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Original Research Article

Bacteriological Qualities of Red Meat (Beef) and Meat Hygiene Practices among Meat Handlers in Aba Metropolis, Nigeria

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ABSTRACT

Poor hygiene and sanitary practices among meat handlers can lead to the contamination of meat. This contamination can occur at any point during the transportation, storage and processing of meat. This study was carried out in Aba metropolis, Southeastern Nigeria to investigate the bacteriological qualities of red meat and the meat hygiene practices of meat handlers. Seventy-two meat samples were purchased from 72 meat handlers at 4 different markets in Aba metropolis. A harmonized HACCP checklist was used to interview the 72 meat handlers. Results of laboratory analysis showed that the bacteria mean colony forming units (CFU/g) ranged from 3.23 x 10^5 to 2.13 x 10^8. *Staphylococcus* species has the greatest number of isolates with 96 (16.11%) occurrence followed closely by *Escherichia coli* with 93 (15.60%) occurrence. *Klebsiella* species had 78 (13.09%) isolates; *Campylobacter* species had 68 (11.41%) isolates; *Pseudomonas* species and *Enterococcus* species had 64 (10.74%) and 63 (10.57%) respectively. Other bacteria isolated include *Bacillus* species, 34 (5.70%); *Enterobacter* species, 30 (5.03%); *Salmonella* species, 28 (4.70%); *Shigella* species, 40 (6.71%); and *Micrococcus* species, 2 (0.34%). Out of the 72 meat handlers interviewed using the harmonized checklist, the mean percentage score for meat storage and meat transportation was 28.57% and 35.71% respectively. None of the meat handers scored above 40% in the checklist for both meat storage and meat transportation. Results from the interview also show that only 9 (11.69%) wear hand gloves; 15 (19.48%) have adequate wash-hand basins with soap and running water; 7 (9.09%) wash their hands routinely with soap and running water; and 25 (32.47%) of the meat handlers are free from skin injuries or enteric illnesses. It was recommended that meat handlers especially in developing countries need proper education and training on the meat hygiene. Regulating agencies were also advised to ensure strict compliance by meat handlers to safety standards by embarking on routine inspection at slaughter houses and market places.

Key words: Bacteria, meat hygiene, red meat, HACCP, meat handlers, sanitation

INTRODUCTION

Growth of spoilage bacteria lead to defects in the products and can be responsible for unwanted taste, color, odor or texture. [1] There are multiple spoilage mechanisms, and they can result from the production of various metabolites such as exopolysaccharides. Once bacteria contaminate meat and constitute the initial microbiota, the storage conditions and the various treatments applied shape the fate of this microbiota. The storage temperature as well as the nature and concentration of the gas used in gas mixtures for packaging are

selective for some bacterial populations. Storage at low temperature favors the growth of psychrotrophic and psychrophilic bacteria while CO_2 has an inhibitory effect on *Pseudomonas* spp. [2] Some species can survive throughout the process, such as *Shewanella putrefaciens*, frequently found on carcasses during the slaughtering process and still present after 14 days of storage under air. [3] During storage, the bacterial load increases but the microbiota diversity decreases compared with that initially present. Microbial spoilage occurs as a consequence of the growth and metabolic activities of spoiling bacteria. In most studies, [2,4,5] the bacteria that dominate spoiled food have been considered those responsible for spoilage and the criterion of microbiological acceptability (total viable counts reaching 7 log CFU/g) has been used to define spoilage.

The important contamination comes from external source during bleeding, handling and processing. During bleeding, skinning, and cutting, the main sources of microorganisms are the body parts of the animal and the intestinal tract. The contaminating bacteria on the knife soon will be found in meat in various parts of the carcass, carried by blood and lymph. The exterior of the animal harbors large numbers of microorganisms from soil, water, feed and manure, as well as its natural surface flora and the intestinal contents. Knives, cloths, air and hands, clothing of the workers can serve as an intermediate source of contaminants. [6] During handling, contamination may come from carts, boxes or other containers, from other contaminated meat from air and from personnel. Sometimes, it comes during refrigeration. The psychrotrophic bacteria may also contaminate meat. The various equipment's, grinders, sausage stuffers, casing, and ingredients in special products e.g. fillers, may add organisms on surfaces touching the meats.

Poor personal hygiene and health status of meat handlers also lead to meat contamination as found by some authors. [7,8] Pathogens from them could be transmitted to consumers through the meat. That is why it is often recommended that meat handlers who have contagious illnesses and wounds on their hands should not handle meat until they are certified to so by competent persons. In addition it is mostly recommended that they should wash their hands and wear clean clothes whenever they handle meat. Personal hygiene practices should prevent undue general contamination, and prevent cross-contamination with human pathogens that may cause food-borne disease. [8]

Persons moving from rooms or areas containing raw meat to rooms or areas used for meat preparations and manufactured meat should thoroughly wash, change and/or sanitize their protective clothing as appropriate, and otherwise limit the possibility of cross-contamination to the lowest level practicable. Persons who come into direct or indirect contact with edible parts of animals or meat in the course of their work should maintain appropriate personal cleanliness and behavior, and should not be clinically affected by communicable agents likely to be transmitted by meat. Persons who come into direct or indirect contact with edible parts of animals or meat should maintain an appropriate standard of personal cleanliness; wear protective clothing appropriate to the circumstances, and ensure that non-disposable protective clothing is cleaned before and during work. Gloves worn during the slaughter and handling of meat should be of an approved type for the particular activity and are used according to specifications. According to Okonko *et al*., [9] protective clothing must be light colored, clean, in good repair and must include safety hats, hair nets, beard nets, head and shoulder capes, white gumboots and safety boots compliant with hygiene requirements and waterproof aprons as required by the work situation. At the start of each working day or shift, the owner must provide personnel with protective clothing. The owner must ensure that such clean

protective clothing is stored and handled so that it does not make contact with private clothes and these private clothes must be kept in a locker that is reserved for that purpose only.

Personnel who handle meat must shower before assuming duties. They must wash their hands and forearms with a liquid germicidal soap and running water immediately after they become soiled or after having used a toilet or when entering a working area. Jewellery, including traditional objects, may not be worn in an area where edible products are handled. Fingernails must be short, clean and free of nail varnish. Eating, drinking or using or handling tobacco are not allowed in any area where meat is handled. All personnel must be trained in hygiene procedures and personal hygiene matters by the owner, and training records must be kept. [8]

Hazard Analysis and Critical Control Points (HACCP) is a systematic preventive approach to food safety from biological, chemical, and physical hazards in production processes that can cause the finished product to be unsafe, and designs measurements to reduce these risks to a safe level. [10] HACCP is designed for use in all segments of the food industry from growing, harvesting, processing, manufacturing, distributing, and merchandising to preparing food for consumption. Meat safety systems based on the HACCP principles have been successfully applied in meat processing plants, retail food stores, and food service operations. [11] The format for a HACCP plan varies according to the product and process. The first task in developing a HACCP plan is to assemble a HACCP team consisting of individuals who have specific knowledge and expertise appropriate to the product and process. It is the team's responsibility to develop the HACCP plan. The team should be multi-disciplinary and include individuals from areas such as engineering, production, sanitation, quality assurance, and food microbiology. Critical control points are set in a HACCP checklist and these are steps at which control can be applied to prevent or eliminate a meat safety hazard or reduce it to an acceptable level. [12] Critical limits are given for each control measure and total points can be recorded in percentage value.

This study reports on the microbiological quality of red meat sold in Aba, Abia State. The study also highlighted on bacterial load and diversities spread across the markets and slaughter houses in Aba metropolis, Southeastern Nigeria.

MATERIALS AND METHODS

Sample Collection

Seventy-two meat samples were purchased from seventy-two meat handlers in 4 different markets located in Aba metropolis in Southeastern part of Nigeria. A harmonized HACCP checklist was used to interview the 72 meat handlers. The harmonized checklist included information on the demographic profile of the meat handlers, information on the transportation, storage, personal hygiene of meat handlers and sanitation of the markets and slaughter houses. The temperature of the meat samples were taken with a digital meat thermometer. The meat samples were collected in sterile containers and transported in ice packed cooler to the laboratory at the College of Medicine and Health Sciences, Abia State University located in Aba, Nigeria. Samples were also taken from the water source and contact surfaces of the meat handlers which included tables, knives and hands.

Preparation of Media and Diluents

All bacteriological media (Nutrient agar, Salmonella Shigella Agar, Mannitol Salt Agar, Campylobacter Blood Free Agar, Eosin Methylene Blue Agar and MacConkey Agar) were prepared according to manufacturer's specification. Nutrient agar was used in the isolation of heterotrophic bacteria, MacConkey Agar for faecal coliform bacteria, Eosin Methylene Blue Agar for *Escherichia coli*, Campylobacter Agar for *Campylobacter* species, Mannitol Salt Agar strictly for

Staphylococcus aureus and Salmonella Shigella Agar for the isolation of Salmonella and Shigella species. [13]

Physiological saline used as diluents was prepared by dissolving 9.8 g of sodium chloride in 1000ml of distilled and dispensed in 90 ml and 9ml portions. Both diluents and media were sterilized in an autoclave at 121^0C for 15 minutes.

Preparation of Samples and Inoculation

Ten grams of meat sample was macerated in a sterile laboratory blender containing 90 ml of sterile physiological saline. Ten-fold dilution method was used by transferring 1 ml from each tube until the required dilution was obtained. Aliquot portion (0.1ml) of appropriate dilution was inoculated into the pre-sterilized and surface dried medium. Inocula were spread evenly to ensure uniform and countable colonies. Plates were incubated at 28^oC for 48 hours for heterotrophic bacteria. Colony counts obtained on the media were expressed as colony forming units per gram (CFU/g) to obtain total population.

Characterization and Identification of Microbial Isolates

Microbial isolates were characterized based on cultural (colonial), microscopic and biochemical methods with reference to standard manuals. The identities of the isolates were cross-matched with reference to standard manuals for the identification of bacteria. [13]

Microorganisms that were not identified by the colonial and microscopic characteristics were further subjected to few biochemical tests.

RESULTS

Seventy-two meat samples from 4 markets in Aba metropolis, Southeast Nigeria were taken to the laboratory for analysis. Results in Table 1 show that with Eosin Methylene Blue Agar, meat samples from Afor-Ule market had the highest bacteria mean colony forming unit (CFU) of 3.11×10^6. With the Mannitol salt Agar, MacConkey Agar and Campylobacter Blood Free Agar, the highest mean colony forming unit was also from Afor-Ule market with 1.52×10^6, 2.13×10^8 and 2.80×10^6 respectively. However, with the Nutrient Agar and Salmonella-Shigella Agar, meat samples from the Waterside slaughter market showed the highest mean colony forming units with 1.77×10^8 and 1.05×10^6 respectively. Table 2 show the bacteria mean colony forming units of contact surfaces. With all the different media used, the highest mean colony forming units were seen in samples obtained from the tables. Mean colony forming units with Eosin Methylene Blue Agar was 1.73×10^6; 1.23×10^6 with Mannitol salt Agar; 7.47×10^7 with Nutrient Agar; 4.43×10^6 with Salmonella-Shigella Agar; 5.15×10^7 with MacConkey Agar; and1.16×10^6 with Campylobacter Blood Free Agar.

Table 1: Bacteria mean Colony Forming Units (CFU/g) of meat samples with different media

Market	EMBA	MSA	NA	SSA	MCA	CAM
Nkwo	9.22×10^5	3.94×10^5	1.13×10^8	3.23×10^5	5.50×10^7	5.12×10^5
Umungasi	6.55×10^5	8.80×10^5	7.28×10^7	4.12×10^5	3.53×10^7	1.05×10^6
Waterside	1.72×10^6	1.21×10^6	1.77×10^8	1.05×10^6	1.85×10^8	1.56×10^6
Afor-Ule	3.11×10^6	1.52×10^6	8.67×10^5	8.67×10^5	2.13×10^8	2.80×10^6

EMBA- Eosin Methylene Blue Agar; SSA- Salmonella-Shigella Agar; MSA- Mannitol Salt Agar; NA- Nutrient Agar; CAM- Campylobacter Blood Free Agar; MCA- MacConkey Agar

Table 2: Bacteria mean Colony Forming Units (CFU/g) of contact surfaces with different media

Contact Surface	EMBA	MSA	NA	SSA	MCA	CAM
Tables	1.73×10^6	1.23×10^6	7.47×10^7	4.43×10^6	5.15×10^7	1.16×10^6
Hands	1.60×10^5	4.60×10^5	1.41×10^7	6.00×10^4	5.80×10^6	7.33×10^4
Knives	3.05×10^6	8.97×10^5	1.98×10^7	2.00×10^4	6.56×10^6	2.00×10^4

EMBA- Eosin Methylene Blue Agar; SSA- Salmonella-Shigella Agar; MSA- Mannitol Salt Agar; NA- Nutrient Agar; CAM- Campylobacter Blood Free Agar; MCA- MacConkey Agar

Table 3 shows the colonial and microscopic characteristics of bacteria isolated from meat samples. The biochemical characteristics and

carbohydrate fermentation of bacterial isolates are shown in Table 4. Three gram positive bacteria namely, *Staphylococcus aureus, Enterococcus faecalis* and *Bacillus subtilis* and seven gram negative bacteria, namely, *Escherichia coli, Klebsiella pneumoniae, Shigella dysenteriae, Enterobacter cloacae, Pseudomonas aeruginosa, Campylobacter jejuni and Salmonella enteritidis* were isolated from the meat samples and contact surface.

Table 3: Colonial and Microscopic Characteristics of Bacteria isolated from meat samples

Colonial Characteristics	MT	SF	CF	Gram morphology/reaction	Probable Identity
Circular moist and shiny golden yellow colonies on Nutrient Agar and light yellow on Mannitol Salt Agar	-	-	-	Gram positive cocci predominantly in clusters, few in tetrads and pairs	*Staphylococcus* sp
Large slimy mucoid colonies on Eosin Methylene Blue Agar	+	-	+	Gram negative short thick rods in chains	*Klebsiella* sp
Small circular moist and shiny low convex cream colonies on Nutrient Agar	-	-	-	Gram positive cocci predominantly in chains and pairs	*Enterococcus* sp
Grayish white colonies on Campylobacter Blood Free Agar	+	-	-	Gram negative short slender rods	*Campylobacter* sp
Light pink mucoid moist and shiny colonies on Salmonella Shigella Agar	+	+	-	Gram negative single and short rods	*Shigella* sp
Serrated dull and dry flat cream colonies on Nutrient Agar				Large gram positive rods with central spores	*Bacillus* sp
Greenish metallic sheen on Eosin Methylene Blue Agar	+	-	-	Gram negative rods predominantly in single and pairs	*Escherichia coli*
Circular moist and shiny cream colonies on nutrient Agar and Mannitol Salt Agar	-	-	-	Gram positive cocci in clusters, few in pairs	*Staphylococcus* sp
Small moist and shiny red colonies on Campylobacter Blood Free Agar	+	-	-	Gram negative short slender rods	*Campylobacter* sp
Cream moist and slimy cream colonies on Nutrient Agar	+	+	-	Large gram positive rods with central spores in chains	*Bacillus* sp
Small shiny black fish eye colonies on Salmonella Shigella Agar	+	-	-	Gram negative short rods in single	*Salmonella* sp
Bluish green moist colonies on Nutrient Agar	+	-	-	Gram negative slightly curves rods	*Pseudomonas* sp
Dull and dry medusa head shape cream colonies	-	+	-	Gram positive rods in short chains	*Bacillus*sp
Small smooth moist and shiny low convex yellow colonies	-	-	-	Cocci predominantly in tetrads and few in pairs and irregular	*Micrococcus* sp
Orange moist and shiny colonies	-	-	-	Cocci predominantly in tetrads and few in pairs and irregular	*Micrococcus* sp

MT – Motility Test; SP – Spore Formation; CP – Capsule Formation

Table 4: Biochemical characteristics and carbohydrate fermentation of bacterial isolates

Cat	Oxi	Coag	IN	VP	Cit	NO_3	Ure	G	S	L	M	Mn	Xyl	Ara	MR	Identity of Isolates
+	-	+	-	+	-	+	+	+	+	+	+	+	-	-	-	*Staphylococcus aureus*
+	-	-	-	+	+	+	+	+	+	+	+	+	+	+	-	*Klebsiella pneumonia*
-	-	-	-	-	+	+	-	+	+	+	=	+	-	+	-	*Enterococcus faecalis*
																Campylobacter jejuni
-	-	-	-	-	+	+	=	-	-	-	+	-	-	+	+	*Shigella dysenteriae*
+	-	-	-	+	+	+	-	+	-	-	-	-	-	-	-	*Bacillus cereus*
+	-	-	+	-	-	+	-	+	+	+	+	+	+	+	-	*Escherichia coli*
=	-	-	-	+	-	+	-	+	+	-	+	+	+	+		*Staphylococcus saprophyticus*
																Campylobacter coli
+	-	-	-	+	+	+	-	+	-	-	-	+	+	+	-	*Bacillus subtilis*
+	-	-	-	-	+	+	-	+	-	-	+	+	+	+	+	*Salmonella enteritidis*
+	+	-	-	-	+	+	+	+	-	-	-	+	+	+	+	*Pseudomonas aeruginosa*
+	-	-	-	+	+	+	-	+	-	-	-	-	+	+	-	*Bacillus licheniformis*
+	-	-	-	-	+	-	+	-	-	-	-	-	-	-	+	*Micrococcus luteus*
+	-	-	-	-	+	+	-	+	+	-	-	-	-	-	+	*Micrococcus roseus*

Cat- Catalase; Oxi- Oxidase; Coag- Coagulase; In- Indole; VP- VogesProskaeur; MR- Methyl Red; Cit- Citrate; NO_3- Nitrate reduction; Ure- Urease; G- Glucose; S- Sucrose; L- Lactose; M- Maltose; Mn- Mannitol ; Ara- Arabinose; Xyl- Xylose

The distribution of the bacterial isolates is shown in Table 5. *Staphylococcus aureus* has the greatest number of isolates with 96 (16.11%) occurrence followed closely by *Escherichia coli* with 93 (15.60%) occurrence. *Klebsiella pneumoniae* had 78 (13.09%) isolates; *Campylobacter* species had 68 (11.41%) isolates; *Pseudomonas aeruginosa* and *Enterococcus faecalis* had 64 (10.74%) and 63 (10.57%) respectively.

Table 5: Distribution of bacterial isolates from meat samples

Bacterial Isolates	Number of Isolates	Percentage (%)
Staphylococcus species	96	16.11
Micrococcus species	2	0.34
Bacillus species	34	5.70
Enterococcus species	63	10.57
Pseudomonas species	64	10.74
Escherichia coli	93	15.60
Klebsiella species	78	13.09
Enterobacter species	30	5.03
Salmonella species	28	4.70
Shigella species	40	6.71
Campylobacter species	68	11.41
Total	596	100.00

Table 6 shows the percentage score distributions of the meat handlers on meat storage and meat transportation. The mean percentage score for meat storage and meat transportation was 28.57% and 35.71% respectively. From the Table, 31 (43.06%) had a score between 0-20% and 41 (56.94%) had a score between 21-40% for meat storage while 32 (44.44%) had a score between 0-20% and 40 (55.56%) had a score between 21-40% for meat transportation. None of the meat handlers scored above 40% for meat storage and meat transportation. Specific questions and observations about their personal hygiene revealed that only 11 (15.28%) wore proper clothing such as aprons and hair restraints when handling meat. This is shown in Table 7. The Table also show that 25 (34.72%) limit their jewelries to wrist watch and plain rings; 8 (11.11%) wear hand gloves; 12 (16.67%) have adequate wash-hand basins with soap and running water; 9 (12.50%) wash their hands routinely with soap and running water; and 22 (30.56%) of the meat handlers are free from skin injuries or enteric illnesses. The Table also shows information on cleanliness and sanitation of the meat handlers. Only 4 (5.56%) have clean work tables and work surfaces; 10 (13.89%) clean their knives and cutting boards between uses; 14 (19.44%) store cleaning chemicals away in their own store; 11 (15.28%) wash their mops after use and 10 (13.89%) clean their buckets after use and invert them to drain.

Table 6: Distribution of percentage scores for meat storage and transportation using HACCP Checklist

HACCP Score (%)	Meat Storage n (%)	Meat Transportation n (%)
0 – 20	31(43.06)	32(44.44)
21 – 40	41(56.94)	40(55.56)
41 – 60	0(0.00)	0(0.00)
61 – 80	0(0.00)	0(0.00)
81 – 100	0(0.00)	0(0.00)
TOTAL	72(100.00)	72(100.00)

Table 7: Personal Hygiene and Sanitation Practices of Meat Handlers

Criteria for Control	YES		NO	
Personal Hygiene	F	(%)	F	(%)
Meat handler wear proper clothing – clean uniforms/aprons and hair restraints.	11	15.28	61	84.72
Jewellery is limited to wristwatch and plain ring.	25	34.72	47	65.28
Wearing of hand gloves and changed at necessary intervals.	8	11.11	64	88.89
Adequate wash-hand basins with soap and running water are available	12	16.67	60	83.33
Hands are washed routinely and thoroughly with soap and clean water	9	12.50	63	87.50
Meat handlers are free from skin/enteric illnesses and injuries.	22	30.56	50	69.44
Cleaning and Sanitation				
Worktables and work surfaces are clean and sanitized between operations.	4	5.56	68	94.44
Small equipment and utensils including cutting boards, knives, etc. are thoroughly cleaned between uses and sanitized.	10	13.89	62	86.11
Cleaning chemicals and equipment are stored properly away in their own store	14	19.44	58	80.56
Mops are washed after use and stored head up.	11	15.28	61	84.72
Buckets are cleaned after use and inverted to drain.	10	13.89	62	86.11

DISCUSSION

The high bacterial load observed in the meat samples could indicate that the carcasses may have been contaminated during the processes of transportation, storage or cutting of meat. Butchers and meat handlers in developing countries do not observe meat safety standards and rather operate at their own convenience. This study revealed that meat was transported in personal motor vehicles or taxi cabs from the slaughter house to the various markets where they were being sold to the public. These vehicles are unsanitized and could pose a source of contamination of the meat carcasses. Lack of adequate storage

facilities were also observed at the markets and slaughter houses. Most of the meat vendors do not have freezers or refrigerators for proper storage of meat. Studies on meat storage [14-16] have showed an increased microbial load in meat among meat vendors who do not have adequate storage facilities. Eneji, *et al*. [17] reported that frozen meat samples had less bacterial load than fresh samples and refrigerated samples.

The water supply for the washing and cleaning of the meat and equipment could be another possible source of contamination. Most of the markets do not have any visible source of running water and meat vendors have to make their own arrangements for water of which the sources are not in conformity with acceptable standards. Some get their water supply from nearby streams exposed to domestic, recreational and anthropogenic activities.

Meat hygiene practices among the meat handlers were similar in all the 4 markets visited in this study. Practically all the meat handlers interviewed were not aware and did not measure up to the hygiene standards. [10] This reflected in the very poor overall scores on the HACCP checklist. No percentage score was above 40% and this showed that they all failed to meet the basic requirement for meat safety. Iro, *et al.* [18] carried out a similar study in Southeastern Nigeria and reported a percentage score of less than 50% for all 417 meat handlers that were interviewed. Oloruntoba, *et al.* [19] sought to assess the compliance of abattoirs in Ibadan, Southwest Nigeria with standards set by Federal Ministry of Environment, Nigeria. From his study 12 abattoirs in Ibadan metropolis, Southwest Nigeria, only one (8.3%) had potable water supply and a functional drainage system. This is similar to was observed in this study. Proper hand washing practice with soap and potable water is lacking among the meat handlers. The spirit of cleanliness and proper sanitary practices is something they are yet to embrace. Other studies [7, 20-22] on meat hygiene also reiterated the lack of awareness of meat handlers on safety guidelines and the poor sanitary and personal hygiene practices of the meat handlers.

Poor meat hygiene and sanitary practices will inevitably lead to the contamination of meat. Table 3 shows that *Staphylococcus* species, *Escherichia coli*, *Klebsiella* species, *Campylobacter* species, *Pseudomonas* species, *Salmonella* species, *Shigella* species and *Enterococcus* species are among the most common isolated bacterial organisms in red meat. Mgbemena *et al.* [23] also found *Staphylococcus aureus, Salmonella species, Shigella species, Pseudomonas aeruginosa*, and *Escherichia coli* showing the highest occurrence in their study of fresh meat marketed in Owerri, Southeast Nigeria. Other studies [24-26] on red meat also found similar microorganisms and they linked the high bacterial load to unhygienic and poor sanitary conditions. *Staphylococcus* species are common as part of the normal flora of individuals and its high level of occurrence is indicative of contamination from the meat handlers. Their poor personal hygiene with specific regard to poor hand washing practices during handling of meat can be attributed as a contamination source. *Escherichia coli* on the other hand is an enteric organism and its high occurrence is an indication of fecal contamination of the meat. This can be attributed to contaminated water supply used for processing the meat or contamination from flies.

CONCLUSION

There was a high bacteriological load found in meat samples and contact surfaces of meat handlers. Irrespective of the presence of these microorganisms, it is believed that cooking processes will greatly reduce the microbial load to a harmless level before consumption. [27] It is therefore very important that red meat must be thoroughly cooked before consumption as these microorganisms pose serious health risks to the individual. The meat handlers were found to have little knowledge and awareness of meat hygiene standards. Meat handlers especially in developing countries

need proper education and training on the meat hygiene.

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