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## Evaluation of sensory and chemical quality difference of frozen *gadus morhua* in open markets of Imo state, Nigeria

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### Abstract

A total of forty (40) frozen *Gadus morhua* obtained from cold room and open markets of three Local Government areas of Imo state were evaluated for their sensory qualities employing the use of nine panelist guided by questionnaire on general appearance, taste, smell and texture and chemical quality changes in their ammonia (AMM), total volatile base nitrogen (TVB-N), trimethylamine nitrogen (TMA-N), acid value (AV), free fatty acid (FFA) and pH at the hands of the final consumers. Results were analysed using a one way analysis of variance employing SPSS package and compared using the Duncan multiple range test. Results shows that frozen *Gadus morhua* obtained from the cold rooms and open markets in the three local government areas under study had very good qualities for general appearance of  $1.22 \pm 0.56$  and  $2.40 \pm 0.72$  as the highest mean respectively. The very good quality still persists in the grilled (cooked) samples of the fish. A significant difference in AMM, TVB-N, TMA-N, AV and FFA at  $p \leq 0.05$  with p-values of 0.00, 0.00, 0.00, 0.00 and 0.02 respectively was recorded while pH values remained insignificantly different at p-value of 1.00. During the fish storage in ice, volatile compounds such as ammonia ( $\text{NH}_3$ ) and trimethylamine (TMA), are produced by autolytic and bacterial processes, resulting in an ammoniacal and strong fish odour, typical of deteriorated fish. These parameters generally are indicators of fish spoilage. Significant rise in Ammonia value from  $15.65 \pm 0.04$  for cold room samples to  $20.96 \pm 0.78$  from an open market in Ohaji LGA and TMA-N cold room values of  $2.46 \pm 0.39$  to  $3.95 \pm 0.45$  from an open market indicating fast rate of spoilage which is concluded to be due to the unsafe exposure of fish and its handling after it must have left the cold rooms. Even though the values obtained in open markets were still good, quality loss was significantly observed. It is recommended that sanitary and food inspection agencies resume function in our markets to reduce the risk of fish contamination which subsequently reduces its quality.

**Keywords:** Sensory quality, chemical quality, open markets, frozen *gadus morhua*, spoilage

### 1. Introduction

Fish freshness refers to the maintenance of sensory, chemical and nutritional characteristics the fish possess at capture after a time period. Alteration of this freshness begins immediately after capture as a result of enzymatic, bacterial and oxidative activity on fish, a state that can be averted by exposing the fish to a form of preservation and on time. In Nigeria, species of fish commonly imported are many with cod (*Gadus morhua*) constituting one of the majority (Agom *et al.*, 2012) [3]. According to the report of Oloalu, (2016), most fish stock come from Port Harcourt and Lagos with wholesalers transporting their goods in refrigerated trucks to cold rooms while retailers use cabs, motorcycles and head load to transport the frozen fish where they are supplied directly to people, hawked publicly, sold on the road side or in stalls of fish markets. Methods employed by retailers to attract customers such as conspicuous display of frozen fish (Olaolu, 2016) [19] can lead to sediment and bacterial accumulation on fish. Fresh fish have been reported by Nwazuo *et al.*, (2016) [17] to be exposed readily to high contamination leading to openings for microbial invasion; inadvertently leading to changes in chemical quality. During the fish storage, volatile compounds such as ammonia ( $\text{NH}_3$ ) and trimethylamine (TMA), are produced by autolytic and bacterial processes, resulting in an ammoniacal and strong fish odor, typical of deteriorated fish. TMA results from the bacterial reduction of trimethylamine oxide (TMAO), which occurs naturally in the marine organisms to

allow osmotic regulation. Chemical changes can be as a result of the presence of TVBN, Histamine, heavy metals, pesticide residues and nitrates (Olaolu, 2016) [19]. The pH determination of the fish stored allows the identification of glycolysis phenomena through its reduction in post-mortem fish, and subsequent increase to values above 7, due to the production of volatile compounds, which indicates advanced decomposition. World Bank, (2013) [26] has predicted a rapid population growth, estimated at 2.3 per cent annually during the 2010 - 2030 period, which will lead to total food fish consumption demand substantially rising - by 30% between 2010 and 2030. South-east Nigeria is a region highly populated with persons who have more preference for fish flesh to beef (Emere and Dibal, 2013) [8], in fact, several diets consumed within its locality includes fish in its various forms. As a result of recent development in Nigeria, beef has become an expensive commodity due to the farmer's herdsmen clash. At this rate of consumption and with the need to avert consequential effects of consuming non-safe fish of low nutritional value this research throws light on the chemical quality of fish available to end users, one that shows the level of bacterial and enzymatic activity on fish.

## 2.0 Materials and Methods

### 2.1 The study area

The study was carried out in Imo state located in south eastern Nigeria. This state is made of twenty-seven local government areas and subdivided into three zones (Imo west- Orlu zone, Imo north- Okigwe zone and Imo East- Owerri zone). The

state holds a total population of 5 408 800 people according to National Bureau of Statistics (2006). The major language of its inhabitants is Igbo although several other languages exists within the region. Most persons are Christians with almost no phobia for fish.

### 2.2 Sampling survey and experimental design

The quality survey of the frozen fish consumed as food was carried out in Imo state of Nigeria represented by its three zones- Orlu zone, Owerri zone and Okigwe zone. Selected frozen fish samples comprised of an imported and commonly consumed frozen fish- stock fish or cod (*Gadus morhua*), Linnaeus, 1758, that is frequently found in the open markets of the state.

Two independent surveys of fish wholesomeness were carried out in each of the three designated zones during the study, one on cold room samples and the other on open market samples in the hands of the end users.

In the first survey, 1 coldroom (a major distributor) was purposively selected from Owerri municipal as control experiment. From the cold room (as control), ten (10) specimen of the fish species were randomly sampled for sensory and chemical quality status. The same design was also applied to the second survey (open markets) however, there were fishes from three open markets randomly surveyed per zone in the state. The experiments were carried out in four month periods spanning a year to cover all climatic seasons. The design layout of the experiment is as presented in tables 1.



Fig 1: Fish species *Gadus morhua* (cod) used for the study

Table 1: Design layout of the experimental survey on fish chemical quality

Month span	Control (cold room)	Treatments(Open Markets)									Total
		Ohaji			Isiala Mbano			Mbaitoli			
	Owerri	IO	IO	IO	An1	An2	An3	A1	A2	A3	
Oct – Jan	3	1	1	1	1	1	1	1	1	1	12
Feb – May	4	2	1	1	1	2	1	1	1	2	16
June –Sept	3	1	1	1	1	1	1	1	1	1	12
Total	10	4	3	3	3	4	3	3	3	4	40

### 2.3 Fish identification, transportation, sensory evaluation, chemical procedures and data analysis

The fishes were identified with the aid of standard fish identification keys by Reed *et al.*, (1967) [21] and FAO (1990) [12] Field identification Guide to the commercial marine resources of the Gulf of Guinea. The length, weight and temperature of the fish samples were recorded and the fish carefully put in well labelled sterile polyethene bags, stocked

inside iced boxes (containing ice blocks to maintain temperatures close to that of the cold rooms) and quickly transported to the laboratory for analysis. The sensory evaluation of the frozen fish was determined in accordance with standard procedure by Eyo (2001) [10] for both raw and cooked fish samples. Raw samples were evaluated based on the appearance of the organs (eyes, flesh, gills and the skin) incorporating Larsen *et al.*, (1992) quality assessment scheme

while cooked samples were assessed on the basis of three parameters of taste, odour and texture.

Sensory evaluation of the cooked samples was carried out by nine trained panel of judges selected from Biology department of Alvan Ikoku Federal College of Education, Owerri, Nigeria. The fish samples were gutted, cut into pieces and packed in aluminium foils and cooked in an oven at 100<sup>o</sup> c for 20mins. The cooked fish were then dished out to the panellists in replicates for evaluation. The chemical analysis was carried

out using the recommended standard methods (AOAC, 2005) [4] and results were compared with one way analysis of variance (ANOVA) as described by Njoku *et al.*, (1998) [16]. The observed significant difference in mean values of treatments was then separated using the Duncan's multiple range test (Duncan, 1955) [7] employing the computer statistical package for Social Sciences (SPSS) version 19 window 7.

### 3.0 Results

**Table 1:** Mean index scores for sensory qualities of frozen *Gadus morhua*

Parameters	Cold room (AC)	Ohaji			Isiala Mbano			Mbaitoli			p-value
		O1	O2	O3	O1	O2	O3	O1	O2	O3	
General appearance	1.22±0.56	2.33±0.97	2.44±0.59	2.32±0.63	2.67±0.72	1.89±0.80	2.87±0.67	2.00±0.89	2.67±0.67	1.89±0.71	0.038*
Smell	1.67±0.64	3.56±0.72	2.44±0.79	1.44±0.52	2.89±0.66	3.44±1.03	3.00±0.67	1.56±0.73	1.84±0.59	1.78±0.77	0.025*
Taste	1.45±0.98	3.56±0.65	1.67±0.59	3.33±0.71	2.89±0.79	2.33±0.50	2.00±0.82	1.67±0.74	1.87±0.50	1.56±0.69	0.191
Texture	1.78±0.90	4.33±0.61	3.11±0.99	4.00±0.58	2.00±0.51	2.89±0.78	3.22±0.69	2.67±0.76	1.89±0.52	3.00±0.52	0.041*
Overall acceptability	1.55±0.87	3.58±0.66	2.62±0.53	2.88±0.67	2.54±0.60	2.49±1.00	2.86±0.71	2.08±0.53	2.17±0.88	2.33±0.65	

Each value is expressed as mean ± SD. Means with P < 0.05 are significantly different.

The result of the mean scores for raw *Gadus morhua* (general appearance) showed a significant difference in values of cold room and open market samples with a range of 1.22±0.56 for cold room sample to 2.87±0.67 in open markets sample of Isiala Mbano. However, some markets of Isiala Mbano and Mbaitoli showed better quality index for general appearance with values of 1.89±0.80 and 1.89±0.71 respectively. The texture of fish also revealed significant difference for cold room and open market samples ranging from 1.78±0.90 of cold room samples to 4.33±0.61 of open markets. With

regards to grilled fish quality, smell showed significant difference with a range of 1.67±0.64 for cold room samples to 3.56±0.72 for open market samples of Ohaji LGA. On the other hand, taste of grilled samples showed no significant difference as the range lingered between 1.45±0.98 of cold room samples to 3.56±0.65 of open market samples. The general acceptability of the fishes in cold room and open markets varied between being very good (1.55±0.87) to good (3.58±0.66) respectively.

**Table 2:** Sensory quality indices for iced *S. scombrus.*, *G. morhua.* and *A. thazard* sold in Imo state

Parameters	Cold room (AC)		Ohaji		Isiala mbano		Mbaitoli	
	Mean ±SD	Quality	Mean ±SD	Quality	Mean ±SD	Quality	Mean ±SD	Quality
General appearance	1.22±0.56	V.good	2.40±0.72	V.Good	2.31±0.66	V.good	2.01±0.73	V.good
Smell	1.67±0.64	V.good	2.67±0.53	V.good	3.03±0.97	Good	1.58±0.57	V.good
Taste	1.45±0.98	V.good	2.01±0.79	V.Good	2.74±0.62	V.good	1.61±0.53	V.good
Texture	1.78±0.90	V.good	4.00±0.68	Good	2.66±0.58	V.good	2.44±0.50	V.good

Results from table 2.2 shows that frozen *Gadus morhua* obtained from the cold rooms and open markets in the three local government under study had very good qualities for general appearance of 1.22±0.56 and 2.40±0.72 as the highest

mean respectively as observed by the panellists. The very good quality still persists in the grilled (cooked) samples of the fish.

**Table 3:** Results of chemical analysis for *Gadus Morhua* collected from sampled areas

Paramaters/ Place of collection	Cold room AC	Ohaji			Isiala Mbano			Mbaitoli			P-value
		IO1	IO2	IO3	AO1	AO2	AO3	AnO1	AnO2	AnO3	
mgNH <sub>3</sub> /100g AMM	15.65± 0.04	20.96±0.78 <sup>a</sup>	19.70±0.25	20.52±0.29	20.34±0.26	20.00±0.65	19.48±0.34	19.13±0.67	19.24±0.39	19.89±0.58	.000
mg/100g TVB-N	11.32±0.04	17.16±0.99 <sup>a</sup>	17.13±0.34	17.22± 0.22	15.03±0.19	15.74±0.36	15.06±0.28	16.23±0.27	17.01±0.22	17.42±0.40	.000
mg/100g TMA-N	2.46 ± 0.39	3.95±0.45 <sup>a</sup>	3.98±0.49	3.68±0.20	3.88±0.24	2.99± 0.30	3.86±0.21	2.87±0.42 <sup>a</sup>	3.00±0.39	3.02±0.21	.000
%Oleic Acid AV	3.09 ± 0.27	5.03±0.21	5.07±0.31	4.96±0.12	4.78±0.45	4.605±0.32	4.53±0.35	4.84±0.38	4.71±0.24	5.0± 0.34	.000
mgKOH/g FFA	1.54 ± 0.19	2.47±0.09	2.48±0.22	2.44±0.32	2.39±0.36	2.42± 0.17	2.37±0.32	2.30±0.45	2.42±0.17	2.39±0.24	.002
PH	6.58± 2.41	6.00±1.77 <sup>a</sup>	6.00±1.63 <sup>b</sup>	6.03±1.83 <sup>c</sup>	6.51±1.89 <sup>d</sup>	6.52±2.08 <sup>e</sup>	6.41±2.17 <sup>f</sup>	6.02±1.99 <sup>g</sup>	6.32±1.92 <sup>h</sup>	6.24±1.76 <sup>i</sup>	1.000

Where; AMM- ammonia, TMA-N- Trimethylamine – Nitrogen, TVB-N- Total volatile base Nitrogen, AV- acid value, FFA- Free Fatty Acid and pH- Acidity or Basicity. Figures in each row with superscript are not significantly different at p > 0.05. Figures in row without superscript are significantly different at p < 0.05.

Results from table 3 shows significant difference across values for AMM, TVB-N, TMA-N, AV and FFA in samples

from cold room and open markets. The pH on the other hand reflected a non-significant difference as it presented a P-value of 1.000. Ammonia indices ranged from 15.65 ± 0.04 to 20.96 ± 0.78 with the least value from cold room samples and the highest value emanating from open markets of Ohaji L.G.A. TVB-N, TMA-N, AV, and FFA values ranged from 11.32 ± 0.04 to 17.42 ± 0.40, 2.46 ± 0.39 to 3.98 ± 0.49, 3.09 ± 0.27 to 5.07 ± 0.31 and 1.54 ± 0.19 to 2.48 ± 0.22 respectively all

of which had their least values from cold room samples and highest values from Ohaji open market with the exception of the TVB-N index which is from the open market of Mbaitoli LGA. On the contrary, lowest value for pH was obtained from the open markets of Ohaji LGA ( $6.00 \pm 0.22$ ) while the

highest value was obtained for the cold room samples ( $6.58 \pm 0.50$ ). Comparison for chemical indices are shown in fig. 2 where from observation, AMM had highest values across all parameters considered whereas FFA had the least.

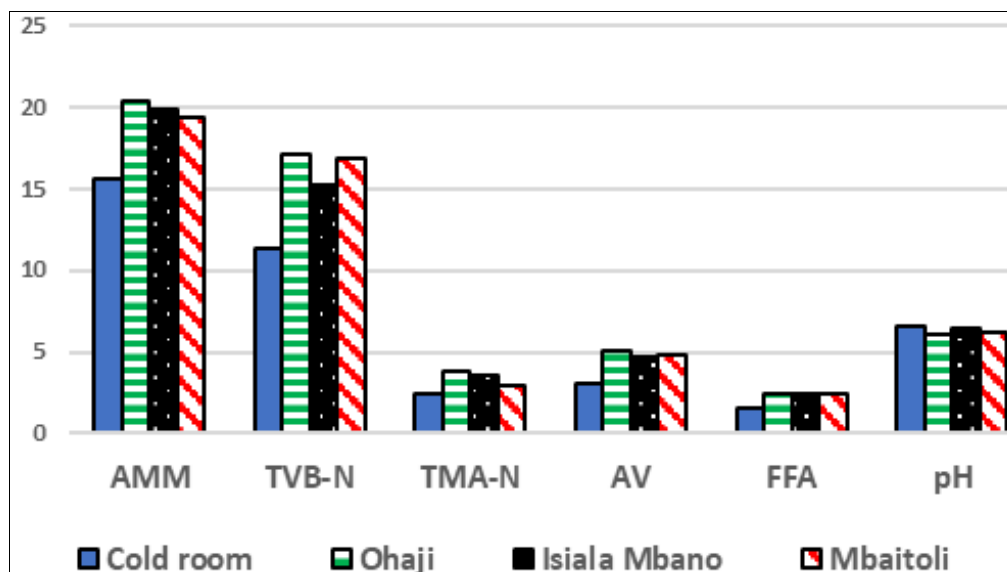


Fig 2: Graph showing relationship of chemical indices for cold room and open market *Gadus morhua* samples in Imo state

## Discussion

In present times the importance of fish having being largely associated with being readily available as a good source of protein (Adebayo-Tayo *et al.*, 2012; Suleiman, Hassan & Elkhalfifa, 2014) <sup>[1, 25]</sup>, has been an answer to the food need of every class of persons, rich or poor, sick or healthy due to its portability and ability to be preserved in different forms wholly or filleted. The quality of frozen products is closely related with the quality of initial fresh fish, freezing settings and thawing conditions due to their influence on chemical reactions and muscle degradation. Trained experts are mostly used to overcome the disadvantages associated with the use of human sensory panel. This is further eased off by the use of numerical scoring points and recording of sensory judgements (Eyo 2001) <sup>[10]</sup>. Results of this study was rated on a demerit score whereby values acceptable are lower than those rejected (0-0.9 –excellent, 1-2.9 – Very good, 3-4.9 – Good, 5-6.9 – fair and 7-10 - unacceptable). The results recorded had all samples obtained from cold room to be very good. While most of those obtained from the open market were very good, many had quality reduced to the good extent as recorded in smell. General appearance of the fish presented both at the cold room and open markets were of very good quality, this result agrees with the findings of Fawole *et al.*, 2018 <sup>[11]</sup> who observed that frozen fishes in Oyo markets were of general acceptability. Samples collected from the cold room however presented superior sensory qualities than those obtained from open markets.

It is however not complete to conclude on quality of fish without looking into other quality aspects. The determination of TVBN considers all volatile nitrogen compounds in the sample like ammonia (NH<sub>3</sub>), Trimethylamine (TMA), and Dimethylamine Acid (DMA) levels to assess the fish freshness as they increase with fish deterioration (Senapati and Sahu, 2020) <sup>[23]</sup>.

The data in table 3 shows obvious difference in chemical properties of the fishes obtained from cold room and various

open markets. Statistically, parameters of AMM, TVB-N, TMA-N, AV and FFA were significantly different at  $p > 0.05$ . Ammonia indices rose to  $20.39 \pm 0.52$  in samples from open markets of Ohaji,  $19.94 \pm 0.35$  in open market samples of Isiala Mbano and  $19.42 \pm 0.34$  in open market samples of Mbaitoli as against  $15.65 \pm 0.16$  value of the cold room samples. FAO (1994) <sup>[13]</sup> opined that volatile amines such as ammonia and small amount of monomethylamine and dimethylamine are produced as bacteria grow on surface of fish tissue- parameters that are general indicators of fish spoilage. TVB-N cannot entirely be used as fish freshness indicator (Castro *et al.*, 2006) <sup>[6]</sup> in stored frozen fish however, the values increases rapidly as temperature increases ( $> 37^{\circ}\text{C}$ ) within 24 hours in marine fish. Roiha, *et al.*, (2018) <sup>[22]</sup> in their experiment observed that TVB-N values for *Gadus morhua* increased from  $12.5 \pm 2.3$  to  $18.8 \pm 12.9$ . In addition, Popelka *et al.*, (2016) <sup>[20]</sup>, showed that TVB-N values from fresh samples were significantly different from frozen samples over a period of time. This opinion is in tandem with the result of this research revealing that samples in cold rooms were of good biochemical quality which progressively reduced as they enter the open markets and further in agreement with results of Khidhir *et al.*, (2013) <sup>[14]</sup> who confirmed that some frozen fish imported and sold in Sulaimani markets are considered fresh. TVB-N values that reach 30mg/100g for any fish would be considered stale while levels of 40mg/100g is unfit for human consumption as proposed by Codex Alimentarius Committee in 1968 and reported by Steel *et al.*, (1996) <sup>[24]</sup>. Production of TMA-N is slow at the start of chemical change in fish and gradually increases exponentially in pace after few days in chilled storage. According to Avramiuc, (2017) <sup>[5]</sup>, 0-1 mg/100g TMA indicates fresh fish, 1-5mg/100g indicates relatively fresh fish while values above 5mg/100g indicates altered fish –gross spoilage. This research result reported highest TMA-N values of 3.98mg/100g which falls within the limit of acceptance according to Avramiuc, (2017) <sup>[5]</sup>. It is however noted that TMA values will vary depending on type

of fish, storage condition, temperature and handling. Open market values for Acid value (AV) and Free Fatty Acid (FFA) were significantly different to those obtained from the cold room at  $p > 0.05$ . Acid values ranged between  $3.09 \pm 0.33$  for cold room to  $5.02 \pm 0.05$  for open markets. Consequently, FFA values ranged from  $1.54 \pm 0.12$  for cold room to open market values of  $2.46 \pm 0.02$  from Ohaji. Generally, marked increase in values of AV and FFA from cold room to open market is an indication of deteriorating quality of fish. Fish contain large proportion of highly unsaturated fat which vary in quantity with species. Fatty species as Mackerel have high lipid content, free fat content and proportion of triglycerides while lean species as cod have low lipid content basically in the form of phospholipids and lipoproteins (FAO, 1994)<sup>[13]</sup>. FFA content shows a possible increase of enzymatic activity due to temperature fluctuation, as lipid deterioration cannot be inhibited in proper conditions after damage has been done. Afugbuom (2016)<sup>[2]</sup> in his work reported similarly for AV and FFA revealing a mean difference that is statistically significant at  $p > 0.05$ . Both work showed higher values for fishes in the open market compared to that in the cold room. Okeoyo, *et al.*, (2009)<sup>[18]</sup> reported that the lower the pH of fish flesh, the slower the growth of bacteria and vice versa. As bacteria produce acid during carbohydrate decomposition, the acidity rises, also indicative of bacterial presence (Eyo 1993)<sup>[9]</sup>. Results revealed that there is no statistical significant difference in values of pH across the local governments on fish experimented. Monteiro (2019)<sup>[15]</sup>, in his study observed that pH of Cod and Mackerel were quite neutral. Despite the insignificant difference obtained statistically, there is a marked reduction in pH values from cold rooms to open markets. This indicates that acidity levels rose as the fish is exposed to open market conditions. This result of this research is in tandem with Afugbuom, (2016)<sup>[2]</sup> who reported that pH values between cold room samples and open market samples showed no significant difference at  $p > 0.05$ .

### Conclusion

Temperature and temperature fluctuations are the most significant factors in maintaining quality through the distribution chain. Chemical, biochemical and physical inevitable and irreversible processes still occur during frozen storage but at a slow rate. If subject to poor handling in connection with freezing and cold storage, the product will be ruined. Sensory quality of *Gadus morhua* in its raw and grilled form were very good even at the open markets. Chemical qualities however showed significant changes in quality of cold room and open markets samples. It is recommended that safe presentation at cold rooms and open market practice should be upheld since chemical changes is an indication of microbial presence in the fish. Added to it, sanitary and food inspection agencies are encouraged to resume function in our markets to reduce the risk of fish contamination which subsequently reduces its quality.

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