, answer question three.
3. Do you have a scheme for evaluating quality of smoke-dried catfish? Yes/No
4. What do you check when carrying out the sensory evaluation of smoke-dried catfish?
   _____
   _____
5. Fill the table with a specific description based on what is considered good and bad quality

Sensory Attributes	**Good Quality**	**Bad Quality**
Appearance		
Texture		
Colour		
Flavour		
Taste		
Odour		

Questionnaire For Regulatory Bodies in Nigeria

This questionnaire is to develop a scheme for smoke-dried catfish. A Sensory scheme gives a detailed interpretation, explanation, and grading of a product. It tells when to consider a product good or bad quality.

Please answer the following questions.

1. Name of regulatory body: -
2. Do you carry out sensory evaluations on smoke-dried catfish? Yes/No
   If yes, answer question three.
3. Does the regulatory body have a scheme for evaluating the quality of smoke-dried catfish? Yes/No
4. What do you check when carrying out the sensory evaluation? A) Texture B) Colour C) Odour E) Appearance F) All of the above G)
   Others_____
   _____
   ___
5. Fill the table with a specific description based on what is considered good and bad quality of smoke-dried catfish. Description for each can be more than one

Sensory Attributes	**Good Quality**	**Bad Quality**
Appearance		
Texture		
Colour		
Flavour		
Taste		
Odour		

Appendix 3. Accelerated Aging Time calculation using ASTM F1980-07 calculator

Accelerated Aging Calculator

Begin by setting a desired real time in months to determine the equivalent accelerated aging time. Leave the other fields at their default values if yo have specific requirements.

Desired Real Time (months):*

6

Temperature of Accelerated Aging Environment (degrees Celsius):*

50

Sabre Medical does not recommend aging at temperatures exceeding +60°C. Common aging temperatures are +50°C, +55°C, and +60°C.

Ambient Room Temperature (degrees Celsius):*

25

This temperature is typically between +20°C to +25°C. A temperature of +25°C is a more conservative approach.

Aging Factor:*

2

This factor is typically between 1.8 to 2.5 with a value of 2.0 being the most common value.

Calculated Accelerated Aging Time (days):

32.26

For practical purposes, the calculated AAT is typically rounded up to the nearest whole day.

Appendix 4. Preliminary scheme for smoke-dried catfish

Appearance

GRADE	DESCRIPTION
EXCELLENT-5	Sensorial impression characteristics of the product, Dry, clear, shiny, and attractive
GOOD-4	Dry, clear but slightly less attractive and shiny,
AVERAGE-3	Oily, dull
QUESTIONABLE-2	Very oily, and grey/black soot
UNSUITABLE-1	Sensorial impressions, not characteristics of the product, burnt and rotten, Margot growth and mouldy, not clean, and unattractive

Colour

GRADE	DESCRIPTION
EXCELLENT-5	Golden yellow,
GOOD-4	Light Brown
AVERAGE-3	Dark brown
QUESTIONABLE-2	Dark
UNSUITABLE-1	Black, very dark, persistent, and discoloured due to decomposition or rancidity.

Texture

GRADE	DESCRIPTION
EXCELLENT-5	Firm, brittle, and rigid to touch, smooth on the outside, stringy to touch
GOOD-4	Firm and not very smooth and stringy to touch
AVERAGE-3	Not very firm but rough feel on the outside,
QUESTIONABLE-2	Soft, Rubbery, very rough feel on the outside
UNSUITABLE-1	Very Soft, gaping, sticky, flabby

Flavour

GRADE	DESCRIPTION
EXCELLENT-5	Meat is Sweet and crispy, Pleasant-salty not overwhelming, smoky flavour
GOOD-4	Smoky flavour, sweet and slightly crispy
AVERAGE-3	Lightly smoky, burnt taste and very crispy
QUESTIONABLE-2	Burnt, bitter, sour taste, overwhelming salty
UNSUITABLE-1	Off flavour, burnt fish, Spoilt

Odour After smoking

GRADE	DESCRIPTION
EXCELLENT-5	Sweet smell, smoky, odour characteristic to the fish, fresh,
GOOD-4	Less sweet, less characteristic, or fresh
AVERAGE-3	Slightly off-odour
QUESTIONABLE-2	Off-odour is apparent
UNSUITABLE-1	Burnt, offensive foul odour (spoilage odour),

Appendix 5. Panellist performance for training and sensory evaluation

a: Panellist training score

Appearance	Pan 1	Pan 2	Pan 3	Pan 4	Pan 5	Pan 6	Pan 7	Pan 8	average
PP_1	2	3	1	3	4	2	2	1	2
PP_2	5		3	4	3	3	5	1	3
PP_3	4	5	4	4	4	2	5	5	4
PP_4	5		5	5	5	5	5	5	5
PP_5	4		2	2	1	1	2	1	2
OM	2		1	1	1	2	1	2	1
Colour	Pan 1	Pan 2	Pan 3	Pan 4	Pan 5	Pan 6	Pan 7	Pan 8	average
PP_1	3	3	1	3	2	2	2	1	2
PP_2	4		3	3	3	2	3	5	3
PP_3	5	5	3	4	4	4	4	5	4
PP_4	5		5	5	4	5	5	5	5
PP_5	3		1	3		1	2		2
OM	2		1	2	1	1	1	2	1
Texture	Pan 1	Pan 2	Pan 3	Pan 4	Pan 5	Pan 6	Pan 7	Pan 8	average
PP_1	4	4	5	4	4	2	3	4	4
PP_2	1		2	4	4	2	5	5	3
PP_3	4	4	2	5	4	3	5	4	4
PP_4	5		5	5	3	3	4	5	4
PP_5	3		1	4	1	1	2		2
OM	2		5		5	2	4		4
Flavour	Pan 1	Pan 2	Pan 3	Pan 4	Pan 5	Pan 6	Pan 7	Pan 8	average
PP_1	2	2	1	4	4	2	2		2
PP_2	2		2	3	4	2	4	3	3
PP_3	5	4	3	3	3	3	3		3
PP_4	5		5	5	3	3	4	4	4
PP_5	5		1	4	3	1	3		3
OM	4		2	1	1	2	2		2
Odour	Pan 1	Pan 2	Pan 3	Pan 4	Pan 5	Pan 6	Pan 7	Pan 8	average
PP_1	4	4	4	4	5	2	3	4	4
PP_2	5		4	4	4	2	3		4
PP_3	5	5	5	4	4	3	3		4
PP_4	5		5	5	4	3	5	5	5
PP_5	4		1	4	3	1	3	5	3
OM	2		1	1	3	2	3		2

b: Panellist sensory evaluation score

APPERANCE	Pan 1	Pan 2	Pan 3	Pan 4	Pan 5	Average
PP_1	1	2	1	4	4	2
PP_2	2	2	1	3	5	3
PP_3	2	3	2	3	5	3
PP_4	5	5	5	5	5	5
PP_5	4	1	1	3	4	3
OM	2	2	1	2	4	2
COLOUR	Pan 1	Pan 2	Pan 3	Pan 4	Pan 5	Average
PP_1	1	3	1	2	4	2
PP_2	3	3	4	3	5	4
PP_3	4	5	5	4	5	5
PP_4	5	5	5	4	5	5
PP_5	3	1	2		3	2
OM	2	2	1	1	3	2
ODOUR	Pan 1	Pan 2	Pan 3	Pan 4	Pan 5	Average
PP_1		2	1	4	3	3
PP_2	3	4	3	4	5	4
PP_3	4	4	5	4	4	4
PP_4	5	5	5	3	5	5
PP_5	4	2	3	4	4	3
OM	2	3	2	1	4	2
TEXTURE AND FLAVOUR	Pan 1	Pan 2	Pan 3	Pan 4	Pan 5	Average
PP_1	1	1	2	4	3	2
PP_2	4	4	4	4	4	4
PP_3		3	5	3	3	4
PP_4	5	5	5	3	5	5
PP_5	4	3		3	3	3
OM	2	2	2	1	3	2

c: Panellist sensory evaluation score without panellist 5

APPERANCE	Pan 1	Pan 2	Pan 3	Pan 4	Average
PP_1	1	2	1	4	2
PP_2	2	2	1	3	2
PP_3	2	2.5	2	3	2
PP_4	5	5	5	5	5
PP_5	4	1	1	3	2
OM	2	2	1	2	2
COLOUR	Pan 1	Pan 2	Pan 3	Pan 4	Average
PP_1	1	3	1	2	2
PP_2	3	3	4	3	3
PP_3	4	5	5	4	5
PP_4	5	5	5	4	5
PP_5	3	1	2		2
OM	2	2	1	1	2
ODOUR	Pan 1	Pan 2	Pan 3	Pan 4	Average
PP_1		2	1	4	2
PP_2	3	4	3	4	4
PP_3	4	4	5	4	4
PP_4	5	5	5	3	5
PP_5	4	2	3	4	3
OM	2	3	2	1	2
TEXTURE AND FLAVOUR	Pan 1	Pan 2	Pan 3	Pan 4	Average
PP_1	1	1	2	4	2
PP_2	4	3.5	4	4	4
PP_3		3	5	3	4
PP_4	5	5	5	3	5
PP_5	4	3		3	3
OM	2	2	2	1	2

Appendix 6. Temperature and relative humidity loggers during storage days

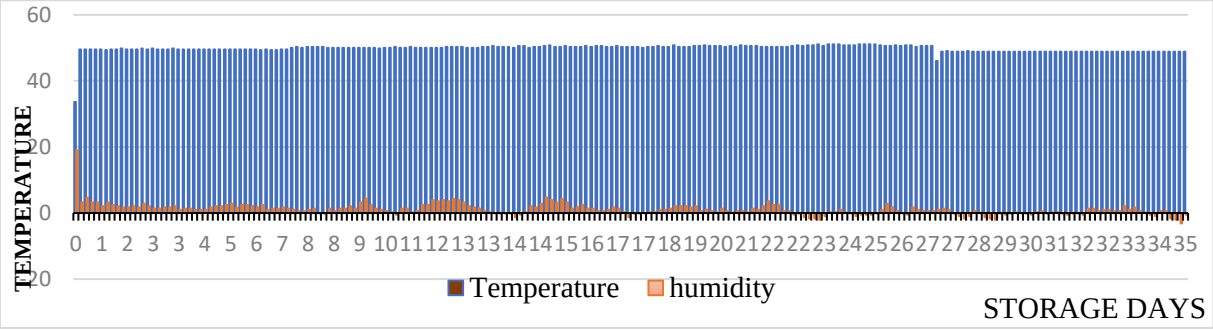


Figure A1. Temperature and relative humidity profile within the storage cabinet for 5-week storage period. (H – relative humidity; T – temperature).

Appendix 7. Pearson's correlation coefficients between chemical and microbiological attributes of smoke-dried catfish

Table A1. Pearson's correlation coefficients between chemical and microbiological attributes of smoke-dried catfish packaged using VP – Vacuum Packaging; and GB - Gunny Bag during the first four weeks of storage (0 – 5 weeks).

	storage time	***moisture content in GB***	***Moisture content in VP***	***water activity in GB***	***water activity in VP***	***TVC in GB***	***TVC in VP***
storage time	1						
moisture content GB	-0.974	1					
Moisture content VP	-0.966	0.891	1				
water activity GB	-0.982	0.916	0.995	1			
water activity VP	-0.986	0.967	0.924	0.957	1		
TVC GB	-0.707	0.569	0.863	0.811	0.606	1	
TVC VP	-0.593	0.759	0.389	0.436	0.613	-0.022	1

Appendix 8. Implementation plan and guidelines for sensory evaluation of smoke-dried catfish

Scope and purpose of the guidelines

The guidelines are purposive to be used by regulatory agencies and quality control managers in smoke-dried catfish processing plants. These guidelines are for sensory evaluation based on the quality scheme of smoke-dried catfish to determine its quality and defects during processing which can affect the quality of the product, which generally is not done by analysis in the field.

Facilities for sensory evaluatio*n*

Facilities for sensory evaluation should be located within the company and easily accessible. The facilities should be in line with the ISO 8589:2007 on the general guidelines for the design of test rooms.

Preparation area

This area is for the preparation of samples for sensory evaluation. It is also for handling and storage of the product. This area should be located separately from evaluation or testing areas to ensure that sample odour does not interfere with sensory analysis during sample preparation and prevent assessors' interference.

Evaluation Area

This area is for evaluating fishery products, and thus preparation of samples, chemical and microbiological analysis should not be conducted here. The area should be well ventilated, spacious, uniformly illuminated with bright lightning, far away from noise and odour sources. No eating, drinking, or smoking should be allowed in this area. This wall should be painted evenly, preferably with an off-white colour.

Sensory Panel leader

It is vital to have a trained coordinator of the sensory evaluation to maintain consistency. This coordinator is known as the panel leader. This individual should have a background in fisheries quality control or related discipline. The panel leader should be well trained in sensory evaluations of smoke-dried catfish and other fishery products. He is charged with the authority to set up and subsequently audit the program's functioning. The panel leader selects and trains the panellist in difference and descriptive tests. The panel leader is also responsible for organizing and implementing training programs, ensuring adequate supplies of training samples are maintained, ensuring all relevant documentation is maintained and updated as appropriate, maintaining the technical skills, and motivating the panellist. He also ensures sensory evaluation is conducted professionally. The panel leader also provides reports and results and the overall performance of the system and panellist

Selection of assessors for training

Assessors for sensory evaluation will be selected based on the ISO 8586 (2012) standard. To be selected as an assessor, the candidate should: -

1. be able to perceive odours, so that the odours of decomposition and other defects will be perceived
2. be able to perceive basic tastes, so that tastes associated with decomposition will be perceived and described

3. have normal colour vision and can detect abnormalities in the appearance of fishery products
4. be able to rely on sensory perceptions and to report them appropriately
5. be able to learn terminology for new or unfamiliar perceptions (odours, tastes, appearance, textures)
6. be able to define sensory stimuli and relate them to underlying causes in the product

Screening for odour perception (According to ISO 5496 and 8586)

Five to ten olfactory stimuli related to smoke-dried catfish should be used for this screening. This set should contain some samples which are easy to recognize and others which are less common. The intensities should be well above the recognition threshold but not significantly above the levels that might be encountered in smoke-dried catfish. Stimuli such as burnt wood, rancid, trimethylamine, sour, smoky, burnt dried-smoked catfish are recommended for the sensory evaluation of smoke-dried catfish. Samples should be hidden properly, e.g., under cotton in odourless containers/flasks. The lid of containers or flasks and properly sealed to prevent odour evaporation. Samples should be coded and labelled in unknown series. Participants should be presented with an evaluation form and asked to describe the odour perceived from each stimulus to the best of their ability.

Screening for the perception of basic tastes (According to ISO 8586)

Flavour is diverse, especially defects from decomposition, which assessors will be required to perceive and describe, making it essential to establish their general ability to perceive basic tastes. Basic taste stimuli should be used for this screening. Samples containing sweet, sour, umami, bitter, and salt should be used. Cups filled with samples containing water mixed solution of sucrose, citric acid, sodium chloride, caffeine, and MSG should be presented in a labelled series unknown to the participants. Repetition of one and one neutral sample should be presented to help correctly identify good tasters.

Screening for the perception of colour and appearance (According to ISO 11037 and 8586)

Three to five smoke-dried catfish of varying colours and appearance should be used for this training. Samples should be coded, and participants asked to name the colour and describe the appearance of the samples presented. Each participant should be presented with an evaluation form and asked to define each taste characteristic.

Note: Participants should be graded according to performance on a scale: 3 points for a correct identification or description of the most frequent association; 2 points for a description in general terms; 1 point for identification or description of an appropriate association following discussion and 0 point for no response or a totally wrong response. The satisfactory level of success is specific to the materials used. Participants must score at least 65% to be fit as panellist. The evaluation form for all screening should contain the following:

Date:….. Your name: ……

Sample no	**Taste/Odour/Colour/ Appearance sample description**
_____	_____

General/ Basic rules

- Drinking, eating, and smoking around the testing area should not be allowed
- Drinking of coffee and smoking before attending a sensory session should not be allowed
- Panellist should not attend sessions hungry or fatigued
- Panellists should be encouraged to rest and breathe fresh air between samples during evaluation
- Drinking water in before, and during training should be encouraged
- Preferable time for sensory test is 10-11 am and 2-3 pm
- Panellist should respect and pay attention to the instructions of the panel leader.
- Panellist should also understand the importance of the sensory evaluation in quality control
- Consistence in attendance is vital
- Panellist interactions during evaluation should be prohibited
- Individuals with health challenges should not participate in sensory evaluation

Sample size, collection, and preparation (According to CAC-GL 31-1999)

A representative size of the entire lot produced at the same time should be randomly selected. A minimum of two to three samples per lot should be used for the sensory evaluation. If samples are in a bag, one each from the top, middle and bottom or in processing kiln, one each from close to the door, middle, and back. There should be no compromising during sample selection. During the collection of the smoke-dried catfish samples for training and evaluation, samples must be handled with care to avoid the sensory properties getting infected. The samples should be packed correctly in a moisture-retaining sealed pack kept at ambient temperature. Smoke-dried catfish samples should be evaluated immediately after they get to the laboratory; otherwise, they should be stored under appropriate conditions.

Training of panellist

The quality scheme developed for smoke-dried catfish within the GRO-FTP at Matis should be used to train panellists. Varying quality of smoke-dried catfish should be prepared for training by panel leader before the arrival of panellist. Three to four samples should be arranged on a sensory evaluation table under bright light. Samples should be labelled with codes that panellist cannot easily decipher and does not indicate information about the samples. The presentation order should be random and balanced.

The training session should start with the panel leader carefully describing the evaluation procedures, panellist expectations, etc. The quality parameters on the quality scheme for smoke-dried catfish should be carefully explained along with the quality changes to look out for. Panellist should be given a copy of the quality scheme and trained on scoring each sensory attribute. Panellist should also be encouraged not to allow their personal judgement to interfere with the evaluation. Panellist should be allowed to interact with other panellists and panel leader about their suggestions and opinions. During subsequent training and evaluation session, discussions should not be allowed. The number of training sessions will be determined by the panellist performance. Panellist should be motivated through word of encouragement and snacks and drinks should also be provided.

Modifications are to be made to the quality scheme if there are any during the training sessions. At the end of the training sessions, a final quality scheme will be developed for the smoke-dried catfish. However, if there is no modification, the scheme should be adopted for quality grading of smoke-dried catfish by the quality assurance inspection service of the Federal Department of Fisheries and the quality control personnel of smoke-dried catfish processing plants. The FDF trained inspectors should in-turn train the quality control team in these shrimping companies

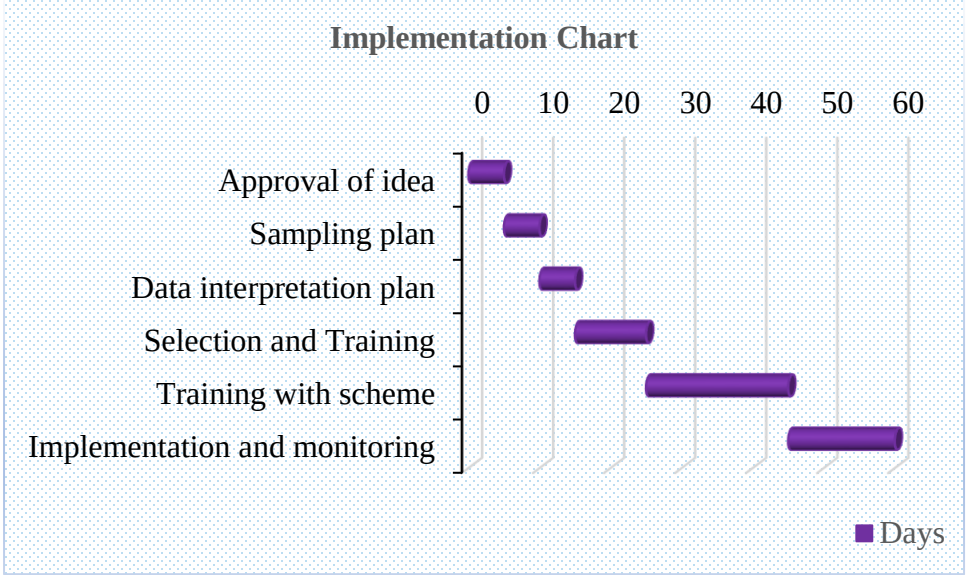
Monitoring of assessors

According to ISO 6658 (2017), the panellist's performance during the evaluation should be monitored by the panel leader. Sensory data from the training should be analysed and interpreted by the panel leader, sensory staff, or project leaders. Statistical analysis (averages, Analysis of Variance, and t-tests) shall be conducted with the scores given by the panellists during the training session to determine the performance of each panellist.

At the end of the analysis, if deviation from the average score per attribute is noticed, panellist should be retrained based on the attribute of deviation. If a lot of missing data from evaluation is noticed, such panellist should not be considered qualified.

Adoption/Implementation of quality scheme

The process from approval of the idea to the implementation and monitoring should take about three months for completion.



Approval of the idea: The implementation of the method has been approved by relevant authorities.
Sampling plan: Number of samples to collect, collection method of samples per lot, and preparation of samples for sensory evaluation.
Data interpretation plan: How sensory results can be used to guide decisions (for example, if the results are bad consult the processor and suggest improvements; where should the product be sold if it is good or bad).
Panellist selection and training: Criteria to fulfil, sensitivity tests, and others according to standard ISO 1107 and 8586, and general basic rules.

Training with the scheme: Training sensory assessors in using the scheme for smoke-dried catfish, including modifications if needed. Includes data analysis of training results
Implementation and monitoring: Scheme and procedure in use, and monitoring of assessors