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Microbiological Evaluation and Public Health Implication of Frozen Scomber Scombrus Sold in Selected Markets of Imo State, Nigeria

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Abstract:

A comparative study was done on the microbiological quality of frozen Scomberscombrus sold in cold room and open markets of Imo state and its public health implication on the final consumers was highlighted. Results revealed nine bacterial species and seven fungal species contaminating the fish but with higher values in the open markets than in the cold room which is attributed to the possible environment of the open market in the study area as temperature increases outside of the cold room storage, pH level reduces as fish starts to deteriorate and concentration rises as water condenses out of the fish with each drip leading to the production of conducive environment for microbial growth and the proliferation of such. Added factors are the exposure of cold room fish to improper handling during transportation, and exposure to environmental contaminants during conspicuous displays and handling at the marketstands. Bacteria isolated such as Salmonella, Staphylococcus spp., Escherichia spp. and Enteroviruses are implicated as the most fish related food-borne pathogens and posing different levels of hazards to consumers. It is therefore recommended that traders and consumers should by all means adopt better hygienic and handling practice and also avoid cross contamination of fresh fish with cooked- ready to eat fish because these two processed types are occasionally sold in same environment. The health safety of all persons lies in the hands of all stakeholders through the food production, storage, processing, transportation and consumption stages.

Keywords: Microbial quality, cold room, open market, public health, scomberscombrus, hazards

1. Introduction

Fish that has quality is one that possess the absence of microbiological and chemical risks. Some consumers worry about what happens to their food before they eat it. They look for quality and they worry about what may have happened to fish before it is consumed. In the end they have to trust fishermen, processors and traders to be very careful with the fish they catch and handle. Pathogenic contamination of fish has been reported to be linked to the handling methods during capture, on the boat, during transportation and marketing by personnel and equipment utilized to actualize these stages of processing.

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. Fish is one of the food commodities that quickly change form by spoilage even when exposed to a form of processing, if not appropriate (Adebayo-Tayo et al., 2012b; Nwazuo et al., 2016). Spoilage is the change in fish form rendering it unacceptable or unsafe for human consumption (Adedeji, 2012). This spoilage constitutes hazards which have been defined by ICMSF (1998) as 'the unacceptable contamination, growth or survival of bacteria in food that may affect food safety or quality (spoilage)'. Fish can still be presentable on the outside but with internal degradation leading to the misleading of consumers- who will buy according to attributes that it does not worth (Eugenio et al., 2013). Hazards are aggravated with several bacteria that have been identified with different behaviour in the environment such as spore forming bacteria that usually survive in heat treated foods (Adebayo-Tayo et al., 2012c).

The composition of imports as is largely observed in Nigeria is largely mackerels, cod, haddock, hakes, herrings and croakers that are caught off the coasts of Eastern Central Atlantic countries of Senegal and Mauritania and from the North Sea (Agom et al., 2012). According to the report of Olaolu, (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. Johnston, et al., (1994) developed the time-temperature tolerance theory which predicted that for each frozen product, there is a relationship between storage temperature and the time it takes to change the product's quality; changes during storage and distribution at different temperatures are cumulative and irreversible over the entire storage period.

Methods employed by retailers to attract customers such as conspicuous display of frozen fish (Olaolu, 2016) can lead to sediment and bacterial accumulation on fish. Fresh fish have been reported by Nwazuo et al., (2016) to be exposed readily to high contamination by dirty water in bottom of boat used for harvesting and unkempt fishing equipment which is made worse by the fact that most fishes caught had opening on their bodies that would permit microbial invasion. According to the Center for Food Safety and Applied Nutrition (2001), most fish-related food borne illnesses are traced to *Salmonella*, *Staphylococcus* spp., *Escherichia coli*, *Vibrio parahaemolyticus*, *Clostridium perfringens*, *Clostridium botulinum* and Enteroviruses. Public health, by Lozano et al., (2012) is the science and art of preventing disease, prolonging life and health by the concerted and organized efforts of the society. To maintain health, collective effort is required which can be preserved when focus is shifted to environmental determinants of health and disease. Results from the studies of Lozano et al., 2012 revealed that about 76% of premature mortality in Sub-Saharan Africa are recorded from communicable, maternal, neonatal and nutritional causes in 2010. Fish has been reported to be of immense benefit to man (Nwazuo et al., 2016; Udeze et al., 2012), serving as food, for health maintenance, a source of international trade (Hassan et al., 2011; Adebayo-Tayo et al., 2012b) and for animal husbandry. Despite its importance, they are highly perishable and prone to microbial contamination (Nwazuo et al., 2016) and vessels for several zoonotic microbial and health hazards (Yagoub, 2009; Adebayo-Tayo et al., 2012b). Zoonotic infection is greatly due to the consumption of raw fish or transmission of microbes from raw fish to ready to eat fish products (Yagoub 2009). this research therefore finds out the microbial quality of fish sold within selected markets of Imo state Nigeria and highlights their public health importance which will further instigate the need for improved technology, policies on import and preservation methods and advise the government and relevant agencies on the need to put more effort into ensuring that fish sold within Imo state and Nigeria as a whole are safety risk free.

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 frozen mackerel (*Scomberscombrus*, Linnaeus, 1758) or scumbia (as is locally identified) collected from a cold room (a major distributor) and three open markets of each of the three representing local government areas of the zones in Imo state- Orlu zone, Owerri zone and Okigwe zone.

2.2. Fish Identification and Transportation

The fishes were identified with the aid of standard fish identification keys by Reed et al., (1967), Loveque et al., (1991) and FAO (1990) 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 fish. 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, Saboraud 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.

2.4. 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 (1980) and Njoku et al., (1998). 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

The primary aim for the heavy import of frozen fish into Nigeria is to bridge the gap between the demand and supply of fish which in turn makes protein needs to be readily met and in its right proportion. Results from this study indicated an increase in microbial load from the cold room to the open markets.

Parameters	Fish Part	Cold Room	Markets I	Markets A	Markets An
TVC	Skin	1.5×10^4	1.2×10^5	8.7×10^4	9.3×10^4
	Tissue	2.8×10^4	9.0×10^4	6.6×10^4	8.4×10^4
	Gill	7.8×10^4	2.3×10^5	1.6×10^5	2.1×10^5
	Intestine	6.0×10^3	9.5×10^4	7.4×10^5	8.3×10^5
TCC	Skin	--	1.4×10^4	8.2×10^3	8.3×10^3
	Tissue	--	2.6×10^5	1.8×10^5	1.9×10^5
	Gill	5.4×10^4	3.4×10^4	2.8×10^4	2.8×10^4
	Intestine	--	1.1×10^6	1.0×10^4	2.4×10^6
TSC	Skin	2.3×10^4	1.1×10^5	9.4×10^4	9.6×10^4
	Tissue	3.5×10^3	1.1×10^5	9.1×10^4	9.9×10^4
	Gill	9.2×10^4	2.7×10^5	1.3×10^5	2.3×10^5
	Intestine	1.9×10^4	7.8×10^4	7.7×10^4	8.5×10^4
TPC	Skin	--	1.5×10^4	1.3×10^4	1.4×10^4
	Tissue	--	3.2×10^4	2.7×10^4	3.1×10^4
	Gill	--	1.2×10^4	8.5×10^3	9.5×10^3
	Intestine	--	3.7×10^4	2.2×10^4	3.1×10^4
TSSC	Skin	--	--	--	--
	Tissue	--	--	--	--
	Gill	--	2.9×10^5	2.6×10^5	2.6×10^5
	Intestine	--	--	--	--
TFC	Skin	1.2×10^3	4.8×10^5	3.1×10^5	4.1×10^5
	Tissue	3.0×10^2	1.2×10^5	1.2×10^5	1.4×10^5
	Gill	1.0×10^4	1.5×10^5	1.1×10^5	1.3×10^5
	Intestine	8.0×10^2	3.9×10^5	2.4×10^5	3.3×10^5

Table 1: Average Microbial Load of (*S. Scombrus*) in Cold Room And Open Markets

The total viable count (TVC) for the samples from cold room (table 1) ranged between 6.0×10^3 cfu/g and 7.8×10^4 cfu/g for the intestine and gills respectively. Whereas the open markets samples had TVC range with the least being 6.6×10^4 and the highest value of 8.3×10^5 obtained from the tissue and intestine respectively. ICMSF (1998) gave recommended limits for bacterial count to be 5.0×10^5 cfu/ml for good quality products and 1.0×10^7 cfu/ml as the maximum acceptable quality. The result of this study falls within the limits thus, frozen *Scomberscombrus* consumed within Imo state are within limits of acceptance with regards to bacterial load. In agreement, Adebayo- Tayo et al., (2012b) working on microbial quality of frozen fish in Uyo Metropolis recorded total heterotrophic bacterial count ranging from 3.0×10^5 to 6.3×10^5 for the three species of fish (Shinna, Bonga and Mackerel) that were investigated, which were within the permissible range for iced fish and its products. Cold room samples showed total coliform count (TCC) present in only gills (5.4×10^4) of the samples while a huge spike in coliform count was recorded in the open market counterparts with a lower limit range of 8.2×10^3 and upper limit of 2.4×10^6 obtained for the skin and intestines respectively. This could mean that temperature fluctuations adds to the microbial proliferation in the open market fish. Total staphylococcal count (TSC) for cold room samples also had a maximum value of 9.2×10^4 which contrasts with the maximum value of open market samples (2.7×10^5) which were both isolated from the gills of the samples. There were no total pseudomonas count (TPC) and total *Salmonelle/Shigella* count (TSSC) obtained for the cold room samples however, these isolations visibly appeared in open market samples with TPC values ranging from 8.5×10^3 to 3.7×10^4 isolated from the gills and intestine respectively and TSSC values completely absent in skin tissue and intestine but present in the gill samples. On a general note, bacterial contaminations varied greatly in the different collection sites of the fish but had the most load occurring in gill samples. The significant rise in values of open market samples could be because strict hygienic market practice are not enforced. Markets for fish are not strictly for fish as other traders of other commodities sell alongside fish traders- a practice that increases the susceptibility of the fish to further bacterial contamination. The total fungal load (TFC) obtained from cold room samples showed fungal count in all four fish parts sampled and ranged from 3.0×10^2 to 1.0×10^4 obtained from the tissue and gills. This values significantly increased in open market samples with the upper limit reaching 4.8×10^5 isolated from the skin. Despite the fact that fungi were highest in the gills of cold room sample, open markets record of highest fungal count is an indication that superficial contamination must have occurred as skin is the most exposed to environmental contamination. Deterioration in fish cannot be extrapolated from the fact that fish are ready carriers of microbes and other health hazards (Adebayo-Tayo et al., 2012c) which are generally held on or inside their bodies especially after exposure to environmental contaminants as opined by Aliyu et al., (2016). This agrees with the findings of Afugbuom, 2016 who compared the microbial state of frozen fish obtained from cold room and open markets of Onitsha markets, Anambra state of Nigeria. In his work, cold room samples had less microbial load to open market samples in the six fish species he studied. It may also be attributed to the further exposure of the fish to environmental factors such as increased temperature, poor handling practice and exposure to dust and microbes as they are made accessible to customers at the open market stalls. From the opinion of Noor et al., (2013), several factors like contaminated ice, transportation, poor storage condition or cross contamination from other fish affects the final overall quality of fish food.

Parameters (Cfu/g)	Cold Room (x10 ⁵)	Markets I (x10 ⁵)	Markets A (x10 ⁵)	Markets An (x10 ⁵)	P-value
TVC	0.32 ± 0.28 ^a	1.34 ± 0.57 ^b	2.63 ± 2.77 ^c	3.04 ± 3.00 ^c	.779
TCC	0.54 ± 0.00 ^a	3.52 ± 4.43 ^c	3.04 ± 4.07 ^c	6.57 ± 10.09 ^f	.532
TSC	0.34 ± 0.34 ^a	1.42 ± 0.75 ^b	0.98 ± 0.20 ^a	1.27 ± 0.5 ^b	.277
TPC	0.00 ± 0.00 ^e	0.24 ± 0.11 ^a	0.18 ± 0.07 ^e	0.21 ± 0.10 ^a	.130
TSSC	0.00 ± 0.00 ^e	0.73 ± 1.26 ^a	0.65 ± 1.13 ^a	0.65 ± 1.13 ^a	.800
TFC	0.03 ± 0.04 ^e	2.85 ± 1.54 ^c	1.95 ± 0.84 ^a	2.53 ± 1.21 ^c	.818

Table 2: Comparative Analysis of Mean Microbial Load of *S. Scombrus* In Cold Room and Open Markets

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

Figure 1: Bar Chart Showing Compared Microbial Indices for Cold Room and Open Market *S. Scombrus* Iced Fish

Bacteria isolated from the present study includes *Micrococcus* spp., *Staphylococcus aureus*, *Bacillus cereus*, *Bacillus subtilis*, *Streptococcus* spp., *Escherichia coli*, *Klebsiella* spp., *Pseudomonas aeruginosa* and *Salmonella* spp. Similar bacterial isolations were obtained by Orji et al., (2014) in their microbial survey on frozen fish marketed in Abakiliki metropolis, Adebayo-Tayo et al., (2012b) from frozen *Auxisthazard*, *Ethmalosafimbriata* and *Scomberscombrus*, Ezemba et al., (2017) from iced fish retailed at Eke-Awka market of Anambra state and Amuneke et al., (2020) from fish caught from Otuocha river in Anambra state.

Bacterial Isolates	Cold Room	Open Market			p-value
		Markets I	Markets A	Markets An	
<i>Micrococcus</i> spp.	10.00 ± 0.00	8.00 ± 1.73	7.00 ± 2.00	8.00 ± 2.00	0.623
<i>Staphylococcus aureus</i>	16.00 ± 0.00	15.00 ± 1.73	14.33 ± 1.52	14.67 ± 2.30	0.884
<i>Bacillus cereus</i>	6.00 ± 0.00	7.67 ± 1.52	6.33 ± 1.52	7.33 ± 1.52	0.654
<i>Bacillus subtilis</i>	8.00 ± 0.00	4.00 ± 2.00	3.67 ± 0.57	4.00 ± 2.00	0.238
<i>Streptococcus</i> spp.	0.00 ± 0.00	7.33 ± 2.08	6.67 ± 2.51	7.33 ± 2.08	0.111
<i>Escherichia coli</i>	0.00 ± 0.00	14.67 ± 2.30	13.67 ± 3.21	13.33 ± 2.08	0.013
<i>Klebsiella</i> spp.	0.00 ± 0.00	4.00 ± 1.00	2.67 ± 0.57	3.33 ± 2.30	0.231
<i>Pseudomonas aeruginosa</i>	0.00 ± 0.00	14.67 ± 1.52	13.00 ± 1.73	13.33 ± 1.52	0.001
<i>Salmonella</i> spp.	0.00 ± 0.00	0.60 ± 1.02	0.89 ± 1.10	1.00 ± 1.00	0.152

Table 3: Comparative Analysis of Average Occurrence of Bacteria in *S. Scombrus* in Cold Room and open Markets of Imo State

Of the nine species of bacteria isolated from the sample, *Streptococcus* spp., *Escherichia coli*, *Klebsiella* spp., and *Pseudomonas aeruginosa* were absent in cold room samples but significantly present in open market samples of the three

local government areas under study. *Micrococcus* spp., *Staphylococcus aureus* and *Bacillus subtilis* had more occurrence in cold room than in open markets. This may be attributed to the fact that although *Micrococcus* spp. are found almost everywhere- on human, animals, in soil, water, plants, dust and air, and are transmitted by direct contact with contaminated surfaces, their growth may be significantly reduced at temperatures greater than 45°C, pH less than 6.0 and when in high salt concentrations of greater than 15% (ICMSF, 1986). This situation is evident with the possible environment of the open market in the study area as temperature increases outside of the cold room storage, pH level reduces as fish starts to deteriorate and concentration rises as water condenses out of the fish with each drip. The results revealed that *Staphylococcus aureus* and *Bacillus subtilis* had higher mean occurrence in cold room samples than in the open markets of locations I, An and A with significant difference of 0.88 at $p \leq 0.05$. This present result could also be as a result of changes in growth simulation which have been reported for food borne organisms (yeast, micrococci, streptococci, lactobacilli and Enterobacteriaceae) by mechanisms involving the absorption of metabolic products from one organism and utilization of such products by another microbe, changes in pH, changes in aw, all of which will influence symbiosis between the organisms (ICMSF, 1986). Evidently, several other bacteria and fungi were isolated from the open market samples. The result negates the work of Afugbuom, 2016 who revealed that the highest coliforms- *E. coli*, *Staphylococcus* and *Salmonella* spp. were seen in the open markets. However, the isolation of *Staphylococcus aureus* and *Bacillus* spp. from fish samples is an indication of poor handling or cross contamination as was observed by Dike-Ndudim et al., (2014), organisms that have been implicated in food poisoning (Gupte, 2006) and isolated in studies done by Okonkwo et al., (2008). Reports given by Ola et al., (2004) reveals that some bacteria like *Bacillus* spp. are part of the normal flora of fresh fish. The high occurrence of *Bacillus subtilis* in cold room samples could be as a result of initial contamination at the harbour as these are terrestrial in nature as opined by Robert (2010).

Fungal Isolates	Cold Room	Open Market			p-value
		Markets I	Markets A	Markets An	
<i>Candida</i> spp.	15.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	--
<i>Aspergillus fumigatus</i>	0.00 ± 0.00	4.00 ± 2.64	3.00 ± 1.73	3.33 ± 0.57	0.392
<i>Rhizopus stolonifer</i>	0.00 ± 0.00	11.33 ± 2.30	10.00 ± 2.00	11.00 ± 3.05	0.035
<i>Rhodotorula</i> spp.	0.00 ± 0.00	8.33 ± 1.15	6.67 ± 1.15	6.67 ± 1.52	0.008
<i>Aspergillus flavus</i>	0.00 ± 0.00	4.00 ± 1.00	3.33 ± 1.15	3.33 ± 1.52	0.145
<i>Mucor</i> spp.	0.00 ± 0.00	4.00 ± 3.46	3.33 ± 2.08	3.67 ± 0.57	0.553
<i>Aspergillus terreus</i>	0.00 ± 0.00	4.67 ± 1.52	3.33 ± 1.52	4.33 ± 1.52	0.149

Table 4: Comparative Analysis of Average Occurrence of Fungi in *S. Scombrus* in Cold Room and Open Markets of Imo State

Fungal occurrence in this study shows an almost non-occurring fungal occurrence in cold room samples whereas, the open market samples had very large occurrence. A total of seven (7) fungi were isolated including *Candida* spp., *Aspergillus fumigatus*, *Rhizopus stolonifera*, *Rhodotorula* spp., *Aspergillus flavus*, *Mucor* spp. and *Aspergillus terreus* from the open market and cold rooms of Imo state markets. Similar isolations have been noted in Adebayo-Tayo et al., (2012a) in fresh catfish (*Arius hendelotic*), and Adebayo-Tayo et al., (2012b) in frozen Mackerel (*Scomberscombrus*). *Candida* spp. which happen to have only occurrence in cold room samples is an indication that the growth and activities of other fungi and bacteria within the medium readily affect their existence. Ibrahim et al., (2015) reported *Candida* spp. to be the most predominant of isolated yeast in his study on mycology of imported frozen fish in markets of Alexandria.

The occurrence of *Aspergillus fumigatus*, *Rhizopus stolonifera*, *Rhodotorula* spp., *Aspergillus flavus*, *Mucor* spp. and *Aspergillus terreus*, which were entirely absent in cold room samples were seen to show significantly increase in occurrence in the open market samples with a $p \leq 0.05$ value of 0.392, 0.035, 0.008, 0.145, 0.553 and 0.149 respectively.

This result showed significant difference in occurrence of *Aspergillus fumigatus*, *Rhizopus stolonifera*, *Aspergillus flavus*, *Mucor* spp. and *Aspergillus terreus* and insignificant difference in occurrence of *Rhodotorula* spp. This buttress the fact that onsite contamination by handlers during transportation from cold room to open stores and exposure of fish to contaminated environment (Adams and Moss, 2000) that characterize the market place amounted to the significant growth of fungi. Adebayo-Tayo et al., (2012b) reported high occurrence of some of these fungi in open markets of Uyo metropolis. He further stated that high contamination may be as a result of temperature fluctuations, fish handler's character, among others.

Contamination of foods by biological hazards (pathogenic bacteria, viruses, parasites and bio-toxins) that causes food-borne diseases has been mainly due to improper handling, insufficient cooling, absence of hygienic standards, and contamination of ready to eat foods or consumption of raw fish (Gill and Barbosa, 2011). According to the subcommittee on Microbiological Criteria (1995), there is a potential of microbial transmission to the consumers because they are likelihood to be found in foods. Hands and handling surfaces are likely means for contamination and route of pathogen infection of other foods (Emikpe et al., 2011; Hastein et al., 2006). The Center for Food Safety and Applied Nutrition in Washington (2001) lists *Salmonella*, *Staphylococcus* spp., *Escherichia* spp., *Vibrio parahaemolyticus*, *Clostridium perfringens*, *Clostridium botulinum* and Enteroviruses as the most fish related food borne pathogens and posing different levels of hazards to consumers. *Staphylococcus aureus* according to – Subcommittee on Microbiological Criteria 1985 and ICMSF 1978 is classified as an organism posing moderate hazard with limited spread. The hazard this organism pose is more from the enterotoxins it produces which are heat-stable rather than from the organism itself. Its symptoms includes nausea, vomiting diarrhoea, general malaise and weakness. The organism which is known for its heat stable enterotoxins

and potential for multiple antibiotic resistance when in a living tissue (Adebayo-Tayo et al., 2009), makes its occurrence in food of more epidemiological danger. *Streptococcus* spp. are quite salt tolerant and are resistant to freezing and is spread by direct or indirect means and have greatly been associated with foods. *Escherichia coli* and *Klebsiella* spp. are organism (thermotolerant faecal coliform) that naturally occur in the intestines of vertebrate organisms thus, their presence in food is an indication of faecal contamination. *E. coli* in a sample gives a more positive assumption of hazard than the presence of other coliforms (ENV/JM/MONO, 2011). *Pseudomonas aeruginosa* have a tendency of infecting immunocompromised individuals of infants with their contamination commonly from human handling. Other isolated organisms of potential hazards such as *Bacillus cereus* produces symptoms that resembles those caused by *Staphylococcus aureus* (gastroenteritis) and *Clostridium perfringens* (enterocolitis). Even though *B. cereus* is regarded as harmless, it is a common cause of food poisoning and often isolated from foods such as rice, milk, spices, meat (ENV/JM/MONO, 2011). They form spores that survive high temperatures of processing (Adebayo-Tayo et al., 2009). All *Salmonella* spp. are considered pathogenic to humans. Salmonellosis is as a result of this organism and commonly cause typhoid and paratyphoid fever, diarrhoea, intestinal cramps and vomiting. Adedeji et al., 2012 reports that contamination of sea foods with *Salmonella* is of public health concern. It is reported as the primary microbial pathogen responsible for the majority of food-borne illnesses in Croatia (Wafaa et al., 2011) and having the highest incidence in central Pacific and African countries (Heinitz et al., 2000). *Salmonella* spp. has been listed as one of the isolated organisms that have zoonotic potentials in man with increased prevalence and severity in immunocompromised individuals (CCARE, 2012).

Aspergillus spp., that tend to dominate spoilage in the tropics (Doyle, 2007), are implicated in the spoilage of many other materials such as grains, spices, beans peanuts and even non-food materials as paper and leather (Doyle, 2007; Adebayo-Tayo et al., 2012). *Aspergillus* spp. in fish samples is likely to cause the incidence of Aspergillosis in consumers as they produce toxins and also cause mycetoma in humans (Adebayo-Tayo et al., 2009). Infection with *Aspergillus* spp. causes bronchopneumonia, infection of the thyroid, brain or myocardium and or hypersensitivity with immune compromised individuals being more at risk (CCARE, 2012). Considering the health implication of most bacteriological and mycological contamination, it is necessary to pay more attention to safety procedures during storage, transportation, display at the markets, and handling in general.

4. Summary

The main focus of this study is to find out the microbial quality of frozen *Scomberscombrus* commonly sold and consumed in Imo state, their quality difference in cold room and open markets as a result of handling practice and the public health implication of these changes. Fish begins to spoil immediately after death. Temperature and temperature fluctuations are the most significant factors in maintaining quality through the distribution chain. Thus, the importance of keeping fish frozen at a stable temperature to maintain fish quality is a reason for the development of the time – temperature theory which states that 'For each frozen product, there is a relationship between storage temperature and the time it takes to change the product's quality; changes during storage and distribution at different temperatures are cumulative and irreversible over the entire storage period' (Johnston, 1994). It is therefore important to cool the fish as quickly as possible immediately after it has been caught in order to minimize the biochemical and microbiological reactions from the very beginning and maintain such temperature even as fish gets transported and made available to the final consumers. A first-class frozen product can be achieved only when using entirely high quality fresh fish, freezing them and storing them at low and stable temperatures. If subject to poor handling in connection with freezing and cold storage, for example in terms of a freezing process spanning a whole day and cold storage temperatures that fluctuate over a longer time, the product will be ruined. Difference in microbial quality of fresh and thawed fish may be negligible if fish is handled with care during and after catching, frozen as quickly as possible and stored at a stable temperature of 30°C (or below). This however is almost impossible with the handling habits found in our markets. It is recommended that traders and consumers should avoid cross contamination of fresh fish with cooked- ready to eat fish because these two processed types are occasionally sold in same environment. Microbial presence in open market fish can cross over to ready to eat fish posing a greater risk to health of consumers.

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