QUALITY ASSESSMENT OF FROZEN MACKEREL FISH (SCOMBER SCOMBRUS) SOLD IN SOME SELECTED COLD STORES IN MAKURDI METROPOLIS

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ABSTRACT Quality assessment of frozen mackerel fish sold in some selected cold stores in Makurdi metropolis was carried out using sensory, microbiological and chemical methods of evaluation. The frozen mackerel fish samples assessed in the three cold stores were all sensory acceptable in the range: appearance (4.3-5.0), texture (3.0-4.0), Odor (3.7-4.4) and general acceptability (3.5-4.5). The total viable count was also within safe limits of $2.7 \times 10^4$ cfu/g, $4.1 \times 10^4$ cfu/g and $9.0 \times 10^4$ cfu/g. Total fungal and coliform count examination showed no growth. Chemical analysis revealed results in the range: moisture (66.50-70.29%), protein (16.22-19.29%), fat (11.34-12.20%), ash (1.33-1.43%), carbohydrate (0.68-0.79%), pH (6.1-7.0) and total volatile nitrogen (26.64-30.7). Total volatile nitrogen analysis showed frozen mackerel fish from cold stores in North bank were stale.

KEYWORDS Frozen mackerel fish; Cold stores; Quality assessment.

1. Introduction

Fresh fish are among the most perishable food products known to man. The monitoring and control of fish quality are among the main goals in the fish industry. Fish and shellfish are highly perishable and prone to vast variation in quality due to differences in species, environmental habitats and feeding habits[25]. Besides, they can also function as carriers of several microbial and other health hazards. Therefore the maintenance of quality is of utmost importance in production and trade of fishery products. Most current quality control techniques are time-consuming and cumbersome [25]. Fish shelf life is influenced by several factors such as initial microbiological load, season and handling and the limited and variable shelf lives of fish are significant problems for fish quality and assurance [18]. According to Huss (1995), the main changes that can occur between capture and consumption of fish can be divided into three (3) stages; the pre-rigour state in which the muscle tissue is soft and pliable, the stiff and rigour condition known as rigour mortis whose onset can occur between 1-24 hours depending on the fish species following the death of fish and the post-rigour state in which the fish softens and starts to deteriorate. It is noteworthy that pollution can also significantly affect the shelf life of fish because the fish species inhabiting polluted waters have already compromised their original healthy status [6].

Generally, in the first couple of hours after death, changes in fish are mainly due to biochemical; processes, however, several hours after death, few bacteria can penetrate the flesh where they degrade tissue components producing the unpleasant odours and flavours that are associated with spoilage [14]. Fish spoilage is as a result of autoysis, oxidation and bacteria growth or by the combination of these. Bacteria spoilage of fish does not begin until after rigour mortis when the juices are released from the fish. Therefore the more rigour is delayed, the longer the keeping quality of fish. Rigor mortis is hastened by struggling of the fish, lack of oxygen and warm temperature and is delayed by low pH and adequate cooling of the fish [13]. Time and temperature are, therefore, the most critical factors to control to ensure that sea foods retain high freshness and quality as long as possible [1]. At room temperature, seafood is likely to deteriorate very fast. Freezing and storage at low temperatures slow down bacteria growth and deterioration of fish through some enzymatic and chemical changes that progress slowly [14].

Quality assessment of fishes has more to do with determining its shelf life or storage life, which is the amount of time that sea foods remain palatable. Different fish species have a different shelf life, which varies depending on the oil level, catch area, season, duration of rigour mortis, intrinsic conditions of the fish and how it was captured and handled [14]. The shelf life of
most fishes has been predicted to range between 2-24 days in ice, five days at 5°C and three days at 10°C[14]. Super chilling at -4°C and below have proven to extensively extend the shelf life of frozen fish to several weeks because, at such temperatures, microbial spoilage is almost impossible, it is only chemical and enzymatic changes that can lead to spoilage after a considerable long time[14]. Marketing of fish in Nigeria is mostly carried out by local fish sellers at ambient temperature. Therefore knowledge of spoilage patterns of tropical fishes and shelf life under ambient conditions is critical. Refrigeration temperatures are also relevant because they are used by most households in Nigeria for the temporary storage of fish. Frozen state condition is also important since most fishes consumed in Nigeria are imported and usually come in a frozen state. In recent times, modern biotechnology has introduced a new technique that can detect early fish contamination, improve the taste, modify the quality of fish and prolong the shelf life and also impact disease resistance to the fish[24]. There are two main methods of assessing fish quality to determine its freshness and shelf life, and these are the sensory and non-sensory methods. Sensory methods rely mostly on appearance, odour and the texture of the fish while non-sensory rely on biochemical, chemical and microbiological means [14]. The research assesses the sensory attributes, microbiological and chemical properties of frozen mackerel fish sold in some selected cold stores in Makurdi Metropolis, Benue State, Nigeria.

2. Methods

2.1 Sample collection

Samples of frozen mackerel fish (Scomber scombrus) were collected from three different cold stores at Wurukum, High-level, and North bank in Makurdi metropolis during the early hours morning (7:00 to 8:00 am local time). This was done when the fish was still being brought out from the cold room and packed in sterile containers with ice. They were transported immediately to the laboratory for microbial, chemical and sensory analysis. The frozen mackerel fish samples were aseptically removed from the laboratory’s container for analysis.

2.2 Sterilization of materials

All glass to be wares used were washed, dried and sterilized in a hot air oven at a temperature of 160°C for 1 hour according to the method described by Adibe and Eze(2004). Culture media were sterilized in an autoclave at a temperature of 121°C for 15 minutes. The wire loop was sterilized using a spirit lamp.

2.3 Sample preparation

Ten (10g) of the fish sample was cut from the head, muscle flesh and tail region with a sterile knife. The cut samples were crushed into small pieces in a sterile mortar with 10 ml sterile water. The crushed sample, 1ml aliquot volume was measured out and homogenized in a clean, dry sterile beaker containing 9 ml of distilled water, giving a 1:10 dilution. This was done for all the fish samples collected.

2.4. Microbial Analysis of frozen mackerel fish

2.4.1 Serial dilution

Twelve (12) test tubes were sterilized, arranged and labelled 10^{-1} to 10^{-4} arranged accordingly. 9.0 ml of distilled water was dispensed into the various test tubes. Two gram (2g) of the fish was poured into 25 ml of the distilled water in a beaker and stirred. 0.1 ml of the sample was taken from the first test tube and transferred into another tube.

2.4.2 Total fungal count media preparation

Ten(10g) of potato dextrose agar powder was added to deionised water in a flask bringing the volume to 1 litre and swirled to mix thoroughly and was autoclave at 120°C for 15 minutes(15psi). 10% sterile tartaric acid was added to the melted potato dextrose agar(4ml acid per 100ml agar), cooled to 45° C to reduce agar pH[3].

2.4.3 Determination of Total fungal count (TFC)

One millilitre (1.0ml) of properly diluted sample was placed in a sterile petri dish. About 15ml of warm, melted acidified potato dextrose agar was added and spread uniformly over the entire surface of the sample by coating the plate following agar solidification. The culture plate was inverted and incubated at 37° C for 24-48 hours. The colonies were counted and resulted recorded (Collin et al., 1989)

2.4.4 Total viable count (TVC)

The method described by Adegoke (2004) [3] was used. Five grams (5g) of nutrient agar was weighed and was dissolved in 250 ml distilled water in a conical flask and then mixed thoroughly. It was gently heated to boiling and then sterilize in an autoclave for 25 minutes for 15 minutes at 121°C. The sterilized nutrient agar was left to cool and poured into a petri dish to gel. The sample was inoculated into plates and incubated at 37°C for 24-48 hours.

2.4.5 Coliform count

2.4.6 Determination of the presumptive coliform count of samples

5ml and 7ml measured amount respectively of single and double strength modified MacConkey broth, or fluid medium were sterilized in culture tubes containing Durham tubes to indicate gas production with sterile graduated D pipettes. Five 10 ml of double strength MacConkey broth and five 0.1 ml of test samples were added to five of single strength MacConkey broth. The bottles containing the inoculum and medium were incubated at 37°C for 24-48 hours. Those that show acid and sufficient gas to fill the concavity at the bottles of the inverted Durham tubes were considered to be presumptive positive as a result of the growth of coliform [23].

2.4.7 Faecal Coliform

Inoculation from presumptive tubes was transferred into the tubes of sterilizing brilliant green bile broth (BGBB) for determination of faecal coliform with the tubes were incubated at 37°C for 48 hours. Tubes were observed for the trap of evolving in the color from the control to yellowish color considered to be positive for faecal coliform [23].
2.5. Analysis

2.5.1 Proximate Composition

2.5.2 Determination of moisture content

This was determined in triplicate by hot air oven method in an indirect distillation method. According to AOAC (2010) method, three gram (3 g) each of the product samples was weighed (W₂) using a digital balance into a clean, dried, cooked and weighed crucible (W₁). The sample in the crucible was transferred into a hot air oven at 150°C and dried for 2 hours. The crucible was weighed periodically until constant weights (W₃) was obtained. The percentage of moisture was calculated as follows:

\[ \% \text{ Moisture} = \frac{W₂ - W₃}{W₁} \times 100 \]

Where:
- \( W₁ \) = Initial weight of empty crucible;
- \( W₂ \) = Weight of crucible + food before drying;
- \( W₃ \) = Final weight of crucible + food after drying;

\% Total solid (dry matter) = 100 - \% moisture

2.5.3 Determination of fat

Crude fat was determined using the Soxhlet extraction method described by AOAC (2010). A 250 ml clean boiling flask (B) was dried in an oven at 100°C using hot air oven. Three gram (3 g) of sample (A) will be weighed (using a digital balance, Model number: No.T 320N) into a thimble. The thimble and its content were placed in the extraction apparatus, and extraction was with ethyl ether in Soxhlet extractor for 6–8 h at a condensation rate of at 3–6 drops per second. The fat was extracted and transferred into a pre-weighed evaporated dish during this process. The petroleum ether was recovered by evaporation using a bath. The remaining fat in the flask was dried in the oven at 80°C for 30 minutes and cooled in a desiccator and finally weighed using a digital balance. The difference in the weight of the empty flask and the flask with oil (C) gave the oil content was calculated as percentage fat content:

\[ \% \text{ Crude fat} = \frac{C - B \times 100}{A - B} \]

A = Weight of sample
B = Weight of empty flask
C = Weight of flask + oil

2.5.4 Determination of crude protein

The crude protein content of the sample was determined by the semi-micro Kjeldahl technique, as described by AOAC (2010). One gram (1.0 g) of the sample was put into a Kjeldahl flask, and 3.0 g of hydrated cupric sulphate (catalyst) was added in the flask. Then, 20 ml of anhydrous sodium sulphate and 1.0 g of concentrated tetraoxosulphate VI acid (H₂SO₄) was added to digest the samples which were topped and swirled. The flask and liquid were clear and free of colouration. The clear solution was cooled and made up to 100 ml with distilled water, and a digest of 5 ml was collected for distillation. Then, 5 ml of 60% sodium hydroxide solution (NaOH) was put into the distillation flask and distilled for some minutes. Boric acid indicator absorbed the ammonia, which was distilled off, and this was titrated with 0.1 ml hydrochloric acid (HCl). A blank titration was similarly carried out, and the titre value is recorded and used for calculation of total volatile nitrogen

Calculation

\[ \text{Carbohydrate} = 100 - (\% \text{ moisture} + \% \text{ ash} + \% \text{ protein} + \% \text{ fat}) \]

2.5.5 Determination of ash content

Ash was determined in a muffle furnace described by AOAC (2010). Crucibles were heated in an oven for five minutes to eliminate moisture, cooled in desiccators and weighed. Two grams of the sample was amassed into a crucible, heated over a Bunsen burner to char after which complete ashing is conducted in a muffle furnace at about 600°C for 6 hours. The heating continued until whitish-grey ash was left in the crucible. The crucible was removed from the furnace, cooled in a desiccator and re-weighed to obtain the ash's weight.

Calculation

\[ \% \text{ Ash} = \frac{\text{weight of crucible + ash} - \text{the weight of crucible} \times 100}{\text{Weight of sample}} \]

2.5.6 Determination of carbohydrate content

The determination of the carbohydrate content of the product was obtained by difference, as described by Ihekoriyone and Ngoddy (1985). This was done by subtraction of the sum of moisture, ash, protein and fat from the total weight of 100. % carbohydrate = 100 – (% moisture + ash + protein + fat)

2.5.7 Determination of total volatile basic nitrogen

The crude protein content of the sample was determined by the semi-micro Kjeldahl technique, as described by AOAC (2010). One gram (1.0 g) of the sample was put into a Kjeldahl flask, and 3.0 g of hydrated cupric sulphate (catalyst) was added in the flask. Then, 20 ml of anhydrous sodium sulphate and 1.0 g of concentrated tetraoxosulphate VI acid (H₂SO₄) was added to digest the samples, which was topped and swirled. The flask and liquid were clear and free of colouration. The clear solution was cooled and made up to 100 ml with distilled water, and a digest of 5 ml was collected for distillation. Then, 5 ml of 60% sodium hydroxide solution (NaOH) was put into the distillation flask and distilled for some minutes. Boric acid indicator absorbed the ammonia, which was distilled off, and this was titrated with 0.1 ml hydrochloric acid (HCl). A blank titration was similarly carried out, and the titre value is recorded and used for calculation of total volatile nitrogen

Calculation

\[ \text{Total volatile basic nitrogen} = \frac{\text{titre value of sample} - \text{titre value of blank} \times 14}{\text{Weight of sample}} \]

Note 30mg N/100g maximum for fish. Above these limit, the sample is considered stale

2.5.8 pH determination

pH was determined by the procedure described by AOAC(2010). 2 g of the sample was homogenized into 20 ml of deionized water in a beaker. pH meter was standardized using a buffer solution of pH 4.0 and 9.20. The electrode was then rinsed with deionized water and dipped into homogenate, allowing sufficient time for stabilization before taking the reading.

2.6. Sensory evaluation of the formulated product

The sensory properties (appearance, texture, odour and general acceptability) of the frozen mackerel fish were assessed by a
15 semi-trained panellist. The panellist from the University of Agriculture used was familiar with the product using a nine-point Hedonic scale with one representing the least score (dislike extremely) and nine, the highest score (like extremely) according to Ihekoronye and Ngoddy (1985).

2.7 Data analysis and experimental design

A complete randomized design was used, and data were analyzed using one-way analysis of variance (ANOVA) with LSD used to separate means of treatment. Statistical Package for Service Solution (SPSS) version 21 software was used and significance accepted at p<0.05 as described by Ihekoronye and Ngoddy(1985).

3.Result and discussion

3.1 Sensory evaluation of frozen mackerel (Scomber scombrus)

Sensory analysis was carried out on the frozen mackerel fish sold in some selected cold stores in Makurdi metropolis using 9 points hedonic scale. The colour of the fish skin, the texture of the flesh, the development of offensive odour and general appearance of the eyes and gills were observed. The criteria for rejection was based on the development of strong ammonial and offensive odours, softening of tissues, discouloration of the skin and the very high microbial count of fish tissue which correlates to high values of total volatile basic nitrogen (TVB-N) and the change of fish pH to alkalinity. General appearance scores ranged from 4.3 to 5.0. Samples from a cold store in North bank and high level scored 4.3 from the panellist. Samples from a cold store in Wurukum scored 5.0 from panellists based on its general appearance. The textural attributes scores ranged from 3.0 to 4.2. Samples from a cold store in high level had the highest score 4.1 for samples in cold storage in Wurukum and the least 3.0 in samples from a cold store in North bank. Odour scores from panellist ranged from 3.7 to 4.4. Samples from a cold store in the north bank in Wurukum and high level both had 4.4 with the least 3.7 samples from a cold store in North bank. The generally sensory acceptability evaluation ranged from 3.5 to 4.5. Samples from a cold store in Wurukum and high level both scoring 4.5 with the least in samples from a cold store in North bank. Sensory evaluation revealed that sample B from a cold store in Wurukum was more preferred by panellist followed by sample C from a cold store in High level and the least preferred sample A from a cold store in North bank. This agrees to previous work on mackerel fish by Dobrinus et al.,(2011) and Aubourg et al., (2002) that freezing and frozen storage have been mainly employed to retain sensory and nutritional properties in mackerel. Aubourg et al. (2002) stated that mackerel has a shorter shelf life at a lower temperature with odour development and yellowish colour, making it unacceptable to consumers. Sensory acceptance was correlated to storage time.

3.2 Microbiological properties of frozen mackerel (Scomber scombrus)

Microbial examination of frozen mackerel fish is shown in Table 2. Total viable count (bacteria count) gave the following: 4.1×10⁴, 2.7×10⁴ and 9.0×10⁴ cfu/g for the three different mackerel samples from a cold store in Wurukum, High level and North bank within Makurdi Metropolis. The highest bacteria count is from mackerel fish samples from a cold store in North bank while high level had the least bacteria count. These values were slightly above the permissible range for ice fish product of 10⁵/g or less for bacterial contamination though still relatively safe for consumption since the infectious dose is at 10⁵/g [4, 2]. Bacteria isolates such as Staphylococcus aureus are known to be enterotoxin producing agents which are poisonous. Common bacterial isolates found in frozen fish include Samonella spp, Vibrio spp, Micrococcus spp, Pseudomonas spp, Klebsiella spp, Citrobacter spp, Enterobacter spp and E.coli [19; 25]. Pseudomonas spp from fish samples is of high importance as it plays a considerable role as an indicator of food quality as a spoilage organism, [19; 17; 25]. The presence of contaminating bacteria in the mackerel fish samples could be attributed to cross-contamination from the environment, source of fish and handling by sellers. It could also arise from certain factors such as temperature which favours some organisms and the character of the fish handler by not maintaining personal hygiene, contaminated water in the ecosystem from faecal matter, washing, bathing and discharge of effluents to rivers where fishes are harvested. Total fungal and coliform counts (cfu/g) showed no growth.

3.3 Chemical properties of frozen mackerel (Scomber scombrus)

Result of chemical properties of frozen mackerel fish is shown in table 3. Moisture content ranged from 66.50 -70.29%. Highest was from samples in a cold store in High level with 70.29%, samples from a cold store in Wurukum (68.76%) and the least in samples from a cold store in North bank(66.50%). Moisture content refers to the water content in a sample, and the frozen mackerel fish assessed had moisture content ranging from 66.50 to 70.29% indicating the percentage moisture in fish muscles are different (P > 0.05). High moisture content is a disadvantage as it increases fish susceptibility to microbial spoilage, oxidative degradation of polyunsaturated fatty acids and consequently decreases the fishes’ quality for long preservation time [21].

Protein ranged from 16.22-19.29% with samples from cold stores in North bank with the highest of 19.29%. 17.61% protein was determined in samples from cold stores in Wurukum and the lowest protein content of 16.22% from samples in cold storage at a high level. Fat content was from 11.34% -12.20. The frozen mackerel fish samples were good sources of protein because fishes are rich sources of protein. Differences observed in the values obtained could be due to fish consumption or ab-

<table>
<thead>
<tr>
<th>Sample</th>
<th>Appearance</th>
<th>Texture</th>
<th>Odour</th>
<th>General Acceptability</th>
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<td>3.7</td>
<td>3.5</td>
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<tr>
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<td>C</td>
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<tr>
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<td>0.15</td>
<td>0.79</td>
<td>0.72</td>
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</tbody>
</table>

Mean values with the superscript in the same column are not significantly different (P > 0.05).

Key: Sample A: cold store in North bank, Sample B: cold store in Wurukum, Sample C: cold store at High level, LSD: Least Significant Difference

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Lipids are substances that are soluble in organic solvents as ether. They serve as a source of energy during starvation and fasting. More fat was determined in samples from a cold store in North bank (12.20%), 11.47% fat from samples in cold stores in Wurukum and lowest of 11.34% in samples from cold stores in High level. Fish can be generally grouped into four categories based on their fat content: lean fish (≤2%), low fat (2 to4%), medium fat (4 to 8%) and high fat (≥8%). Frozen mackerel assessed in this study has high-fat content being a marine fish and hence classified as a high-fat fish. This agrees to works by Olagunju et al.,(2012) that marine fishes are a better source of lipids in the body when consumed and plays a vital role in preventing cardiovascular diseases(CDS) with a fat content of 12.33±1.08 in mackerel. Ash content was from 1.33-1.43 with samples in cold stores from a high level with highest of 1.43%, 1.37% in samples from Wurukum and the least of 1.33% in samples from a cold store in North bank. Ash content in the fish samples assessed indicates that they are all good sources of minerals as calcium, potassium, zinc, iron and magnesium. Carbohydrate, which is a good source of instant energy, helps in body’s development and growths is generally very low in fish and practically zero [22]. It was determined to be in the range of 0.72- 0.79. Samples from a cold store in Wurukum had the highest of 0.79% with 0.72 at high level and 0.68% in samples from North bank. The samples were significantly different (p ≤ 0.05) and agreed to report by Olagunju et al., 2012 that the relatively low values of carbohydrate in fish could be due to higher values of protein. pH ranged from 6.1 -7.0. Samples from a cold store in Wurukum had the highest pH of 7.0 with 6.3 in samples from High level and 6.1 from those in North bank. The pH values were significantly different and within acceptable levels for mackerel fish.

Total volatile Nitrogen was determined in the samples from 26.64-30.70 mg N/100. It was highest in samples from cold stores in North bank (30.70 mg N/100), 29.55 mg N/100 from samples in cold stores in Wurukum and the least of 26.64 mg N/100 in samples from a cold store in High level. Sample B and C from a cold store in Wurukum and High level respectively fall within the acceptable limit of 30 mgN/100 while sample A from a cold store in North bank was slightly higher than the acceptable limit which is judged as staled fish. This higher value in sample A could be attributed to the inconsistency in power supply during frozen storage. The level of total volatile nitrogen (TVN) for whitefish is generally considered to be fresh if values are less than 20 mgN/100, staled if values reach 30 mg N/100g. In contrast, at the level of 40 mg N/100g the fish is regarded as unfit for consumption (Connel, 1995).

4. Conclusion

Quality assessment of frozen mackerel fish (Scomber scombrus) sold in Makurdi Metropolis based on sensory evaluation, microbiological and chemical properties showed that frozen mackerel fish in Makurdi had good sensory attributes. Microbiological properties were slightly above the recommended acceptable concentration of 103 or less set by the International Commission of Microbiological Standards for Food [15] but lower than an infectious dose of 105. This means the mackerel fishes were safe for consumption based on microbial load. Chemical analysis based on total volatile nitrogen showed sample B and C from Wurukum, and High level was within the acceptable limit of 30 mg N/100g and safe for consumption. In contrast, sample A from the North bank was stale. Frozen mackerel is highly nutritious and a good diet to reduce for those suffering from cardiovascular diseases. Poor frozen storage due to power fluctuation needs to be improved upon to ensure. Mackerel fish sold in Makurdi Metropolis is safe for consumption. Food inspectors need to intense efforts to ensure not just meat in abattoirs are safe, but fish and fish products inclusive.

Author’s Contributions

This work was carried out in collaboration among all authors. Author OAO designed the study, performed the statistical analysis, managed the study's analyses, wrote the protocol and wrote the first draft of the manuscript. Author EMO supervised the work. Author GST managed some of the literature searches. All authors read and approved the final manuscript.
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