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Full Length Research

Assessment of the sanitary condition of contacts surfaces of meat and fish displayed for sales in local markets in Rivers State Nigeria

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ABSTRACT: Food-borne pathogen are the primary source of infection in developing countries. The widespread practice of raw fish and meat consumption is a potential cause of food-borne diseases in Nigeria. Hence, this study was initiated to assess the sanitary condition of contact surfaces of fresh fish and meat samples from the markets in Obio/Akpor LGA in Rivers State. Swab samples from contact surfaces were collected from the sellers of fish and meat for microbial analysis. The study revealed that the table had the highest mean total heterotrophic bacterial count (THBC) of 5.71log_{10} (cfu/cm^3) > knife (5.7 log_{10} (cfu/cm^3)) > the hand (5.47log_{10} (cfu/cm^3)) > the 4.55log_{10} (cfu/cm^3) and 3.8 log_{10} (cfu/cm^3) on cutting board and apron swabs. Staphylococcus count of all samples shows of 5.02 log_{10} (cfu/cm^3), 4.69 log_{10} (cfu/cm^3), 4.58log_{10} (cfu/cm^3), 4.56log_{10} (cfu/cm^3) and 4.55log_{10} (cfu/cm^3) for apron, cutting board, hand, knife and table samples respectively. Coliform count of apron is zero (0), hand is zero (0), cutting board is 0.61log_{10} (cfu/cm^3), hand is 0.49log_{10} (cfu/cm^3), knife is 1.17log_{10} (cfu/cm^3) and table is 0.66log_{10} (cfu/cm^3). Apron for Salmonella count is 0.55log_{10} (cfu/cm^3), cutting board is zero (0), hand is 0.49log_{10} (cfu/cm^3), knife is zero (0) and table is zero (0). The knife samples had a fungal count of 2.66log_{10} (cfu/cm^3) < apron (3.18log_{10} (cfu/cm^3)) < table (3.3log_{10} (cfu/cm^3)) < hand samples (3.33log_{10} (cfu/cm^3)) < cutting board (3.40log_{10} (cfu/cm^3)). *Staphylococcus sp, Salmonella sp, Escherichia coli, Klebsiella sp, Bacillus sp, Shigella sp, Proteus sp, Enterobacter sp and Citrobacter sp* are all bacteria isolated from this study. *Aspergillus flavus, Aspergillus niger, Penicillium sp, Fusarium sp, Saccharomyces sp and Aspergillus terreus* were all the fungal species isolated. In this study, it was observed that all swab samples obtained from the contact surface detected a significant count of microbes. Hence, adequate sanitary measures should be taken into consideration.

Keywords: Coliform count, food-borne pathogen, heterotrophic bacterial count, meat and fish, Rivers State, Salmonella count, Staphylococcus count.

INTRODUCTION

Fish and meat are the main source of protein and valuable vitamins for most people in many parts of the world and are essential for the growth, repair and maintenance of body cells and our daily activities. Despite their nutritional value, fresh fish and meat are highly susceptible to contamination. Ingestion of contaminated food can cause mild to severe illness that can lead to hospitalization or even death. consumption of food of animal origin, such as fish, meat and their products, especially raw, are considered high-risk products (Yousuf and Ahmed, 2008). In Nigeria, there is a common habit of consuming partially cooked fish and meat, which can be a potential cause of foodborne illness (Birhaneselassie and William, 2013). This may be due to poor food handling and sanitation practices, inadequate food safety regulations, weak regulatory systems and lack of training for food handlers (WHO, 2014). Therefore, the microbiological quality of the contact surface between fish and meat must be evaluated

in order to design hygiene measures applied in butcher shops to reduce foodborne diseases. Microorganisms easily spoil fish and meat because it contains many nutrients, growth factors, etc. Obeng *et al*. (2013) reported in their study that although meat may contain contaminants, it may not be meat spoilage. The most likely sources of contamination may be improper and unhygienic handling, processing, transport, storage, hygienic conditions at various retail outlets, and environmental conditions of butchers and vendors. Microorganisms from soil, water, slaughterhouse, scales, cuts, seller's hands, wooden boards, cutting boards and aprons form the dominant flora of fish and meat. The threat to public health posed by foodborne pathogens is difficult to mitigate, and the underreporting of disease has been overshadowed by the problem of foodborne pathogens (Oosterom *et al*., 1991).

Improving awareness about hygienic production practices and proper implementation of fish and meat inspection procedures during slaughtering are vitally needed part of the national public health protection program to address a day-to-day threat to consumers. Because of continuous consumer demand for fish and meat products, especially the consumption of raw fish and meat as part of the culture, it is necessary to ensure good quality, safe fish and meat products through regular assessments of hygienic production practices, the microbial quality of fish and meat products, and adequate waste management systems. The presence of bacterial pathogens in meat-processing equipment and associated surfaces may contribute to the contamination of meat. It is generally accepted that microbial loads on surfaces and equipment vary in different food plants depending on the microbial quality of the food (Evans *et al*., 2004). It is already known that most bacteria form biofilm on hydrated surfaces (Costerton *et al*., 1999). Most of these bacteria have the ability of producing a matrix of biofilms which protect them from external harm and enables them to adhere strongly to contact surfaces making it necessary to go an extra mile during cleaning. Typical food contact surfaces in Nigerian retail markets may include handler’s hands and outer garments, wooden tables, cutting knives, weighing scales, carton papers, cleaning sponges/ brushes, aprons and water-holding utensils such as metal buckets or plastic containers. This food handling equipment should therefore be maintained and stored in a way that will minimize the chance of food becoming contaminated as their contamination can contribute to cross-contamination of non-contaminated meat. Microorganisms, once in the interior of the wood, may persist in the inner structure. Improperly washed weighing scales and cutting knives may also have biofilms with bacteria within their matrix. Unless such equipment are thoroughly sanitized, they may continue to contaminate foodstuff as noted (Costerton *et al*., 1999; Ali *et al*., 2010). Hence, uncontaminated meat will become contaminated by the time it comes in contact with such surface. On the other hand, contaminated meat is able also to disseminate food-borne pathogens to clean contact-surfaces (Gorman *et al*., 2002).

Raising awareness of hygienic production practices and proper implementation of fish and meat inspection procedures at slaughter is an important part of the national public health protection program to address the daily threat to consumers. Due to the constant consumer demand for fish and meat products, especially the use of raw fish and meat as part of culture, it is necessary to ensure good quality, safe fish and meat products by regularly evaluating hygienic production practices, microbial quality. fish and meat products and appropriate waste management systems. The presence of bacterial pathogens in meat processing equipment and related surfaces can contribute to meat contamination. It is generally accepted that the microbial load on surfaces and equipment varies in different food plants, depending on the microbial quality of the food (Evans *et al*., 2004; Çetin *et al.,* 2006). It is already known that most bacteria form biofilms on hydrated surfaces (Costerton *et al*., 1999). Most of these bacteria can produce a biofilm matrix that protects them from external damage and allows them to strongly adhere to contact surfaces, thus spending more time during cleaning. Typical food contact surfaces in the Nigerian retail market may include handler's hands and outer clothing, wooden tables, knives, scales, cardboard papers, cleaning sponges/brushes, aprons and water storage devices such as metal buckets or plastic containers. Therefore, these food handling equipment must be stored and maintained in a manner that minimizes the possibility of food contamination, as their contamination can contribute to cross-contamination of uncontaminated meat. Within wood, microorganisms can survive in the internal structure. Improperly washed scales and scalpels may also have biofilms with bacteria in the matrix. As noted, such equipment can still contaminate food if not fully disinfected (Costerton *et al*., 1999; Ali *et al*., 2010). Thus, uncontaminated meat becomes contaminated when it comes into contact with such a surface. On the other hand, contaminated meat can also spread food pathogens to clean contact surfaces (Gorman *et al*., 2002).

Fish is particularly susceptible to rotting due to its high nutrient content, near neutral pH and high water activity. In addition to their natural microbiota, which is found mainly in the gut, gills and surface mucus, fish can also be contaminated by improper handling and storage caused by spoilage and pathogenic bacteria, as well as by the aquatic environment (Ghaly *et al*., 2010; Mol and Tosun, 2011). Also, poor hygiene of the surfaces that come into contact with fish during the sale significantly affects the quality of the final product (Kusumaningrum *et al*., 2003; Temelli *et al*., 2006; Mol and Tosun, 2011). Appropriate hygiene procedures must be used to remove dirt particles and bacteria, otherwise adhesion

processes can start and lead to biofilm formation (Salustiano *et al.,* 2010; Andrade, 2008). According to some studies (Temelli *et al*., 2006; de Oliveira *et al*., 2008; Kahraman *et al*., 2010), equipment and tools in food processing areas are rich in microorganisms as a result of improper hygiene practices. It has a significant negative impact on public health or the economy. Good Hygienic Practices (GHP) are often neglected in low and middle income countries, Nigeria is no exception, in a typical Nigerian market, meat and fish are often displayed on wooden tables with various microorganisms that can be pathogenic to consumers. also be the cause of the spread of infectious diseases, a wooden table can support the reproduction of these organisms, because during sawing or chopping, microbial impurities remain between the wood and it can be difficult to wash it off, therefore it is necessary. to conduct health and safety studies on its meat and fish (Aarnisalo *et al.*, 2006).

Ensuring the sanitary condition of contact surfaces where meat and fish are displayed for sale is of paramount importance in the realm of food safety and public health. The microbial quality of these surfaces serves as a critical indicator of the cleanliness and hygienic practices employed within markets. Contamination of contact surfaces with pathogenic microorganisms can pose significant risks to consumer health, leading to foodborne illnesses and potential outbreaks. The assessment of the microbial quality of contact surfaces plays a pivotal role in mitigating these risks and maintaining the integrity of meat and fish products offered for sale. By systematically evaluating the microbial load present on these surfaces, food establishments can identify potential sources of contamination, implement effective sanitation measures, and uphold stringent hygiene standards. Therefore, the study is aim at assess the sanitary quality of contact surfaces of meat and fish displayed for sales.

MATERIALS AND METHODS

Study area/collection of samples

A total of 50 samples comprising of 25 meat contact surfaces and 25 fish contact surfaces were randomly source from 5 markets within Obio-Akpor Local Government Area, Rivers State aseptically. The swap samples were taken from knives, cutting board, apron, butcher hands and table using sterile swabs soaked into a 0.1% saline solution and was transported to the Food Microbiology Laboratory, Department of Microbiology, University of Port Harcourt, for analysis.

Sample preparation

Each tube containing swab samples (10ml of 0.1% saline water) was vortex to ensure a mixture of the sample. A tenfold serial dilution was prepared by transferring 1ml of (fish and meat contact surface swab) to 9ml diluents. From appropriate serial dilutions, a 0.1ml aliquot was plated on various types of media for microbial count.

Preparation of culture media

Commercially available nutrient media were used for isolation, identification and characterization of microorganisms. The media used include: Plate count agar for Total Heterotrophic Bacteria Count, Potato dextrose agar for Total Fungal Count, MacConkey agar for Total Coliform Count, and Mannitol salt agar for Total Staphylococcus Count.

Microbial analysis

Bacteriological analysis of the swab samples

The swab samples were serial-diluted and exactly 0.1 ml were aseptically inoculated using the spread plate technique. The inoculated plates were aseptically incubated at 37°C for 24hr and were observed for colony development. The colonies were counted to obtain colony forming unit per gram (cfu/g) of samples. Colonies with different cultural characteristics were sub cultured on a freshly prepared nutrient agar medium and used to carry out biochemical tests and microscopy for identification/characterization. Isolates were identified based on their morphological and cultural characteristics on growth media. Identification materials, reagents and protocols according to Cheesbrough (2000) were used to identify discrete colonies from the bacteriological media of sub-cultured isolates. The identities of the isolates were confirmed using biochemical tests (Cheesbrough, 2005). Tests carried out include indole, catalase, methyl red production, Voques-Proskauer reaction, citrate and triple sugar iron agar test (TSIA) and sugar fermentation tests for all isolates. The antibiotic test was carried out to detect organisms that were susceptible or resistant to standard antibiotics. Susceptibility testing was carried out according to clinical and laboratory Standard Institute, CLSI (CLSI M100-2010; M100-2017) using the commercially prepared antibiotics disc with the following antibiotics; Amoxicillin (AMX) 25 ug, Ofloxacin (OFX) 5 ug, Erythromycin (E) 30 ug, Streptomycin (S) 10 ug. Sparfloxacin (SXT) 5 ug, Chloramphenicol (CHL) 10 ug Spiramycin (SP) 100 ug, Ciprofloxacin (CPX) 5 ug, Augmentin (AU) 30 ug, Cefotetan (CN) 30 ug, Ofloxacin (OFL) 5 ug Pefloxacin (PEF) 5 ug, Rifampicin (RA) 30 ug, and Azithromycin (AZ) 30 ug.

Total fungal count

The swabbed samples were serial-diluted and exactly 0.1

Table 1. Mean microbial counts of the contact surfaces of meat and fish.

Fish and meat sellers' materials	THBC	Staphylococcus count	Coliform count	Salmonella count	TFC
Fish seller 1					
Apron	$6.8X10^4$	$1.9X10^4$	Nil	Nil	$5X10^2$
Cutting board	$3.2X10^5$	$6.8X10^4$	$1.2x10^3$	Nil	$1.1X10^3$
Hand	$1.06X10^5$	$1.64X10^5$	Nil	Nil	$7X10^2$
Knife	$5.6X10^5$	$8.6X10^4$	$8x10^2$	Nil	$8X10^2$
Table	$3.6X10^5$	$5.0X10^4$	Nil	Nil	$7x10^2$
Fish seller 2					
Apron	$4.2X10^3$	$3.5X10^4$	Nil	$6×10^2$	$2.1X10^3$
Cutting board	$3.0X10^5$	$4.2X10^4$	Nil	Nil	$3.1X10^3$
Hand	$3.8X10^5$	$3.0X10^4$	Nil	$3×10^2$	$3.3X10^3$
Knife	$4.6X10^5$	$2.0X10^4$	$9x10^2$	Nil	$2.9X10^3$
Table	$5.0X10^5$	$2.5X10^4$	$2.1×10^2$	Nil	$4.1x10^3$
Fish seller 3					
Apron	$3.6X10^3$	$2.8X10^3$	Nil	nil	$2.0x10^3$
Cutting board	$4.6X10^5$	$3.4X10^4$	Nil	Nil	$3.0x10^3$
Hand	$6.0X10^5$	$4.0X10^4$	Nil	Nil	$4.0x\ 10^3$
Knife	$6.2X10^5$	$3.8X10^4$	Nil	Nil	$3.6x10^3$
Table	$6.6X10^5$	$3.8X10^4$	Nil	nil	$3.0x10^3$
Fish seller 4					
Apron	$4.2X10^3$	$3.0X10^3$	Nil	Nil	$2.1X10^3$
Cutting. board	$5.0X10^5$	$2.9X10^4$	Nil	Nil	$3.2X10^3$
Hand	$3.0X10^5$	$4.2X10^4$	Nil	Nll	$3.0X10^3$
Knife	$2.8X10^5$	$3.2X10^4$	Nil	Nil	Nil
Table	$5.2X10^5$	$3.8X10^4$	Nil	nil	$1.2x10^3$
Fish seller 5					
Apron	$4.6X10^3$	$3.2X10^3$	Nil	Nil	$2.0X10^3$
Cutting board	$5.5X10^5$	$3.2X10^4$	Nil	Nil	$3.2X10^3$
Hand	$3.6X10^5$	$3.6X10^4$	Nil	Nl	$1.8X10^3$
Knife	$4.0X10^5$	$4.0X10^4$	Nil	Nil	$2.6x10^3$
Table	$5.7X10^5$	$3.5X10^4$	Nil	nil	$4.0x10^3$

ml was inoculated onto Potato dextrose agar at room temperature for 5 to 7 days. Plates were observed for colony count development. The colony was counted to obtain colony forming unit per gram (cfu/g) of samples. Colonies with different cultural characteristics were sub culture on a freshly prepared potato dextrose agar. On maturation, colonies were observed and described as seen on plates (i.e macroscopically) and viewed microscopically for morphologic features for identification/ characterization. The cultural characteristics of each fungi isolates were identified according to their colour, shape and the cell morphology was done based on mycelial, hyphae, septate, spore formation using lacto phenol blue. A piece of the mycelium from the petri plates was mounted on a clean grease free slide using a sterile wire loop and covered with a cover slip, after which a drop of lactophenol cotton blue was added and examined with the microscope.

RESULTS

Microbial counts of the contact surfaces of meat and fish

The mean microbial counts of the contact surfaces of meat and fish seller is shown in Table 1.

Table 1. Contd.

Fish and meat sellers' materials	THBC	Staphylococcus count	Coliform count	Salmonella count	TFC
Meat seller 1					
Apron	$8.2X10^3$	$4.0X10^3$	Nil	$1.2x10^3$	$6.2X10^3$
C. board	$3.6X10^5$	$1.7X10^5$	$5x10^2$	Nil	$5.4X10^3$
Hand	$3.4X10^5$	$1.6X10^5$	$1.7x10^3$	Nl	$2.1X10^3$
Knife	$6.0X10^5$	$8.0X10^4$	Nil	Nil	$1.3x10^3$
Table	$4.2X10^5$	$2.1X10^5$	$9.3x10^3$	$1.3x10^3$	$2.8x10^3$
Meat seller 2					
Apron	$3.2X10^3$	$1.8X10^3$	$1.6x10^3$	Nil	$2.6X10^2$
C. board	$4.0X10^5$	$3.0X10^5$	$1.0x10^3$	Nil	$4.8X10^3$
Hand	$4.6X10^5$	$2.6X10^5$	$1.2x10^3$	Nl	$8.1X10^3$
Knife	$6.2X10^5$	$3.8X10^4$	Nil	Nil	$6.0x10^3$
Table	$3.3X10^5$	$2.8X10^5$	Nil	Nil	$4.1x10^3$
Meat seller 3					
Apron	$3.0X10^3$	$2.6X10^3$	Nil	Nil	$8X10^2$
Cutting board	$6.0X10^5$	$4.2X10^5$	$1.0x10^3$	Nil	$1.0X10^3$
Hand	$6.6X10^5$	$3.6X10^5$	$1.2x10^3$	$1.2x10^3$	$2.6X10^3$
Knife	$6.2X10^5$	$4.2X10^5$	Nil	Nil	$3.2x10^3$
Table	$3.8X10^5$	$3.5X10^5$	Nil	Nil	$3.8x10^3$
Meat seller 4					
Apron	$3.2X10^3$	$4.0X10^3$	Nil	Nil	$7X10^2$
C. board	$5.8X10^5$	$3.7X10^5$	$1.6x10^3$	Nil	$3.8X10^3$
Hand	$6.0X10^5$	$4.0X10^5$	$1.0x10^3$	$1.2x10^3$	$3.0X10^3$
Knife	$6.6X10^5$	$3.8X10^5$	Nil	Nil	$4.0x10^3$
Table	$3.8X10^5$	$2.9X10^5$	Nil	$1.0x10^3$	$5.0x10^3$
Meat seller 5					
Apron	$3.1X10^3$	$3.0X10^3$	Nil	Nil	$1.0X10^2$
C. board	$3.7X10^5$	$2.8X10^5$	$1.4x10^3$	$1.0x10^3$	$3.6X10^3$
Hand	$5.0X10^5$	$4.0X10^5$	Nil	Nil	$4.0X10^3$
Knife	$4.2X10^5$	$3.8X10^5$	Nil	Nil	$4.0x10^3$
Table	$5.2X10^5$	$4.2X10^5$	Nil	Nil	$5.0x10^3$

Mean total THBC from the contact surfaces

The mean total heterotrophic bacteria count from the fish contact surfaces ranged from 3.85 to 5.71 $\log_{10}$ (cfu/cm^3) with swabbed from the apron having the least count and the table having the highest counts as shown in Figure 1. The mean total heterotrophic bacteria count of the meat contact surface ranged from 1.11 to 3.31 $\log_{10}$ (cfu/cm^3). Swabbed samples from the cutting boards had the lowest heterotrophic bacteria count while the tables had the highest heterotrophic bacteria count as shown in Figure 2.

Mean total *Staphylococcus* count from contact surfaces

The total staphylococcus counts for the fish contact surfaces ranged from 4.55 to 5.02 $\log_{10}$ (cfu/g), swabbed samples from the apron had the highest Staphylococcus count and the table had the lowest Staphylococcus count as shown in Figure 3. The total Staphylococcus count for the meat contact surface ranged from 3.46 to 5.47 $\log_{10}$ (cfu/cm^3), swabbed samples from the apron had the least Staphylococcus count while the table and seller hands had the highest Staphylococcus count as shown in Figure 4.

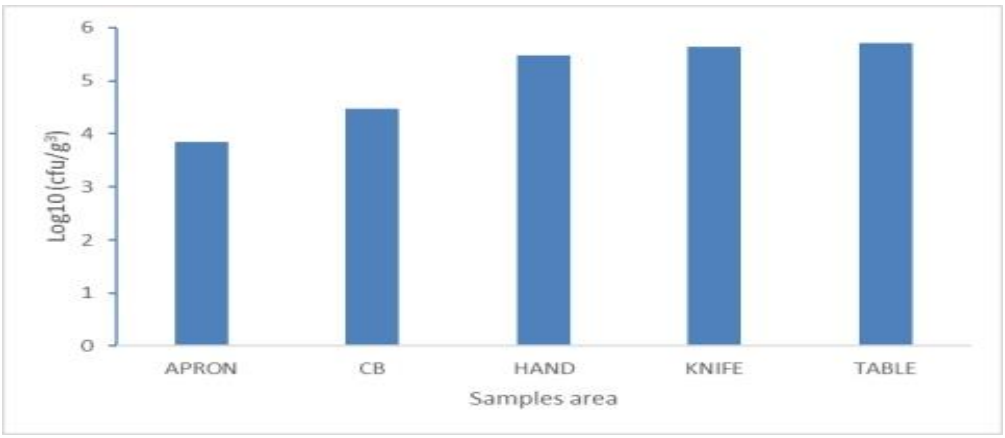

Figure 1. Mean THBC of fish contact surfaces at market.

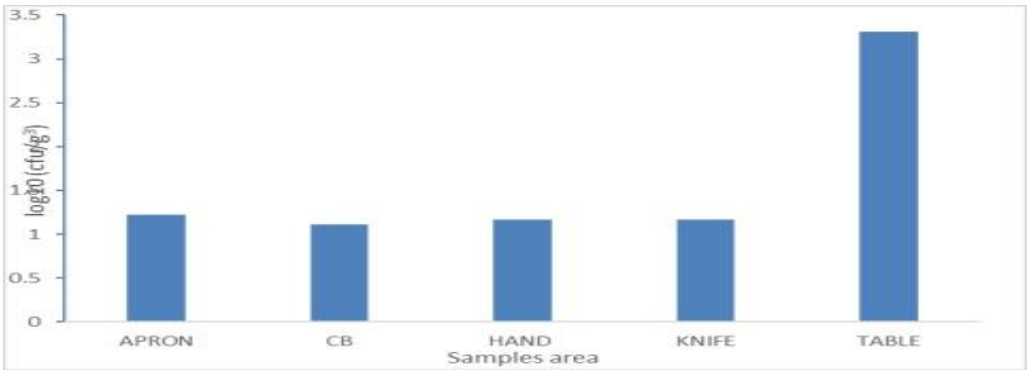

Figure 2. Mean THBC of meat contact surfaces at market.

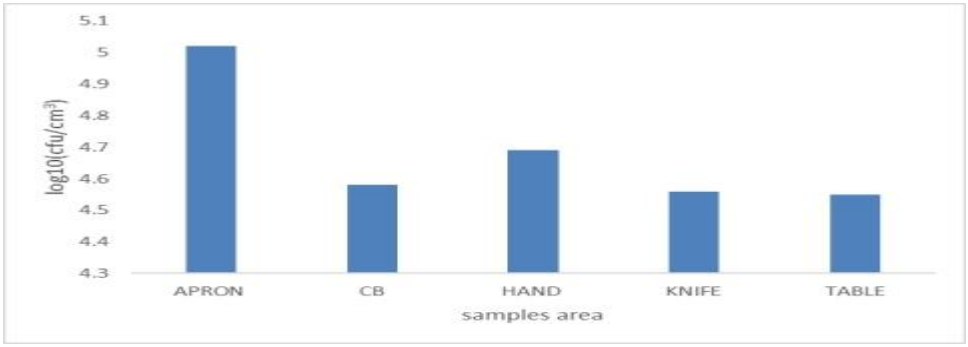

Figure 3. Mean Tstap Count of fish contact surfaces at market.

Mean total Coliform count from contact surface

The mean total coliform count from the contact surfaces for the fish contact surface ranged from 0 to 1.17log$_{10}$ (cfu/cm^3), swabbed from the apron and the seller hands had zero count while the knife samples had highest coliform count of 1.17log$_{10}$ (cfu/cm^3) as shown in Figure 5. The mean total coliform count for the meat contact surfaces ranged from 0.60 to 3.20 log$_{10}$ (cfu/cm^3). Swabbed samples from knife had the least coliform counts while the cutting board had the highest count as shown in Figure 6.

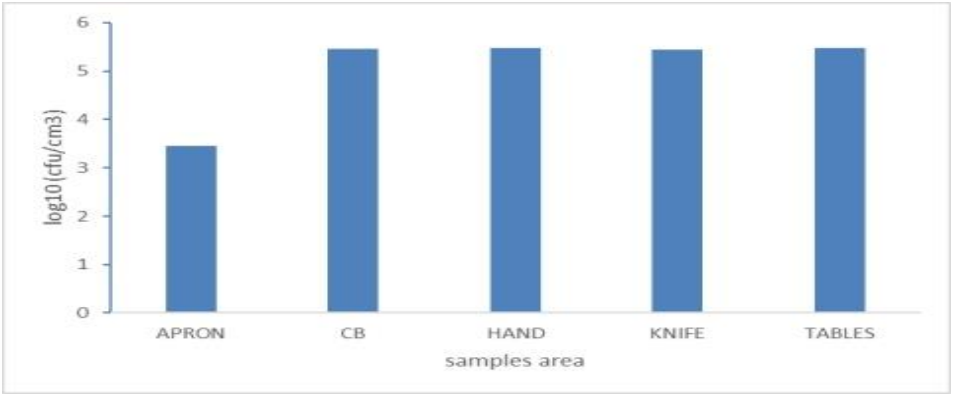

Figure 4. Mean Tstap count of meat contact surfaces at market.

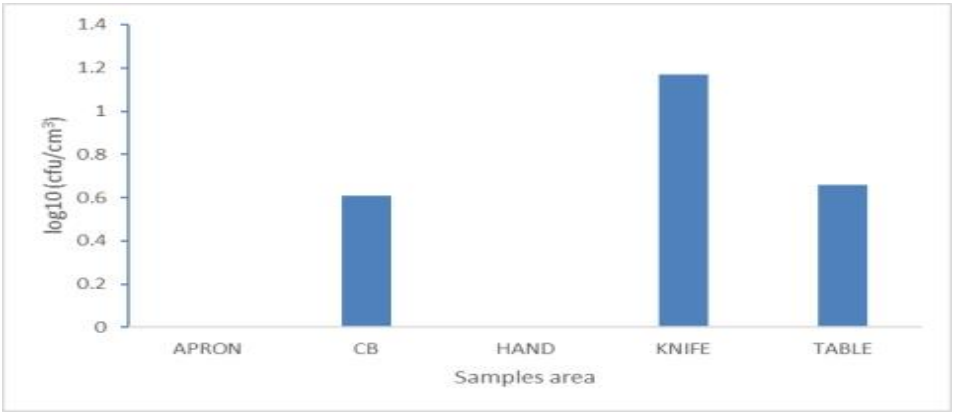

Figure 5. Mean total coliform count of fish contact surfaces at market.

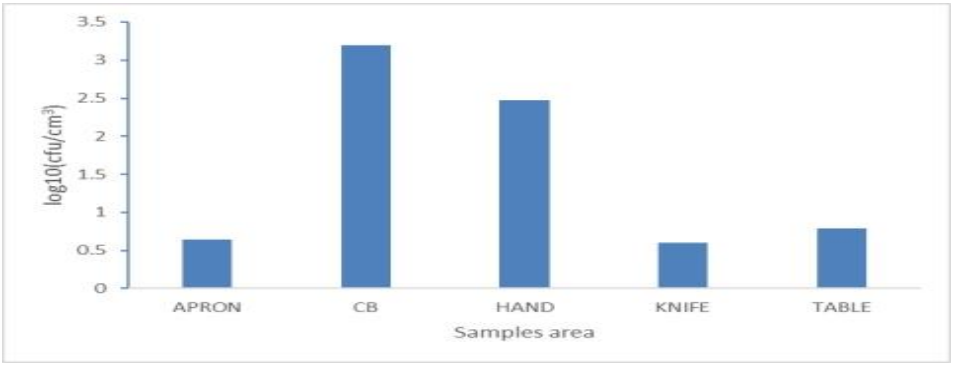

Figure 6. Mean total coliform of meat contact surfaces at market.

Mean total *Salmonella* count

The mean total *Salmonella* count for fish contact surfaces ranged from 0 to 0.55 $\log_{10}$ (cfu/cm^3). Swabbed samples from the apron had counts of 0.55 $\log_{10}$ (cfu/cm^3) which was higher than that of the swabbed samples from table, knife and cutting board as shown in Figure 7. The mean total *Salmonella* count for meat contact surface ranged from 0 to 1.24 $\log_{10}$ (cfu/cm^3), swabbed samples from the knife had low counts of Salmonella while aprons had the higher count as shown in Figure 8.

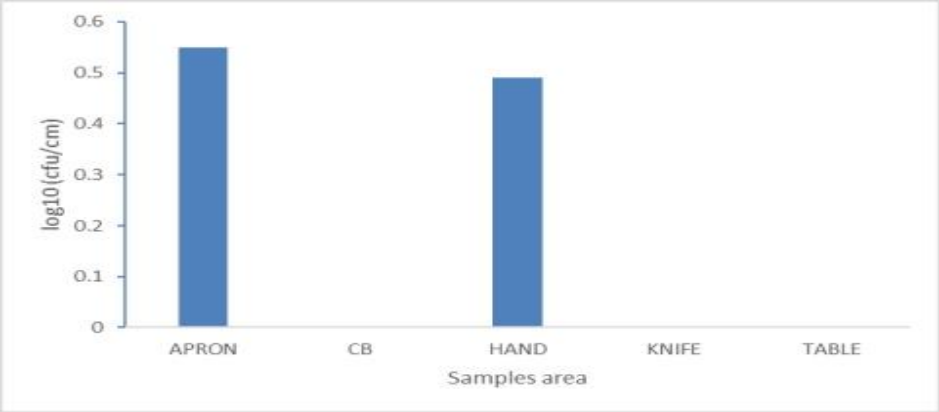

Figure 7. Mean total *Salmonella* count of fish contact surfaces at market.

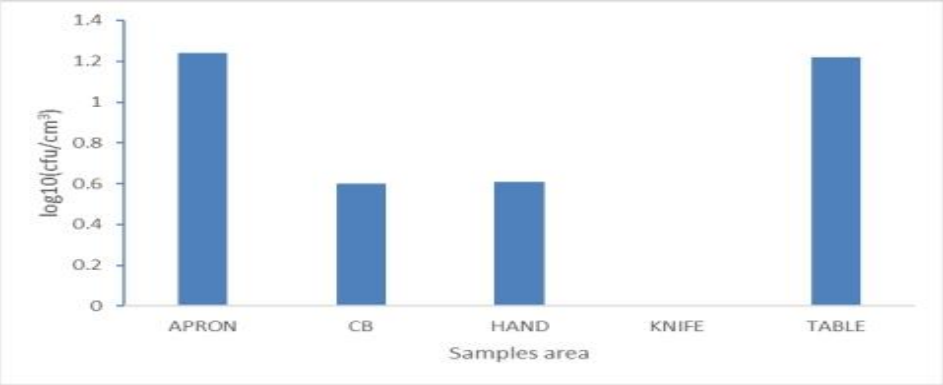

Figure 8. Mean total *Salmonella* count of meat contact surfaces at market.

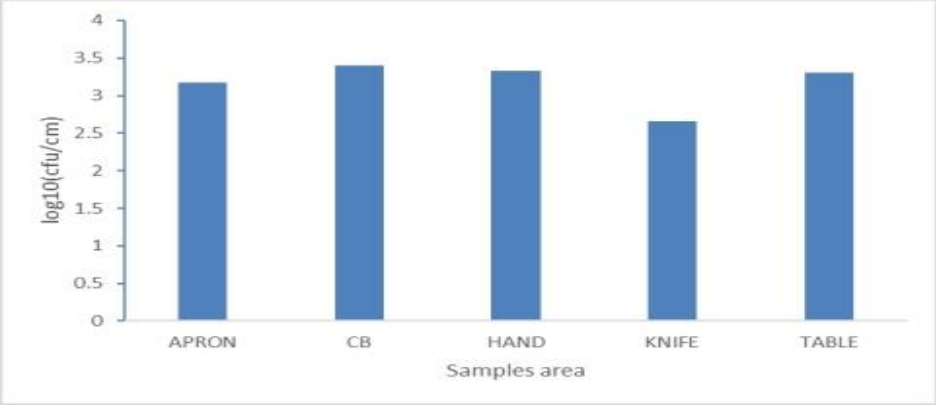

Figure 9. Mean total fungi count of fish contact surfaces at market.

Mean total fungi count (TF) from contact surfaces

Mean total fungal count of fish contact surface ranged from 2.66 to 3.40 $\log_{10}$ (cfu/cm^3). Swabbed samples from knife had the lowest fungal count which was lower than that of the swabbed samples from the sellers' hands as shown in Figure 9. The mean total fungal count from the meat contact surfaces ranged from 2.58 to 3.60 $\log_{10}$ (cfu/cm^3). Swabbed sample from the apron had the least fungal count while table has the highest count as shown in Figure 10.

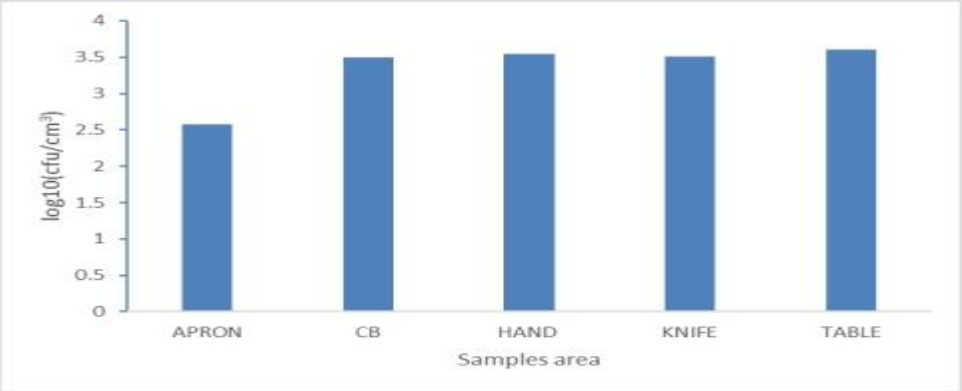

Figure 10. Mean total fungal count of meat contact surfaces at market.

Table 2. Antibiotic susceptibility of gram negative organism isolated from contact surfaces.

SN	Tentable organism	SXT (mm)	CHL (mm)	SP (mm)	CPX (mm)	AMX (mm)	AU (mm)	CN (mm)	PEF (mm)	OFX (mm)	S (mm)
1	*Citrobacter sp*	20	18	18	22	18	18	18	18	18	20
2	*E. coli*	18	24	26	30	16	14	24	30	30	30
3	*Enterobacter sp*	26	28	Nil	Nil	Nil	Nil	Nil	Nil	Nil	20
4	*Klebsiella sp*	22	18	24	28	22	Nil	20	28	28	22
5	*Proteus sp*	20	26	26	30	22	20	24	32	32	28
6	*Salmonella sp*	30	28	28	30	30	32	28	30	30	30
7	*Shigella sp*	30	28	30	30	30	30	28	28	28	30

Table 3. Antibiotic susceptibility of gram positive organism isolated from contact surfaces.

S/N	Tentable organism	PEF (mm)	CN (mm)	APX (mm)	AZ (mm)	AM (mm)	RA (mm)	CPX (mm)	S (mm)	SXT (mm)	E (mm)
1	*Bacillus sp*	22	20	18	Nil	18	Nil	20	21	20	20
2	*Staphylococcus sp*	23	22	24	16	16	20	22	18	18	22

Antibiotic susceptibility of gram negative and gram positive organism isolated from contact surfaces

Enterobacter sp was resistant to most of the antibiotics used. The gram positive and gram negative bacteria associated with the contact surfaces showed highest sensitivity to Streptomycin and Ofloxacin respectively as shown in Tables 2 and 3.

Percentage occurrence of the different organisms isolated from the different contact surfaces

Staphylococcus sp (47%) was the highest occurring organism followed by Bacillus (34%) and *E. coil* (22%) from the different contact surfaces as shown in Table 4.

DISCUSSION

Foodborne diseases are common in developing countries, especially in Africa, due to inadequate food handling and sanitation, inadequate food safety laws, weak regulatory systems, lack of funds to invest in safer equipment and lack of training for food handlers (WHO, 2014). Of the foods intended for humans, the most dangerous are foods of animal origin, unless the principles of food hygiene are followed. Animal products, such as meat, and products derived from them are generally considered high-risk commodities in terms of pathogen concentrations, natural toxins, and other potential contaminants and degraders (Yousuf *et al*., 2008). Contamination of meat and fish can be caused by contaminated surfaces and the seller's hands used during handling (Lues *et al*., 2007; Sagoo *et*

Table 4. Percentage occurrence of the different organisms isolated from the different contact surfaces.

Organisms	Apron N(%)	Cutting board N(%)	Hand N(%)	Knife N(%)	Table N(%)	Total N(%)
Staphylococcus sp	11(33.6)	11(33.6)	9(6.9)	9(6.9)	7(13.5)	47(22)
Bacillus sp	5(15.6)	6(15.7)	6(15.7)	8(14.4)	9(6.9)	34(14.4)
Salmonella sp	3(2.3)	2(4.8)	2(3.8)	1(2.9)	3(1.8)	11(4.3)
E. coli	5(3.7)	4(9.6)	4(7.8)	4(8.9)	5(11.8)	22(9.8)
Proteus sp	2(1.7)	1(4.5)	1(5.6)	3(10.0)	0(0)	7(2.7)
Enterobacter sp	0(0)	1(5.1)	1(6.7)	0(0)	0(0)	2(0.2)
Shigella sp	1(2.9)	0(0)	1(3.7)	0(0)	1(2.8)	3(0.5)
Klebsiella sp	2(4.8)	5(12.1)	3(10.0)	5(9.6)	1(4.2)	16(7.0)
Citrobacter sp	0(0)	0(0)	0(0)	0(0)	1(2.7)	1(0.5)
Total	30(100)	30(100)	30(100)	33(100)	29(100)	143(100)

al., 2013). The quality of water used in meat processing is also of great importance to reduce or increase meat contamination, as water is used to wash work surfaces, carcasses, meat blood, equipment and workers' hands. Bacterial contamination of meat products is an inevitable consequence of meat processing (Jones *et al*., 2008). The result presented in fig 1-10 showed different counts from the contact surface of fish and meat. Global standards for total viable counts on food contact surfaces includes guidelines by the US Public Health Service (maximum of 10 bacterial cells per cm^2. A study by Clayton *et al*. (2002) has concluded that time is one of the contributing factors to poor hygiene practices whereby food handlers reported that they have limited time to spend on washing their hands and the contact surfaces frequently. The degree of sanitary procedures at the numerous meat and fish booths/stands in Port Harcourt metropolis is shown by the fact that this creates a severe public health risk to the consumers of these meats and fish. High microbial counts on contact surfaces can suggest the presence of pathogens, the danger of cross-contamination, and the potential for biofilm development (Aarnisalo *et al*., 2006; Lequette *et al*., 2010). When foods come into touch with a contaminated surface, their microbiological quality may be compromised, particularly if they are eaten raw or if the heat treatment is insufficient to destroy any potential vegetative cells or bacterial toxins (Temelli *et al*., 2006; Jha *et al*., 2013). In this study, the bacteria isolated on the contacts surfaces include *Staphylococcus sp*, *Salmonella sp*, *Bacillus* sp, *E. coli*, *Proteus* sp, *Enterobacter sp*, *Shigella sp*, *Klebsiella sp*, and *Citrobacter sp*. This result corroborates with the report of Nwankiti *et al*. (2012), Orannusi *et al*. (2013), Fraser *et al*. (2014), Ayalew *et al*. (2015), Obhioze *et al*. (2019), Omorodion and Dike (2023). The isolation of *Bacillus sp* and *S. aureus* is line with the findings of Nichols *et al*. (1999), Mensah *et al*. (2002), Idowu and Rowland (2006), Taulo *et al*. (2008), Oranusi *et al.* (2013). The predominant organism is *Bacillus sp* on the surfaces could be attributed to its spore forming ability which probably caused it to be dispersed into the air and thus be able to settle on the surface of formites, though some studies have reported the persistence of non-spore formers on dry surfaces (Adegoke and Okoh, 2011).

The presence of *Staphylococcus sp* indicates the possibility of oral or nasal contamination. Isolation of *E. coli* from contact surfaces indicates fecal contamination of the hands of people who do not wash their hands properly at the market. However, the presence of *E. coli* on the table may be due to the fact that the tables are not cleaned with clean cloths and disinfectants, or they were not cleaned frequently during sales hours. Contamination of these surfaces can be caused by insufficient cleaning and disinfection of these surfaces before and after sale, as well as insufficient personal hygiene of food handlers which can lead to surface contamination and act as an intermediary of *E. coli* infection (Cosby *et al.,* 2008; Mohammed *et al.,* 2018). *Salmonella sp.* is a common contaminant in many retail environments and has public health concerns regarding potential cross-contamination of contact surfaces with meat and fish. *Salmonella sp*. spread just as easily in the home environment, where they can last up to four days. Surface-associated *Salmonella sp*. has a significant risk of cross-contamination, which means that this pathogen can multiply in conditions of mild temperature abuse of cross-contaminated foods (De Boer and Hahné 1990).

Bacterial isolates associated with contact surfaces showed varying susceptibility pattern to commercial standard antibiotics. The gram positive isolate (*Staphylococcus sp*) showed high susceptibility in Amoxicillin while *Bacillus* showed high susceptibility to Pelfloxacin. *E. coli,* the predominant gram negative isolate, showed highest sensitivity to Pelfloxacin, Ofloxacin, and Streptomycin and least sensitivity to Augmentin. The gram positive and gram negative bacteria associated with the contact surfaces showed highest sensitivity to Streptomycin and Ofloxacin, respectively. The resistance pattern of bacteria associated with contact surfaces has

been reported (Boma and Olieme, 2011; Akubuenyi *et al*., 2011; Ezeonu and Ugwu, 2011; David *et al*., 2011).

Fungi are common contaminant of fish and meat, they either cause spoilage or produce mycotoxin, making it dangerous for consumption. The result obtained in this study showed a total number of six (6) fungi and their percentage of occurrence of the different organisms isolated from the different samples (apron, cutting board, hand, knife and table) such as *Aspergillus nige*r (40.6%), *Saccharomyces sp* (13.1%), *Aspergillus flavus* (8.7%), *Aspergillus terreus* (5.4%), *Penicillium sp* (14.2%) and *Fussarium sp* (17.5%). Adams and Moss (2000) has 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 and meat handlers' character, among others. *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*., 2012a). *Aspergillus spp*. in fish and meat 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*., 2008). 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.

Conclusion

The major factors that contributed to the contamination of meat and fish were low-level awareness of hygienic practices, improper handling of fish and meat, and poor sanitation of the stalls. The meat and fish sellers should observe strict hygienic measures such as daily washing of their tables before and after sales. This should be followed by a consistent sterilization of all knives and other contact surfaces.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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