

BACTERIOLOGICAL ANALYSIS OF RAW MUTTON RETAILED IN SELECTED OPEN MARKETS IN KAURA NAMODA, ZAMFARA STATE

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Abstract

*Meat is an important source of proteins, vitamins and minerals needed for growth and development of the body. Conversely, raw mutton can offer favorable conditions for the survival and growth of potentially pathogenic bacteria. Contaminated raw meat is an important potential source of foodborne infections. The objective of this study was to analyze the bacteriological quality of raw mutton sold in selected open markets at Kaura Namoda, Zamfara State. Five samples of mutton were aseptically collected from each of the 5 selected retail location units which comprises Central Market, Birnin Magaji Road, Akada, Federal Low Cost and Kofar Zurmi location units and transported to Microbiology Laboratory of the Federal Polytechnic Kaura Namoda, Zamfara State for analysis. The mutton samples were examined for bacterial contamination using conventional microbiological methods. Kirby-Bauer multi-disc diffusion method was used for testing antibiotic susceptibility. The total viable heterotrophic bacterial (TVHB) counts varied from 2.0×10^6 to 5.7×10^6 CFU/g across the sampled locations which indicated no significant differences ($P < 0.05$) between the TVHB of the fresh meat samples collected from the numerous retail locations units. *Staphylococcus aureus* appeared to be the most frequently isolated bacteria (33.33%), followed by *Micrococcus spp.* (23.80%), *Escherichia coli* (19.05%) and *Enterococcus spp.* (14.28%). *Enterococcus spp.* were resistant to all antibiotics used in this*

investigation, Staphylococcus aureus remained fully susceptible to them all. The existence of Escherichia coli, Staphylococcus aureus, Micrococcus spp., Streptococcus sp. and Enterococcus sp. indicated poor hygienic standards, such as inadequate infrastructure, unsanitary animals, and improper handling techniques, are frequently found in abattoirs and meat processing plants, which contribute to high bacterial loads in meat.

Keywords: Raw mutton, Bacteriological analysis, Antimicrobial sensitivity, Open market and Retailed meat.

Introduction

Meat is a vital constituent of human diet because it offers high quality protein composed of essential vitamins and mineral needed for growth, repair of damaged tissues, and normal physiological functions (Hocquette *et al.*, 2018; Zerabruk *et al.*, 2019; Orpin *et al.*, 2018). Meat is widely consumed in Nigeria and represents an important source of animal protein in different parts of the country. Its nutritional value makes it a significant constituent of diets, especially where sufficient dietary protein is required. However, the nutrient-rich nature of the meat promote the growth of bacteria, yeast and molds when appropriate environmental conditions are available (Opara and Omeje, 2024). Meat is defined as the flesh of animals suitable for human intake (Wasley, 2018). Animals produced different varieties of meats comprising mutton, poultry meat and beef. Because meat contains, moisture, nutrients, and other conditions that support microbial growth, it can provide a suitable environment for a wide range of microorganisms (Adu-Gyamfi *et al.*, 2012; Falegan *et al.*, 2017). The comparatively high levels of protein, moisture contents, vitamins, and minerals in meat can as a result encourage microbial establishment, resulting in deterioration and probable contamination of meat products (Bryant *et al.*, 2014). With 75% water content, fresh meat are among the most perishable food (Friis, 2007). Meat is considered as one of the perishable foods, making it an ideal habitat for the growth of microorganisms due to high protein, water content, pH and intrinsic chemical and enzymatic

activities (Lulietto *et al.*, 2015; Doulgeraki *et al.*, 2012).

Raw meat may possibly harbor microorganisms, comprising pathogenic bacteria capable of causing illness and posing risks to food safety. Certain microorganisms can cause diseases either through direct contamination or through the production of toxins. They can usually be removed by standard cooking conditions, even though they cannot be seen with the naked eye or smelled on the meat (Moshood *et al.*, 2012). Contamination may occur at several points along the meat-handling chain, including slaughter, dressing, cutting, processing and retail handling. Bacteria originating from the animals skin or gastrointestinal tract may be transferred to meat during these activities (Kadariya, Smith, and Thapaliya, 2014). Inadequate temperature control during storage and refrigeration can further promote microbial survival and increase the risk of contamination (Larsson and Orsini, 2013; Rani *et al.*, 2017; Azuamah *et al.*, 2018). The increased risk of foodborne illnesses connected to contaminated meat makes the microbiological assessment of pathogenic microorganisms in raw meat crucial. The microbiological quality of meat is therefore an important food-safety concern. Raw and processed meat may harbor organisms such as *Salmonella*, *Staphylococcus*, *Campylobacter*, and *Escherichia coli*, *Enterobacter*, *Micrococcus*, *Bacillus* and *Clostridium spp.* (Wolk, 2016; Iwuagwu *et al.*, 2023). Certain organisms contribute mostly to spoilage however, others are connected with foodborne illness. Poor personnel hygiene during slaughter, transportation and storage increase the microbial flora of meat and the contact surface (Rani *et al.*, 2017; Ibrahim, 2021; Iwuagwu *et al.*, 2023; Tesson *et al.*, 2020). Subsequently, observing the bacteriological quality of meat sold to customers is significant for identifying possible risks and informing the proper food-safety practices. This present study assessed the bacteriological quality of raw mutton retailed in some selected open markets in Kaura Namoda, Zamfara State.

Statement of the problem

Raw mutton is a vital source of protein, due to its high moisture and

nutrient content make it suitable medium for the growth, survival and replication of microorganisms particularly bacteria. During slaughter, transport, handling, storage and retailing meat may become contaminated through contact with contaminated surfaces, water, insects, and dust and meat handlers. However, in Kaura Namoda raw mutton is frequently retailed in open-markets areas where poor hygiene, exposure to dust insufficient storage facilities, and improper handling could increase the risk of bacterial contamination. Contamination is significant from a public-health concern since raw meat could harbor possibly bacterial pathogen, comprising *E. coli* and *S. aureus* which cause food-borne diseases. The present study therefore, identified the need to assess the bacteriological quality of raw mutton available to consumers in some selected retail location units in Kaura Namoda, Zamfara State.

Objectives of the Study

The objectives are to :

1. evaluate the bacterial load of raw mutton samples obtained from selected open markets in Kaura Namoda.
2. isolate and identify the bacterial species associated with raw mutton samples in the selected open markets using Gram-staining and biochemical test.
3. determine the frequency and percentage of occurrence of the bacterial isolate identified from raw mutton samples.
4. evaluate the antibiotic susceptibility testing and resistance pattern of the bacterial isolates against some selected antibiotics.

Research Questions

1. What is the bacterial load of raw mutton samples in the selected open markets in Kaura Namoda?
2. What bacterial species are present in raw mutton retailed in the selected location units?
3. What is the frequency and percentage of occurrence of each bacterial isolate identified from raw mutton samples?
4. What are the antibiotic susceptibility patterns of the bacterial isolates obtained from the raw mutton samples.

Methodology

This was a descriptive cross-sectional survey of retail mutton in some open markets at Kaura Namoda, Zamfara State. Five (5) different mutton samples were carefully collected from five (5) different retail places which comprise Central market unit, Birnin Magaji Road unit, Akada unit, and Federal Low Cost unit and Kofar Zurmi unit. To avoid cross-contamination, samples were collected under sterile conditions into distinct sterile plastic bags and swiftly placed into ice-packed cool container and transported to Microbiology laboratory of the Federal Polytechnic Kaura Namoda, Zamfara State.

Sample Preparation

For the preparation of samples, 1 g of each mutton samples was aseptically transferred into a sterile container containing 9 mL of normal saline and homogenized for 15 seconds. One (1 mL) aliquot of homogenate was then transferred into another 9 mL of distilled water to obtain a 10^{-1} dilution. Serial dilutions were subsequently prepared up to 10^{-7} for bacteriological analysis (Oso and Fawale, 2001).

Identification of Bacterial Isolates

The total viable plate count of bacteria (TVC), 0.1 ml of 10^{-6} dilution was achieved and inoculated using sterile Petri dish along with 25 ml of sterilized solidified Nutrient Agar to culture these microorganisms, Mannitol Salt Agar for the culturing of harmful *Staphylococci*, and Eosin methylene blue agar (EMB) for the detection of coliform bacteria. The inoculum was then distributed evenly using a flame-tipped bent rod and incubated at 37°C for 24 to 28 h. The quantity of live bacterial cells in meat samples was evaluated and described as colony forming units (CFU/mL). The numerous isolates were exposed to the standard Gram's staining process and additional confirmation of bacterial isolates was attained using biochemical tests that comprising Catalase, Citrate utilization, Urease test, Indole test and Coagulase test to allow genuine confirmation of the recognized bacteria isolated from the different mutton samples as described by Cheesbrough (2010).

Antibiotic Susceptibility Testing

In agreement with Cheesbrough (2010) and in accordance with the procedures of the National Committee for Clinical Laboratory Standards (NCCLS, 2018) and the Clinical and Laboratory Standards Institute (CLSI, 2020) disc diffusion technique was employed to carry out this test. By means of a sterile wire loop, microorganisms were extracted and inoculated in normal saline. Colonies from 24 hour culture plates were inoculated into nutrient broth. A homogeneous inoculum corresponding to 0.5 McFarland turbidity was arranged from 24-h old cultures. With sterilized cotton swabs, the test organism was spread across the surface of Muller-Hinton agar plate. With a sterile forceps, the discs loaded with commercially accessible antibiotics were steadfastly deposited on plates in an aseptic method. The inoculated plates were incubated for 24 hour at 37°C . Consequently, the zones of inhibition were enumerated in millimeters. Antibiotics used and their zones of sensitivity were measured by means of Vernier caliper and categorized according to sensitive, intermediate, or resistant (Mirzarazi *et al.*, 2013). The inoculated plates were air dried, and antibiotic discs were placed on Mueller-Hinton agar using sterile forceps and gently pressed down to ensure contact. The following seven (7) antibiotics were used: Ciproflox (CPX 10 mg), Augmentin (AU 30 mg), Gentamycin (CN 10 mg), Streptomycin (S 30 mg), Ceftiofur (CEF 10 mg), Nalidixic Acid (NA 30 mg) and Septrin (SXT 30 mg).

Statistical analysis of Data

The data were analyzed using descriptive statistics was used to determine the frequency of occurrence of bacterial isolates. Microbial loads of raw mutton samples were expressed as means $\pm$ standard deviations.

Results

The variation in bacterial loads among the 5 retail locations (Table 1 and 2). Central Market recorded the highest bacterial count 5.7×10^{-7} CFU/g, however, the lowest bacterial counts was observed in some samples from Akada and Zurmi (2.0×10^{-6} CFU/g). The results

indicated that differences in microbial load of raw mutton across the sampled retail units.

Table 1:
Total viable heterotrophic bacterial counts from raw mutton samples from different retail locations.

Total viable heterotrophic bacteria count (CFU/g) (Mean ± SD) (mm)					
Sampling unit	Central market unit	Birnin magaji road unit	Akada unit	Federal Low Cost unit	Kofar Zurmi unit
1.	5.1 x 10 ⁶ ±1.07	4.3 x 10 ⁶ ±0.69	3.0 x 10 ⁶ ±0.51	4.0x10 ⁶ ±0.62	2.0 x 10 ⁶ ±0.45
2.	5.7 x 10 ⁶ ±1.13	5.0 x 10 ⁶ ±1.05	2.0 x 10 ⁶ ±0.45	4.0x10 ⁶ ±0.62	2.1 x 10 ⁶ ±0.44
3.	5.2 x 10 ⁶ ±0.94	4.7 x 10 ⁶ ±0.96	4.1 x 10 ⁶ ±0.61	4.0 x10 ⁶ ±0.62	2.0 x 10 ⁶ ±0.45
4.	4.8 x 10 ⁶ ±0.99	5.1 x 10 ⁶ ±1.07	5.1 x 10 ⁶ ±1.07	5.9 x 10 ⁶ ±1.1	2.0 x 10 ⁶ ±0.45
5.	4.6 x 10 ⁶ ±0.73	3.9 x10 ⁶ ± 0.55	4.2 x 10 ⁶ ±0.65	5.0 x 10 ⁶ ±1.05	3.8 x 10 ⁶ ±0.55

The results were expressed as mean ± SD of triplicates

Table 2:
Microbial counts of raw mutton on the selective media for bacterial groups (CFU/g) (Mean ± SD) (mm)

Bacteria	Central market unit	Birnin magaji road unit	Akada unit	Federal Low Cost unit	Kofar Zurmi unit
Total Coliform	5±1.40	4.15±1.1	6.21±1.2	4.25±1.1	5.21±1.2
Total viable heterotrophic bacteria	6.25±0.91	4.25±0.3	2.25±1.2	4.25±0.3	4.15±1.1
Total Staphylococcal	4.25±0.60	3.25±0.55	4.25±1.0	2.25±1.1	3.1±0.9

The results were expressed as mean ± SD of triplicates

Table 3:
Biochemical test for the Identification of Bacterial Isolates

S/N	Catalase	Coagulase	Urease	Citrate	Indole	Organism
1	+	-	-	-	+	<i>Escherichia coli</i>
2	+	+	+	+	-	<i>Staphylococcus aureus</i>
3.	-	-	-	-	-	<i>Micrococcus sp.</i>
4.	-	-	-	+	-	<i>Streptococcus sp.</i>
5.	+	-	-	-	-	<i>Enterococcus sp.</i>

Key. + = Positive, - = Negative

The biochemical test of the bacterial isolates are shown in Table 3. *Escherichia coli* was positive for Catalase and Indole but showed negative for Coagulase, Urease, and Citrate. Conversely, *Staphylococcus aureus* showed positive reactions for Catalase, Coagulase, Urease and Citrate, but showed negative reaction for Indole. The outstanding isolates displayed varied biochemical reactions that supported their identification.

Table 4:
Occurrence of Bacterial isolates from the raw mutton samples in retail units

Organism	Occurrence (%)
<i>Escherichia coli</i>	4 (19.05%)
<i>Staphylococcus aureus</i>	7 (33.33%)
<i>Micrococcus sp.</i>	5 (23.8%)
<i>Streptococcus sp.</i>	5 (23.8%)
<i>Enterococcus sp.</i>	3 (14.28%)
Total	24 (100%)

Table 4 showed the percentage of bacteria identified in raw mutton samples from retail locations. *Escherichia coli* (19.05%), *Enterococcus sp.* (14.28), *Micrococcus sp.* (23.8%), and *Staphylococcus aureus* (33.33%) were the most prevalent bacteria.

Table 5:
Antibiotic Sensitivity Pattern in Bacteria Isolated from raw mutton samples in retail units.

Bacterial isolates	CPX (10 mg)	AU (30 mg)	CN (10 mg)	S (30 mg)	CEP (10 mg)	NA (30 mg)	SXT (30 mg)
<i>Escherichia coli</i>	R (13)	S(21)	R(0)	S(38)	R(0)	R(0)	R(20)
<i>Staphylococcus aureus</i>	S(10)	S(22)	S(18)	S(26)	S(20)	S(22)	S(36)
<i>Micrococcus sp.</i>	S(12)	R(0)	R(0)	S(32)	R(0)	R(0)	S(30)
<i>Streptococcus sp.</i>	R(14)	R(0)	R(12)	S(24)	R(18)	S(28)	S(31)
<i>Enterococcus sp.</i>	R(0)	R(14)	R(0)	R(14)	R(0)	R(0)	R(0)

Key: Ciproflox (CPX 10 mg), Augmentin (AU 30 mg), Gentamycin (CN 10 mg), Streptomycin (S 30 mg), Ceprorex (CEP 10 mg),

Nalidixic Acid (NA 30 mg) and Septrin (SXT 30 mg), S = Sensitive, I = Intermediate and R = Resistant

The antibiotic sensitivity and resistance patterns found in the isolated bacteria were shown in Table 5. It was clearly that different antibiotics had distinct effects on bacteria, *Staphylococcus aureus* remained completely sensitive to all antibiotics, however, *Enterococcus sp.* showed resistance to all the antibiotics used. Ciproflox, Augmentin, Gentamycin, Streptomycin, Ceprorex, Nalidixic, and Septrin were all susceptible to the other isolates tested but resistant to *Enterococcus sp.* The most susceptible isolate was *Staphylococcus aureus*, which was followed by *Micrococcus sp.*, *Streptococcus sp.*, and *Escherichia coli*.

Discussion of Findings

The results demonstrated that raw mutton sold within the sampled retail locations carried considerable microbial loads. The Central Market accounted for the highest bacterial counts, signifying that environmental conditions connected to the retail locations probably contributed to greater contamination. Frequent exposure to dust along roadsides, insects and contaminated surfaces, equipment and human contact contribute to source of microbial transfer during retailing. The detected contamination could relatively reflect inadequate handling and storage practices, together with environmental conditions that promote bacterial transfer. These high bacterial counts are ascribed to the fact that the marketplaces were right next to hectic roads and were open, unsanitary markets. Meat contamination can result from flies, dust from roadsides, cross-infection from chopping tables, and the techniques used to obtain the meat from the slaughterer shop to the store. According to Falegan (2017) high bacterial load in food is a symptom of both the overall quality of meat and the possibility of spoiling. But eating raw meat or inadequately prepared meat products poses the biggest hazard to public health. However, every species of bacteria that was isolated comprising *Escherichia coli*, *Staphylococcus aureus*, *Micrococcus*

sp., *Streptococcus sp.* and *Enterococcus sp.* is known to cause disease (Maria *et al.*, 2021). The studies showed that the mutton that was sold was contaminated with bacteria from different species, with *Staphylococcus aureus*, *Micrococcus sp.* and *Enterococcus sp.* being the most predominant (James *et al.*, 2000). The observed contamination may relatively reflect inadequate handling and storage practices, together with environmental conditions that promote bacterial transfer. Public health is alarmed about the isolation of pathogenic bacteria such as *Staphylococcus aureus*, which are significant foodborne illness. Conversely, proper cooking will eliminate these infections, consumers are however, at risk while buying mutton from the various retail units, at Kaura Namoda metropolis. Knives, intestinal contents, cutting boards, skins, meat handlers, containers, vehicles used to transport meats, and the atmosphere surrounding the sale of meat are all possible sources of contamination (Opara and Omeje 2024).

In this present study, the most prominent bacteria isolated from the raw mutton samples were *Staphylococcus aureus*, *Micrococcus sp.*, *Enterococcus sp.*, *Escherichia coli* and *Enterococcus sp.* from raw and processed meat product in different parts of Nigeria (Opara and Omeje 2024, Iwuagwu *et al.*, 2023; Maria *et al.*, 2021; Iroha *et al.*, 2011; Falegan *et al.*, 2017). These could consequently be most important causes of gastrointestinal disorders, food poisoning and foodborne illness. From the results obtained, there were high levels of *Staphylococcus aureus*, *Micrococcus sp.*, *Streptococcus sp.* and *Escherichia coli* in the fresh meat sample. This is in agreement with reports from previous studies Azuamah *et al.*, (2018), Iro *et al.*, (2020), Fasanmi *et al.*, (2010) and Clarence *et al.*, (2009), which indicated that these organisms are the primary contributors of contamination. Moreover, the results of this study are consistent with those of Tesson *et al.*, (2020) and Nouichi and Hamdi (2009), who found that *Staphylococcus*, *Salmonella*, *E. coli*, *Listeria*, and *Clostridium* are the most commonly found bacterial pathogens connected to the consumption of beef products. ***Escherichia coli***

accounted for 19.5% of the isolates recovered in this study. Its occurrence is particularly related because the organism is connected with fecal contamination and inadequate hygiene practices during slaughtering and meat handling and processing. Similar observations, have been reported in studies of retail meat, supporting the need for improved hygiene throughout the meat supply chain (Zhao, 2001; Ahmad et al., 2013; Sulaiman et al., 2022 and Okonko, 2022).

Most of the organisms in meat sample get into meat as a result of poor hygiene condition of slaughterhouse because most slaughterhouses environment are untidy especially where meat sold at different locations as stated by Grandin (2000) that untidy environment at abattoir can cause foodborne illness to the public when such meat on the table were consumed. However, the use of glass boxes can reduce such contamination. Correspondingly, certain organisms can come in contact with meat during transportation since most meats are conveyed to the market in open and therefore microorganisms from air come in contact with the meat thereby making it contaminated (Ahmad *et al.*, 2013). Insects deposit a lot of microorganisms on meat particularly flies from the toilet which harbors a lot of microorganisms and transfers it to meat when such meat is expose to the air, water used in the washing of meat in most of the Abattoirs are from untreated source, this can also contaminate the meat as water harbors microorganisms (Sulaiman, *et al.*, 2022). Mutton sample collected from central market unit and Birnin Magaji road unit might be contaminated from intestines of the animal during skinning process as Sulaiman *et al.*, (2022) stated that contamination can come from the inside of animal during skinning process some microorganisms such as *Escherichia coli* a species which occurs in the lower portion of the intestine of humans and warm-blooded animals, where it is part of the normal flora (Okonko, 2020).

The results of antibiotic susceptibility testing indicated the variations among the bacterial isolates. *S. aureus* was susceptible to all tested antibiotics, while *Enterococcus spp.* indicated resistance to all the

antibiotics tested. The resistance observed in *Enterococcus spp.* is significant because resistant bacteria in food may signify a probable public-health risk. Comparable antimicrobial resistance patterns have been reported in bacteria occurred from meat products in Nigeria (Iroha et al., 2011; Oluwatobi et al., 2021).

Conclusion

The study indicated the presence of numerous bacterial species in raw mutton retailed in the selected markets of Kaura Namoda, Zamfara State. The comparatively high bacterial loads and detection of potentially pathogenic bacteria specify insufficiencies in the microbial quality of some sampled meat. The frequency of antibiotic resistance profile especially *Enterococcus spp.* further highlights the significance of strengthening hygienic practices and monitoring meat sold at retail units.

Recommendations

It is therefore, recommended that :

1. Meat vendors should maintain good personal hygiene and adopt proper practices for handling, storage and display of raw meat.
2. Retail location areas should always be kept clean and meat should be protected from dust, insects and contaminated surface as well as other probable sources of bacterial contamination.
3. Consistent monitoring of the bacteriological quality of retail meat and proper antimicrobial resistance investigation could however, help strengthen food-safety control measures.

References

- Adu-Gyamfi, A, Torgby-Tetteh, W & Appiah V (2012) Microbiological Quality of Chicken Sold in Accra and Determination of D10-Value of *E. coli*. Food and Nutrition Sciences, 3 (5), 693-698.
- Ahmad, MD, Sawar, A, Najeeb, MI, Nawaz, M, Anjum, AA, Ali, MA and Mansur, A (2013) Assesment of microbial load of raw

- meat at abattoir and retail shops. *Journal of Animal and Plant Sciences*. 23: 745- 748.
- Ajiboye, EA, Sani, A, Adedayo, RM, Kolawole, MO and Oladosu, OT (2011) Physicochemical properties and microorganisms isolated from dried meat obtained in Oja-Oba market in Ilorin, Nigeria. *Advances in Applied Science Research*, 2 (4):391-400
- Azuamah YC, Amadi AN, Iro OK, Amadi COA, Braide W (2018) Bacteriological qualities of red meat (Beef) and meat hygiene practices among meat handlers in Aba Metropolis, Nigeria. *Inter. J. Res.* 2018; 8:41-49.
- Bryant J, Gill CO, Jones T, Brereton DA (2014) The microbiological conditions of the carcasses of six species after dressing at a small abattoir. *Food Microbial*. 17:233-239.
- Cheesbrough, M (2010) *District laboratory practice in tropical countries* (Part 2). Cambridge University Press.
- Clarence, SY, Obinna, CN Shalom, NC (2009) Assessment of bacteriological quality of ready to eat food (Meat pie) in Benin City metropolis, Nigeria. *African Journal of Microbiology*, 3, 390-395.
- Clinical and Laboratory Standards Institute (2020) *Performance standards for antimicrobial susceptibility testing* (30th ed.; CLSI supplement M100). CLSI.
- Doulgeraki AI, Ercolini D, Villani F, Nychas GJ (2012) Spoilage microbiota associated to the storage of raw meat in different conditions. *Int J Food Microbiol*. 2012 Jul 2; 157(2):130-41. doi: 10.1016/j.ijfoodmicro.2012.05.020. Epub 2012 May 25. PMID: 22682877.
- Falegan CR, Akoja, SO Oyarekua, MA (2017) Microbiological assessment of suya (sliced roasted beef) in Ado- Ekiti Metropolis, Ekiti State, Nigeria. *Biological Medicine*, 2(3), 266-269.
- Fasanmi, G, Olukole, SG Kehinde O (2010) Microbial studies of table scrapings from meat stalls in Ibadan Metropolis, Nigeria: implications on meat hygiene. *African Journal of Biotechnology*, 9, 3158- 3162.
- Friis RH (2007) *Essentials of environmental health*. Jones and Bartlett Publishers. Boston, USA. 27-35.
- Grandin T (2000) *Best practices for Animal Handling and Stunning*. Journal of meat and poultry.
- Hocquette, J, Ellies Oury, M, Lherm, M, Pineau, C, Deblitz, C, Farmer, L, (2018) Current situation and future prospects for beef production in Europe—a review. *Asian-Australas. J. Anim. Sci*. 31, 1017.
- Ibrahim, AB (2021) Possible sources of contamination in meat and meat products. *Journal of Food Safety and Hygiene*, 12(3), 45-53.
- Iro OK, Enebeli UU, Iloh GUP, Azuamah YC, Amadi AN, Amadi COA, Ezejindu C, Ingwu J, Ogamba SE (2020) Food Hygiene and Safety Management in Nigeria. *Intern. J. of Res. Sci.* 2020; 7:101-109.
- Iroha, I. R., Ugbo, EC, Ilang, DC, Oji, A, E & Ayogu, TE (2011) Bacterial contamination of raw meat sold in Abakaliki, Ebonyi State Nigeria. *Journal of Public Health and Epidemiology*, 3(2), 49-53.
- Iwuagwu UO, Amadi AN, Nworuh BO, Iwuala CC, Innocent DC, (2023) Assessment of the bacteriological qualities of meat and contact surfaces in markets in Abia State, Nigeria. *J Clin Microbiol Biochem Technol* 9(1): 003-013. DOI: <https://dx.doi.org/10.17352/jcmbt.000053>
- James, MJ, Martin, JL Golden, AD (2005) *Modern Food Microbiology* 7th edition. Springer Publishing, New York, USA. pp. 12 – 63.
- Kadariya J, Smith TC, Thapaliya D (2014) *Staphylococcus aureus* and *staphylococcal* food-borne disease: an ongoing challenge in public health. *Biomed Res Int*. 2014;2014: 827965. doi: 10.1155/2014/827965. Epub 2014 Apr 1. PMID: 24804250; PMCID: PMC3988705.
- Larsson SC, Orsini N (2013) Red meat and processed meat consumption and allcause mortality: a meta-analysis. *Am J Epidemiol*. 2014 Feb 1;179 (3):282-9. doi: 10.1093/aje/kwt261. Epub 2013 Oct 22. PMID: 24148709.

Li, M, Havelaar, AH, Hoffmann, S, Hald, T, Kirk, MD, Torgerson, PR, Devleeschauwer, B, (2019) Global disease burden of pathogens in animal source foods. PloS One 14, e0216545.

Lulietto MF, Sechi P, Borgogni E, Cenci-Goga BT (2015) A Critical Review of a Neglected Alteration due to Ropy Slime Producing Bacteria. Italian J. of Animal Sci. 2015; 14:4011-4016. <https://doi.org/10.4081/ijas.2015.4011>

Maria Fredriksson-Ahoma, Etinosa Osemwowa, Iyekhoetin Matthew Omoruyi, Paula Kurittu, Annamari Heikinheimo (2021) Bacterial quality and safety of raw beef: A comparison between Finland and Nigeria. Journal homepage: www.elsevier.com/locate/fm

Mirzarazi, M, Rezaatofghi, S, Pourmahdi, M and Mohajeri, M (2013) Antibiotic resistance of isolated Aram Negative Bacteria from urinary tract infections (UTIs) in Isfahan. Judishapur Journal of Microbiology, 6:1-5.

Moshood, AY, Tengku, HA, Tengku, AH Ibrahim, H (2012) Isolation and Identification of bacteria associated with Balangu (roasted meat product) sold in Bauchi, Nigeria. Journal of Pharmacy, 2(6), 38-48.

National Committee for Clinical Laboratory Standards (2018) *Performance standards for antimicrobial disk susceptibility tests* (Approved standard M02) NCCLS.

Nouichi, S, Hamdi, TM (2009) Superficial bacterial contamination of ovine and bovine carcasses at El-Harrach slaughter house Algeria. European Journal of Scientific Research, 38(3), 474-485.

Okonko IO, Ogunjobi AA, Adejoye OD, Ogunnusi TA and Olosogba MC (2020) Comparative studies and Microbial risk assessment of different water samples used for processing frozen sea-foods in Ijoraolopa, Lagos State, Nigeria. African Journal of Biotechnology. 7(16): 2902- 2907 29.

Oluwatobi, FB, Stephen-Amzat, B and Fabulous-Fabowale, TA (2021) Isolation and Identification of Pathogenic Bacteria Associated with Raw Meat from Different Locations in Ado-Ekiti. International Journal of Research and Innovation in

Applied Science (IJRIAS) | Volume VI, Issue III, March 2021|ISSN 2454-6194

Opara and Omeje (2024) Microbiological quality, antibiotic susceptibility patterns of bacteria and safety of raw beef sold in open markets. International Journal of Microbiology and Applied Sciences. 3(1): 375 - 381.

Orpin, JB, Mzungu, I and Osuj, CG (2018) Isolation and Identification of Bacteria Associated with Suya (Roasted Meat Product) Sold in Dutsinma Local Government Area, Kastina State. Journal of Advances in Biology & Biotechnology. 20(2): 1-8. Article no.JABB.34736 ISSN: 2394-1081

Oso, BA Fawole, MO (2001) Laboratory manual of Microbiology: Revised edition. Spectrum. Ibadan. Pp 127.

Rani, ZT, Hugo, A, Hugo, CJ, Vimiso, P, Muchenje, V, (2017) Effect of post-slaughter handling during distribution on microbiological quality and safety of meat in the formal and informal sectors of South Africa: a review. S. Afr. J. Anim. Sci. 47, 255–267.

Sulaiman, T, Isma'il, A, Saleh, KJ, Adam, AS Auta, AM (2022) Isolation and identification of microorganisms from raw beef sold in Dutsin-ma metropolis, Katsina State, Nigeria. Bayero Journal of Pure and Applied Sciences, 15(2): 28 – 33.

Tesson V, Federighi M, Cummins E, de Oliveira Mota J, Guillou S, Boué G. (2020) A Systematic Review of Beef Meat Quantitative Microbial Risk Assessment Models. Int J Environ Res Public Health. 2020 Jan 21;17(3):688. doi: 10.3390/ijerph17030688. PMID: 31973083; PMCID: PMC7037662.

Wasley, A (2018) "'Dirty meat': Shocking hygiene failings discovered in US pig and chicken plants". The Guardian.

Wolk A (2016) Potential health hazards of eating red meat. J. of Inter. Med. 12:79-85.

Zerabruk, K, Retta, N, Muleta, D, Tefera, AT (2019) Assessment of microbiological safety and quality of minced meat and meat contact surfaces in selected butcher shops of Addis Ababa,

Ethiopia. J. Food Qual. 2019.

Zhao, C, Ge, B, De Villena, J, Sudler, R (2001) Prevalence of *Campylobacter* spp., *Escherichia coli*, and *Salmonella* serovars in retail chicken, turkey, pork, and beef from the Greater Washington, D.C., area. *Appl Environ Microbiol*, 67(12), 5431-6.

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