



# Microbial Contamination and Proximate Carcass of Cod (*Gadus morhua*) Obtained from Local Markets of Imo State

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## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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## ABSTRACT

The microbial and proximate quality of Cod *Gadus morhua* obtained from cold room and open markets of three Local Government Areas of Imo state, Nigeria was carried using standard methods. Microbial analysis revealed that the total viable count for the fish species sampled from cold room ranged from  $5.3 \times 10^4$  –  $9.5 \times 10^4$  cfu/g while that of the open market samples ranged from  $8.0 \times 10^4$  cfu/g to  $2.8 \times 10^5$  cfu/g. Total Fungal Count (TFC) had increasing microbial values in the open markets than in the cold rooms and ranged from  $1.0 \times 10^3$  cfu/g to  $7.2 \times 10^3$  cfu/g for cold room samples whereas a range of  $1.0 \times 10^5$  cfu/g to  $3.4 \times 10^5$  cfu/g was obtained for open markets. Generally, ten bacterial species and nine fungal species were isolated and identified during

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characterization from the cold room and open market samples, bacteria being *Micrococcus spp.*, *Staphylococcus aureus*, *Bacillus cereus*, *Bacillus subtilis*, *Streptococcus spp.*, *Escherichia coli*, *Klebsiella spp.*, *Proteus spp.*, *Pseudomonas aeruginosa*, *Salmonella spp.* while fungi include *Geotrichum spp.*, *Candida spp.*, *Rhizopus stolonifera*, *Mucor spp.*, *Rhodotorula spp.*, and four species of *Aspergillus*. Result for proximate composition shows that crude protein cold room value was  $17.24 \pm 0.52$  but significantly increased in the open market samples ( $19.44 \pm 0.94$ ) just as there was significant difference in crude fiber values of cold room ( $6.98 \pm 0.54$ ) and open markets (ranged between  $3.04 \pm 0.81$  and  $4.39 \pm 1.30$ ). On the other hand, an insignificant increase in values of moisture content, NFE, ash content and ether extract but with values reducing from cold room ( $1.30 \pm 0.62$  and  $1.06 \pm 0.50$ ) to open market ( $0.12 \pm 0.70$  and  $1.00 \pm 1.00$ ) as their minimum value for the later. It is suggested that fish be appropriately handled in ice boxes during transport and storage before sale especially in the absence of refrigerators so as to reduce microbial contamination and maintain its original proximate value.

**Keywords:** *Gadus morhua*; microbial contamination; proximate composition; cold-room; open-market; Imo state.

## 1. INTRODUCTION

Fish, a commodity of high importance, is highly perishable and unless correctly treated after harvesting, can soon become unfit to eat and possibly dangerous to health through microbial growth, chemical change and breakdown of endogenous enzymes [1]. Fish is one of the food commodities that quickly change form by spoilage if not appropriately exposed to a form of processing [2]. Despite the great importance attributed to fish consumption, it is often overlooked when sustainable and safe food are discussed. Previous studies indicates that the importation of frozen fish plays a key role in bridging the gap between the demand for and supply of fish from domestic sources [3]. This demand for high quality, safe and healthy fish is now on a global increase [4,5] yet, low income earning countries like Nigeria preferably export high market value products and import low market value products for domestic consumption as previously stated by Asche et al. [6].

*Gadus morhua* (cod) is benthopelagic lean fish, distributed in the North Atlantic and in the Arctic and abundant in cold and temperate shelf areas [7]. Cod is one of the top imported fishes in Nigeria with high demand necessitating its importation in its various sizes and variously preserved forms especially, frozen form. Global capture production of cod in 2020 exceeds 1000kilo tonnes which is nothing to be compared to aquaculture production rated at around 662kilot tonnes of the same year [8]. External uncontrolled factors are likely to affect bacterial composition in the wild than in the controlled products. In addition, the removed function of the fish immune system at death allows for bacteria and enzymes to penetrate the walls of the

tissues leading to spoilage of the tissue. This action of bacteria is further enhanced by the exposure of fish to unfavourable conditions during storage and handling [9].

Fish constitute a major delicacy during all occasions in the south eastern part of Nigeria especially the frozen form as reported by Agom, et al. [10] who noted that some fish like croaker and mackerel has its most supply during the festive season and off the market or scarce during non-festive seasons. With the fish high rate of consumption and the need to avert consequential effects of consuming non-safe fish of low nutritional value, this paper indirectly instigates the need for improved policies on import and preservation methods, buttress the need for diversification into local production and consumption of fresh live fish and inform the government on the need to put more effort into ensuring that fish sold within Imo state and Nigeria as a whole are safety risk free. This is because there is a time and temperature relationship which tells on the final quality of fish as microbes acclimatize better in lower temperatures of higher than  $30^{\circ}\text{c}$  [11,12]. This paper therefore exposes the microbial composition and carcass quality of *Gadus morhua* (cod) which is a commonly consumed frozen fish in Imo state.

## 2. MATERIALS AND METHODS

### 2.1 Study Area and Experimental Design

The study was carried out in Imo state located in South Eastern Nigeria, constituting of twenty seven local government areas and subdivided into three zones (Imo west- Orlu zone, Imo north-Okigwe zone and Imo East- Owerri zone). Most

persons in this region are Christians with almost no phobia for fish. A total of eighty (80) samples were used for the experiment constituting eight samples each of the *Gadus morhua* (cod) collected from a cold room (a major distributor) and three local fish open markets of each of the three representing local government areas of the zones in Imo state- Orlu zone, Owerri zone and Okigwe zone. Representing Orlu zone were three local markets selected from Ohaji Egbema LGA, Owerri Zone was represented by local markets from Mbaitoli LGA while Okigwe zone was represented by local markets from Isiala Mbanda LGA.

For experimental purposes, fish samples were coded based on place of collection (Table 1). This served to keep information discrete and remove subjective judgement of samples.

## 2.2 Fish Identification and Transportation

The fishes were identified with the aid of standard fish identification keys by Reed et al. [13], Loveque et al. [14] and FAO [15] 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 and quickly transported to the laboratory for processing and analysis. Temperature close to that of the cold rooms was maintained in the iced boxes using ice blocks.

## 2.3 Microbial Analysis

Microbes were isolated from the skin, tissue, gills and intestines of the sample fishes. Media used for inoculation included Nutrient agar (all-purpose bacteriological media) at 2.8g/100ml, Macconkey agar (for enumeration of coliforms) at 4.9g/100ml, Sabouraud Dextrose agar (for enumeration of fungi) at 6.5g/100mls, Salmonella

Shigella agar (for enumeration of Salmonella and Shigella) 6.4g/100mls, Manitol Salt agar (for Staphylococcus spp.) at 11.1g/100mls and Centrimide agar (for enumeration of Pseudomonas sp.) at 4.8g/100mls. Media were poured aseptically, samples serially diluted adapting 10-fold serial dilution and samples inoculated by spread plate method. Bacteriological plates were incubated at 37°C for 24 hours while mycological plates incubated at 27°C (room temperature) for 48 hours. To identify species of microbes, cultural characteristics such as shape, colour, size and consistency was carried out where isolates were gram stained and subjected to appropriate biochemical tests which included Oxidase, Motility, Indole test, Spore stain, Catalase, Citrate, Coagulase and Sugar utilization tests [16].

## 2.4 Proximate Composition of Carcass Quality

Samples of each test fish carcass was analysed chemically in accordance with the Official Analytical Chemists [17] for such parameters as crude protein, moisture and dry matter, ash, crude fibre, crude fat (or lipid), carbohydrate, caloric value and Nitrogen free extract (NFE) to ensure that the fish meat meet the basic nutritional requirements of consumers. This analysis was carried out at the Food Science and Technology laboratory of the Federal University of Technology Owerri and subsequently at National Root Crops Research Institute Umudike, Abia state. The routine semi micro-kjeldahl procedure was used to determine crude protein, whereas moisture content was determined with a modified version of the AOAC 967-08 [17]. The NFE was determined by difference. This was done by subtracting the sum of (% moisture + % crude protein + % ether extract + % crude fiber + % ash) from 100 i.e.  $100 - (\%M + \%CP + \%EE + \%CF + \%Ash)$ .

**Table 1. Code allocation for the place of fish sample collection**

Local government areas	Codes			
	Cold room	Open markets		
		I	II	III
Owerri Municipal	AC			
Ohaji		IO <sub>1</sub>	IO <sub>2</sub>	IO <sub>3</sub>
Isiala Mbanda		AO <sub>1</sub>	AO <sub>2</sub>	AO <sub>3</sub>
Mbaitolu		AnO <sub>1</sub>	AnO <sub>2</sub>	AnO <sub>3</sub>

Where AC .... Cold room

IO<sub>1,2,3</sub> – Open market I, II, III in Ohaji, AO<sub>1,2,3</sub>... Open market I, II, III in Isiala Mbanda

AnO<sub>1,2,3</sub>... Open market I, II, III in Mbaitolu

## 2.5 Comparative Statistical Analysis

The experiment was designed as a completely randomized experiment (CRD). Consequently the resulting data compared with one way analysis of variance (ANOVA) as described by Steel and Torrie [18] and Njoku et al. [19]. The observed significant difference in mean values was separated using the LSD multiple range test. The analysis employed the computer statistical package for Social Sciences (SPSS) version 20 window 7.

## 3. RESULTS AND DISCUSSION

Fish, in the form of *Gadus morhua*, a necessary commodity that bridges the gap of protein supply and hunger alleviation is readily available in its frozen form to meet almost all occasions in Imo state, showed varying levels of increasing microbial content and load as fish moved to the open markets from the cold rooms.

The result of the microbial and fungal loads/occurrence on the fish species from cold room and open markets together with the

bacterial and fungal isolates are presented in the tables.

The total viable count for the fish species sampled from cold room (Table 2.2a) ranged from  $5.3 \times 10^4$  –  $9.5 \times 10^4$  cfu/g with the most overall viable count as obvious in the tissue and the least from the intestine. TVC of the open market samples however ranged from  $8.0 \times 10^4$ cfu/g to  $2.8 \times 10^5$ cfu/g with samples obtained from Ohaji LGA open markets showing the most viable count as samples from the gills revealed the most TVC. Cold room samples had Total coliform count (TCC) that ranged from not being detected in the gills to  $3.7 \times 10^4$ cfu/g obtained from the skin. On the other hand, open market samples showed varying TCC ranges from being totally absent (in intestinal samples) to as high as  $8.6 \times 10^4$ cfu/g,  $8.4 \times 10^4$ cfu/g and  $1.3 \times 10^5$ cfu/g in samples of the skin from Ohaji, Mbano and Mbaitoli respectively. Total Staphylococcal count (TSC) likewise recorded increasing values from cold room to open markets with the highest TSC value obtained from the skin ( $1.3 \times 10^4$ cfu/g) of the cold room and from the intestine ( $2.8 \times 10^6$ cfu/g) of the open market sample.

**Table 2.1. Length, weight and temperature data of experimental *Gadus morhua***

LGA	Place of collection	Mean length (cm)	Mean weight (kg)	Initial temp	Final temp
Owerri Municipal	Cold room	40.3	3.91	-22	-1
OHAJI	Open market	39.6	4.00	13	19
ISIALA MBANO	Open market	40.4	4.02	-6	-1
MBAITOLI	Open market	40.0	3.99	3	3.2

**Table 2.2a. Mean microbial load of cold room frozen *Gadus morhua* samples collected from Owerri market**

Site of collection	TVC (Cfu/g)	TCC (Cfu/g)	TSC (Cfu/g)	TPC (Cfu/g)	TSSC (Cfu/g)	TFC (Cfu/g)
Skin	$6.7 \times 10^4$	$3.7 \times 10^4$	$1.3 \times 10^4$	$4.0 \times 10^2$	-	$7.2 \times 10^3$
Tissue	$9.5 \times 10^4$	$6.0 \times 10^3$	$6.8 \times 10^3$	$6.0 \times 10^2$	-	$1.0 \times 10^3$
Gill	$8.5 \times 10^4$	-	$4.0 \times 10^3$	-	-	$8.2 \times 10^3$
Intestine	$5.3 \times 10^4$	$2.0 \times 10^4$	$1.1 \times 10^3$	-	$4.0 \times 10^2$	$2.2 \times 10^3$

**Table 2.2b. Mean microbial load of open market frozen fish samples collected from Ohaji LGA markets**

Site of collection	TVC (Cfu/g)	TCC (Cfu/g)	TSC (Cfu/g)	TPC (Cfu/g)	TSSC (Cfu/g)	TFC (Cfu/g)
Skin	$1.5 \times 10^5$	$8.6 \times 10^4$	$6.2 \times 10^5$	$3.1 \times 10^3$	$5.6 \times 10^4$	$3.4 \times 10^5$
Tissue	$1.4 \times 10^5$	$2.5 \times 10^4$	$4.0 \times 10^5$	$2.8 \times 10^4$	$9.5 \times 10^4$	$2.0 \times 10^5$
Gill	$2.8 \times 10^5$	$9.4 \times 10^3$	$1.8 \times 10^5$	$3.8 \times 10^4$	$5.7 \times 10^5$	$2.6 \times 10^5$
Intestine	$1.2 \times 10^5$	-	$2.8 \times 10^6$	-	-	$1.8 \times 10^5$

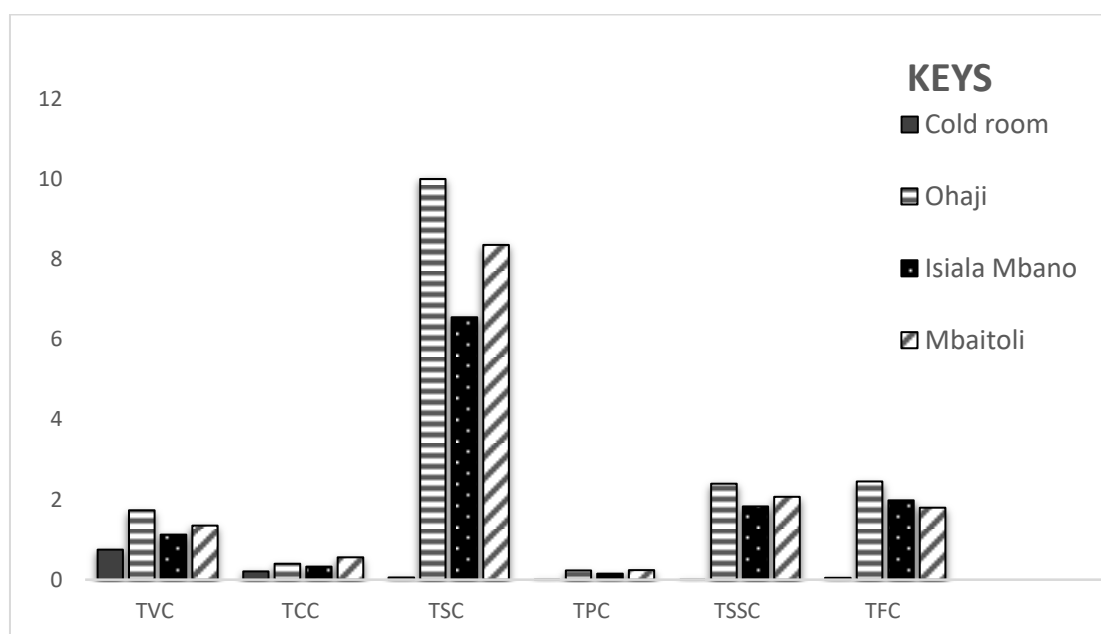
**Table 2.2c. Mean microbial load of open market frozen fish samples collected from Isiala Mbano LGA markets**

Site of collection	TVC (Cfu/g)	TCC (Cfu/g)	TSC (Cfu/g)	TPC (Cfu/g)	TSSC (Cfu/g)	TFC (Cfu/g)
Skin	$9.0 \times 10^4$	$8.4 \times 10^4$	$2.9 \times 10^5$	$2.8 \times 10^3$	$4.8 \times 10^4$	$3.5 \times 10^5$
Tissue	$1.0 \times 10^5$	$1.5 \times 10^4$	$2.0 \times 10^5$	$1.7 \times 10^4$	$6.0 \times 10^4$	$1.6 \times 10^5$
Gill	$1.8 \times 10^5$	$1.4 \times 10^4$	$1.3 \times 10^5$	$2.5 \times 10^4$	$4.4 \times 10^5$	$1.8 \times 10^5$
Intestine	$8.0 \times 10^4$	-	$2.0 \times 10^6$	-	-	$1.0 \times 10^5$

**Table 2.2d. Mean microbial load of open market frozen fish samples collected from Mbaitoli LGA markets**

Site of collection	TVC (Cfu/g)	TCC (Cfu/g)	TSC (Cfu/g)	TPC (Cfu/g)	TSSC (Cfu/g)	TFC (Cfu/g)
Skin	$1.2 \times 10^5$	$1.3 \times 10^5$	$4.4 \times 10^5$	$2.4 \times 10^4$	$4.6 \times 10^4$	$3.0 \times 10^5$
Tissue	$1.2 \times 10^5$	$2.0 \times 10^4$	$3.0 \times 10^5$	$2.0 \times 10^4$	$8.5 \times 10^4$	$1.8 \times 10^5$
Gill	$2.0 \times 10^5$	$1.9 \times 10^4$	$2.0 \times 10^5$	$2.7 \times 10^4$	$4.9 \times 10^5$	$1.0 \times 10^5$
Intestine	$1.0 \times 10^5$	-	$2.4 \times 10^6$	-	-	$1.4 \times 10^5$

Where TVC- total viable count, TCC- total coliform count, TSC- total Staphylococcal count, TPC- total pseudomonas count, TSSC- total Salmonella/Shigella count, TFC- Total fungal count and Cfu/g- colony forming unit per gram



**Fig. 1. Bar chart showing compared microbial indices for cold room and open market *Gadus morhua* iced fish**

**Table 3. Comparative analysis of mean microbial load in cold room and open markets iced fish in Imo state**

Sample	Parameters (Cfu/g)	Cold room ( $\times 10^5$ )	Ohaji ( $\times 10^5$ )	Isiala Mbano ( $\times 10^5$ )	Mbaitoli ( $\times 10^5$ )	p-value
<i>Gadus morhua</i>	TVC	$0.75 \pm 0.18$	$1.73 \pm 0.72$	$1.13 \pm 0.45$	$1.35 \pm 0.44$	0.089
	TCC	$0.15 \pm 0.16$	$0.30 \pm 0.38$	$0.28 \pm 0.37$	$0.42 \pm 0.59$	0.838
	TSC	$0.06 \pm 0.05$	$9.95 \pm 12.16$	$6.62 \pm 8.94$	$8.57 \pm 10.33$	0.462
	TPC	$0.00 \pm 0.00$	$0.17 \pm 0.18$	$0.11 \pm 0.12$	$0.17 \pm 0.12$	0.226
	TSSC	$0.00 \pm 0.00$	$1.80 \pm 2.62$	$1.37 \pm 2.03$	$1.55 \pm 2.25$	0.601
	TFC	$0.05 \pm 0.03$	$2.45 \pm 0.71^a$	$1.97 \pm 1.07^b$	$1.80 \pm 0.86^c$	0.005

**Table 4. Comparative analysis of average occurrence of bacteria in *Gadus morhua* in cold room and open markets of Imo state**

Bacterial isolates	Maximum occurrence	Cold room	Open market			p-value
			Ohaji	Isiala Mbanjo	Mbaitoli	
<i>Micrococcus spp.</i>	16	16.00 ± 0.00	11.00 ± 2.65	10.00 ± 5.19	10.00 ± 2.00	0.532
<i>Staphylococcus aureus</i>	16	13.00 ± 0.00	14.67 ± 1.52	13.33 ± 0.57	13.33 ± 0.57	0.340
<i>Bacillus cereus</i>	16	8.00 ± 0.00	5.00 ± 1.00	3.33 ± 1.15	4.00 ± 2.00	0.130
<i>Bacillus subtilis</i>	16	7.00 ± 0.00	11.00 ± 1.00	10.33 ± 1.52	10.67 ± 3.55	0.452
<i>Streptococcus spp.</i>	16	13.00 ± 0.00 <sup>a</sup>	7.33 ± 1.15 <sup>b</sup>	6.00 ± 2.00 <sup>c</sup>	6.00 ± 1.00 <sup>d</sup>	0.024
<i>Escherichia coli</i>	16	6.00 ± 0.00	7.67 ± 1.52	6.67 ± 1.52	7.33 ± 2.08	0.087
<i>Klebsiella spp.</i>	16	3.00 ± 0.00	4.00 ± 1.00	3.33 ± 0.58	3.33 ± 0.57	0.586
<i>Proteus spp.</i>	16	3.00 ± 0.00	4.00 ± 1.00	3.67 ± 1.15	3.33 ± 1.52	0.705
<i>Pseudomonas aeruginosa</i>	16	7.00 ± 0.00	10.67 ± 2.51	10.67 ± 4.72	10.67 ± 4.50	0.861
<i>Salmonella spp.</i>	16	4.00 ± 0.00	15.67 ± 0.57	14.67 ± 1.15	15.33 ± 1.15	0.000

**Table 5. Comparative analysis of average occurrence of fungi in *Gadus morhua* in cold room and open markets of Imo state.**

Fungal isolates	Maximum occurrence	Cold room	Open market			p-value
			Ohaji	Isiala Mbanjo	Mbaitoli	
<i>Geotrichum sp.</i>	16	4.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	NA
<i>Candida spp.</i>	16	13.00±0.00 <sup>a</sup>	0.33 ± 0.577 <sup>b</sup>	0.00 ± 0.00 <sup>c</sup>	0.33 ± 0.57 <sup>d</sup>	0.000
<i>Aspergillus fumigatus</i>	16	0.00 ± 0.0	4.00 ± 1.73	3.33 ± 1.52	3.33 ± 2.08	0.366
<i>Rhizopus stolonifer</i>	16	0.00 ± 0.00 <sup>a</sup>	8.33 ± 1.52 <sup>b</sup>	6.67 ± 1.52 <sup>c</sup>	8.00 ± 2.00 <sup>d</sup>	0.025
<i>Rhodotorula spp.</i>	16	0.00 ± 0.00	4.00 ± 1.00	3.33 ± 1.52	3.33 ± 1.52	0.193
<i>Aspergillus flavus</i>	16	0.00 ± 0.00	8.00 ± 2.64	5.67 ± 1.52	6.67 ± 1.52	0.062
<i>Mucor spp.</i>	16	0.00 ± 0.00	4.00 ± 1.73	2.67 ± 1.15	2.67 ± 1.52	0.240
<i>Aspergillus terreus</i>	16	0.00 ± 0.00	12.00 ± 3.60	10.33 ± 2.51	11.67 ± 3.21	0.068
<i>Aspergillus niger</i>	16	0.00 ± 0.00	4.00 ± 3.46	3.37 ± 2.08	4.00 ± 1.00	0.538

Emikpe et al. [20] noted that the means of contamination and route of microbial transmission are likely to be through handling. Onsite contamination of fish during transportation, display and handling as reported by Nwazuo et al. [2] and Adams and Moses [21], explains the increase in microbes as the fish proceeds from cold rooms to the open markets. Of note is the gill isolation of the cold room samples which had isolations ( $2.0 \times 10^4$ cfu/g) but absent in the open market samples. Same is recorded for the Total Salmonella/Shigella Count (TSSC) which were present ( $4.0 \times 10^2$ cfu/g) in cold room samples but entirely absent in the open market samples. Total Fungal Count (TFC) showed increasing values from cold room with a range of  $1.0 \times 10^3$ cfu/g -  $7.2 \times 10^3$ cfu/g to open markets samples with a range of  $2.0 \times 10^5$ cfu/g -  $3.5 \times 10^4$ cfu/g the latter obtained from the skin.

### 3.1 Comparison of Mean Microbial Composition of Cold Room and Open Market Frozen Fish Samples

Results from the comparative analysis reveals that TFC values alone showed significance difference at p-value 0.005 across the cold room and open markets collection points. Comparatively, there is no significant difference in the bacterial occurrence of *Micrococcus spp.*, *S.aureus*, *B. cereus*, *B. subtilis*, *E. coli*, *Klebsiella sp.*, *Proteus spp.*, and *P. aeruginosa* across cold room and open markets of the three local government areas with p-values of 0.532, 0.340, 0.130, 0.452, 0.087, 0.586, 0.705, and 0.861 respectively but significant difference in values of *Streptococcus spp.* and *Salmonella spp.* Just as was reported in Onyeonula et al. [22] and Orji et al. [23], in their studies on frozen fish marketed in Imo State and Abakaliki metropolis respectively, similar bacteria were isolated. Values for *Micrococcus spp.*, *Bacillus cereus*, and *Streptococcus spp.* were higher in cold room samples (16.00, 8.00 and 13.00 respectively) than in open markets with 11.00, 5.00 and 7.33 (Ohaji), 10.00, 3.33 and 6.00 (Isiala Mbanjo) and 10.00, 4.00 and 6.00 (Mbaitoli). This may be attributed to the fact that their growth may be significantly reduced at higher temperatures and lower pH which is evident in fish that have left the cold rooms to warmer temperatures and susceptible to other microbial contamination which will likely increase the pH. Onyeonula et al. [22], observed same with *Scomber scombrus* obtained in Imo State local market. Decrease in occurrence of *Bacillus cereus* and *Streptococcus*

*sp.* from cold room to open markets however negates the observations of Onyeonula et al. [22] and may be attributed to the physiochemical composition of *Gadus morhua*. Fungal occurrence showed a non-significant difference for *A. fumigatus*, *Rhodotorula spp.*, *A. flavus*, *Mucor spp.*, *A. terreus* and *A. niger* across the cold room and open market samples with p-value of 0.366, 0.193, 0.062, 0.240, 0.068 and 0.538 respectively (Table 5). *Geotrichum sp.* occurred in only cold room samples but was absent in open markets just as *Candida sp.* and *R. stolonifera* presented statistical significance across cold room and open market samples. Similar observation of fungal isolations was made for *Scomber scombrus* as reported by Onyeonula et al. [22]. Of all the nine fungi isolated, *Geotrichum sp.* showed significant difference at  $p \leq 0.05$ . Adebayo-Tayo et al. [24], Ibrahim et al. [25] and Onyeonula et al. [22,22] reported similar isolations with *Candida spp.* having the most average occurrence as observed in this study. Nishihara et al. (2008) also reported that despite disinfection of fish samples surface, its incubation for up to 14 days at room temperature still presented *Candida sp.* among few other fungi isolated. Isolates of the other fungi from the present study had no occurrence in cold room samples but significantly increased values in open market samples. This further buttress the fact that improper storage, transport and display facilities predispose these food commodities to fungal growth [26,22].

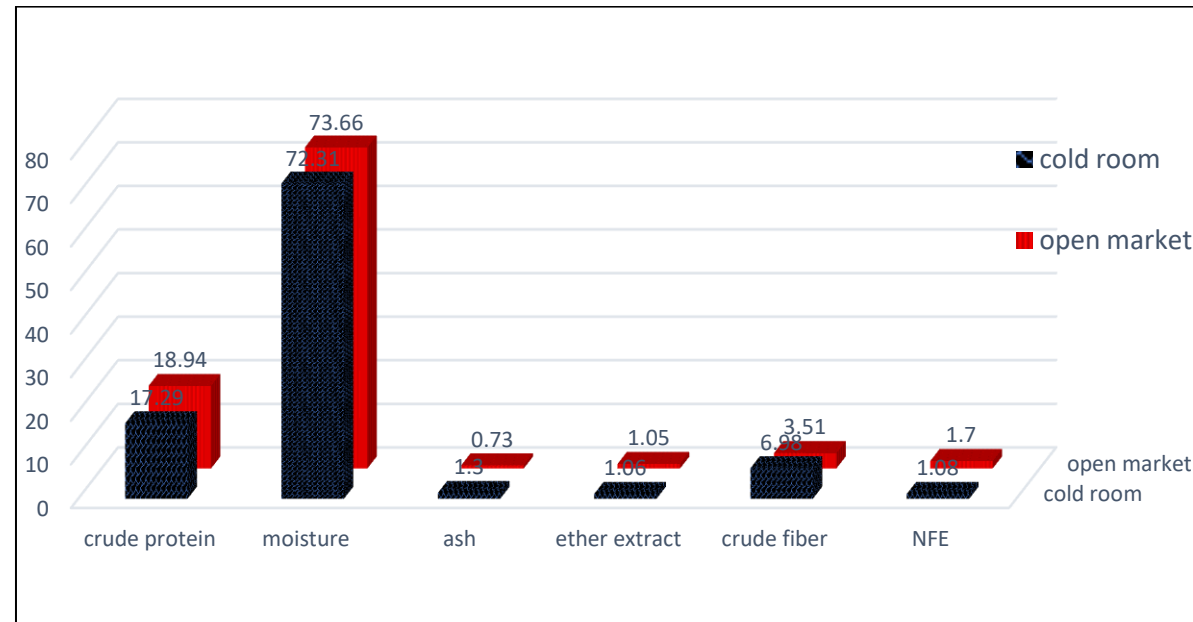
### 3.2 Proximate Composition for Frozen Fish Sold in Imo state Markets

Result shows that crude protein cold room value was  $17.24 \pm 0.52$  but significantly increased in the open market samples ( $19.44 \pm 0.94$ ) but with a unique value of  $17.29 \pm 0.63$  in one open market of Mbaitoli. The increase in values of moisture content from the cold room ( $72.31 \pm 0.57$ ) to the open market ( $74.09 \pm 1.05$ ) was insignificant just as was recorded for NFE to be  $1.08 \pm 0.60$  for cold room and  $2.95 \pm 1.78$  as maximum value for open market. On the other hand, an insignificant difference was recorded for ash content and ether extract but with values reducing from cold room ( $1.30 \pm 0.62$  and  $1.06 \pm 0.50$ ) to open market ( $0.12 \pm 0.70$  and  $1.00 \pm 1.00$ ) as their minimum value respectively. Crude fiber showed significant difference in values of cold room ( $6.98 \pm 0.54$ ) and open markets (ranged between  $3.04 \pm 0.81$  and  $4.39 \pm 1.30$ ), thus a significant difference ( $p < 0.05$ ) was observed in crude

**Table 6. Proximate analysis for frozen *Gadus morhua* from cold room and open market showing mean values**

Fish specie	Parameters	Cold room (AC)	Ohaji			Isiala Mbanjo			Mbaitoli			p-value
			O1	O2	O3	O1	O2	O3	O1	O2	O3	
<i>Gadus morhua</i>	CP	17.24±0.52	19.44±0.94	19.44±0.72	19.44± 7.05	19.34± 0.53	19.14±1.01	19.14±0.51	19.13±0.71	18.14±1.00	17.29±0.63	0.042*
	M	72.31±0.57	72.88±0.58	73.15±1.05	73.27± 0.70	74.00± 1.06	74.09±1.05	73.09±0.58	73.66±0.91	73.63±0.53	71.63±0.51	0.671
	A	1.30± 0.62	0.98± 0.63	0.12± 0.70	0.13± 0.99	0.84± 0.87	0.97± 0.83	0.87± 1.00	0.92± 0.72	0.91± 0.72	0.84± 0.58	0.611
	EE	1.06± 0.50	1.05± 0.93	1.05± 0.50	1.05± 1.05	1.05± 0.61	1.05± 1.08	1.06± 1.31	1.05± 0.65	1.00± 1.00	1.04± 1.74	0.993
	CF	6.98± 0.54	3.38± 0.86	4.37± 0.66	3.16± 0.50	3.80± 0.87	4.39± 1.30	4.39± 0.81	3.17± 0.81	3.06± 0.50	3.04± 0.81	0.001*
	NFE	1.08± 0.60	2.28± 0.94	1.88± 0.92	2.95± 1.78	0.98± 0.73	0.36± 0.50	1.45± 0.73	2.08± 0.52	2.00± 1.11	1.91± 0.54	0.612

Where CP= crude protein, M= moisture, A= ash, EE=ether extract, CF= crude fiber, NFE= nitrogen free extract  
p-values with "\*" shows significant difference p<0.05



**Fig. 2. Bar chart comparing mean values for proximate evaluation of fishes sampled from cold room**



protein and crude fiber values of *Gadus morhua* which is possibly related to an increase in the number of bacteria and fungi. Proximate composition values obtained from this study agrees with those undertaken by Tawfik [27] and Nurnadia et al. [28] with their nutritional properties acceptable especially for those obtained from the cold-rooms. Crude protein mean values indicates an increase in values in fish obtained from the open market to fish obtained from the cold room. The protein content of Atlantic mackerel in Olaolu et al. [29] supports this finding. Post rigor mortis is also associated in increased water retention capacity of proteins, thus may be responsible for the increased protein content in the open market [30].

#### 4. CONCLUSION

There is a marked recorded difference in microbial and carcass quality of fish in the cold rooms and those in the open markets available to vast majority of consumers, the microbial load being evident and carcass quality being reduced in the open market samples than in the cold room samples. Most of these quality difference has been linked to the handling method used within the state and negligence of the use of best practices. Because frozen fish is exposed to large variations of temperature fluctuations, during storage and transport, short-term storage of the raw material, gentle processing, quick freezing, short-term storage as a semiprocessed product, and short-term cold storage at temperatures lower than 30°C, will result in the best product.

#### 5. SUMMARY

The study looked at the microbial composition and carcass quality of *Gadus morhua* (a commonly sold and consumed fish) obtained from local markets of Imo state. An effective way of long term preservation of fish is by freezing [31]. The fluctuation of temperature is one of the most significant factors in maintaining quality through the chain of distribution. Just as it is important to quickly cool fish immediately it is caught to inhibit the onset of biochemical and microbiological change, it is equally important to maintain a relatively steady temperature as it is transported and made available to the final consumers. Results revealed that the difference in microbial and carcass quality of fresh and thawed fish may be negligible if fish was handled with care during and after purchase from the cold rooms, kept frozen as quickly as possible and

stored at a stable temperature of about 30°C even at the point of display for sale. This however is almost impossible with the handling habits found in our markets. Handlers and traders act as they deem fit depending on the limited resources available to them and market place involved. Small scale traders stay at cold room sites to share a carton of fish- and in so doing, start the exposure of the fish to microbial contamination accounting for the high levels of microbes in open market samples.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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