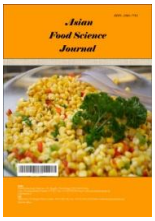

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Isolation and Identification of *Salmonella* and *Escherichia coli* from Raw Goat Meat in Uyo Metropolis, Akwaibom State

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Authors' contributions

This work was carried out in collaboration among all authors. Author HOA designed the study, wrote the protocol and supervised the field work. Authors MOA and NSEUE managed the analyses of the study, performed the statistical analysis and wrote the first draft of the manuscript and managed the literature searches. Author NSEUE carried out the field work. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: In Nigeria, abattoirs have become a source of infection and pollution, attracting domestic animals, wild carnivores and rodents due to lack of adequate slaughtering and disposal facilities. Improper processing of meat consumed by the majority of people in Nigeria is a serious public health issue.
Aims: This study was aimed at isolating, characterizing, and identifying *Salmonella* sp. and *Escherichia coli* from raw goat meat in Uyo metropolis.
Study Design: Fresh goat meat samples were collected from different locations within Uyo metropolis namely; such as goat meat collected at Itam junction market (GTI), Anua junction

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market (GTA), Ikot Okubo junction market (GTO), Itak Uyo market (GTU), Etuk market (GTE), Ndueh Otong market (GTN) and Mbiere Ebeh market (GTM).

Results: The analysis of fresh raw goat meat in Uyo metropolis showed that the total viable count of bacterial load detected on the fresh raw goat meat samples ranged from $9.1X10^2$cfu/g to $1.07X10^4$cfu/g. The highest bacterial count for *E. coli* was obtained from raw goat meat obtained from GTA1 ($3.4X10^3$ cfu/g) followed by GTM2 ($3.2X10^3$ cfu/g). The highest bacterial count for *Salmonella* was obtained from raw goat meat obtained from GTO1 ($1.07X10^4$) followed by GTM 2 ($1.02X10^4$). The result showed that in addition to *E. coli* (100%) that was found in all goat meat samples, the most common isolated microorganisms from the fresh raw goat meat samples was *Salmonella choleraesuis* (38.8%) followed by *Salmonella salaemae* (34.4%) and *Salmonella kauffmanni* (9.5%) respectively.

Conclusion: This study has indicated high microbial contamination of *Escherichia coli* and *Salmonella* sp. in the raw goat meats sold at the selected junctions of Uyo metropolis which suggested a high level of contamination of raw goat meats use for consumed in homes within Uyo metropolis.

Keywords: Goat meat; Salmonella; Escherichia coli; contamination; abattoirs; foodborne diseases.

1. INTRODUCTION

The consumption of animal protein by the average Nigerian is very low [1,2]. Beef represents the main source of meat consumed in Nigeria. Presently, beef is very expensive leading to a shift to small ruminants consumption especially goats. Goat meat contributes immensely to the human diet in Nigeria. Goat meat is an essential, low-cost source of animal proteins which encourages consumption of goat among a large number of animal consumers. Goat meat is more popular in the market because of advantages such as easy digestibility and acceptance by the majority of people [3]. The prevalence of foodborne diseases has resulted in profound impediment to small animal production in Nigeria by causing high mortality and low production [4]. In Nigeria, abattoirs have become a source of infection and pollution, attracting domestic animals, wild carnivores and rodents due to lack of adequate slaughtering and disposal facilities [5]. Improper processing of meat consumed by the majority of people in Nigeria is a serious public health issue [6]. Fresh goat meats are often hawked on trays or displayed on tables in an open market without hygienic precaution and are kept at ambient temperatures. Transport facilities were inadequate and unhealthily distributed through different intermediaries leading to difficult coordination [7]. Previous researches had indicated bacterial contamination of raw goat meat [8].

In order to have effective goat meat-associated disease control programme, it is pertinent to have a documented common disease in an area. The knowledge of public exposure to zoonotic diseases through goat consumption is very important to Public Health and Preventive Medicine [9,10]. Provision of both ante-mortem and post-mortem inspection by qualified health personnel at the slaughterhouse or abattoir for ascertaining wholesomeness of animals brought in for slaughter and carcasses produced for meat trade is very important [11].

Salmonella species were responsible for the highest number of documented cases of meat poisoning in the developed country [12]. *Salmonella* species and *Escherichia coli* were indicated as meat-borne pathogens of public health concerns in Nigeria and the United States [13]. *Salmonella* infection is an important cause of morbidity and mortality in goat and a major cause of meat-borne illness [14,15]. In developed countries, gastroenteritis is the most common and self-limiting illness of short duration which is characterized by diarrhoea and fever [16]. Enteric fever is due to serotype *S. typhi* which is adapted to human hosts without animal reservoir and could also be caused by another serotype such as paratyphi A, B and C [17].

Escherichia coli has been recognized as a serious human enteric pathogen in several different countries [18]. It was unprecedentedly isolated in Oregon and Michigan during Haemorrhagic colitis epidemics in the United States of America [19].

The presence of pathogenic microorganisms on raw goat meat during and after sales of these products makes it a public health issue. The need for good hygienic practices in the entire

production chain becomes more and more pressing as goat products are increasingly indicated as vehicles for the transmission of foodborne infections. Both animal husbandry practices and processing technology hugely determine the extent of presence of microbial flora on carcasses which explains the hygienic practices observed at farm, transportation process and during slaughtering [14].

The heterogenous population of microorganisms which inhabit the goat farms and processing plants include both microorganisms which are responsible for spoilage of products such as *Pseudomonas*, *Acinobacter brochotrix* and lactic acid bacteria and the potentially pathogenic organisms such as *Salmonella spp* and *E. coli* that may cause diseases in human beings [7]. The microbiological situation such as global presence and variation of microorganisms associated with goat meat production has changed over the last decade [20]. There is documentation of high prevalence of *Salmonella typhimurium*, *Salmonella enteritidis* and *E. coli* species in a goat in many countries [21]. Due to the high contamination of goat meat with pathogenic bacteria, raw goat meat products are reported to be responsible for a significant number of cases of food poisoning in man [6].

The presence of pathogenic and spoilage microorganisms in goat meat and its by-products remains an important issue for suppliers, consumers and public health personnel. Bacterial contamination of these foods depends on the bacterial loads of the goat carcasses used as the raw products, the hygienic practices during manipulation and on the time and temperature of storage [22]. Goat slaughtering in Nigeria is mostly traditional which is practised on the slaughter slabs such as cemented floor or concrete and wooden materials. Controlling microbial contamination in goat meat during slaughtering, processing, storage handling and preparation becomes a great challenge [23,24]. Goats are slaughtered and eviscerated mostly by hand. Before and after evisceration, goat carcasses are subjected to washing and other operations which may disseminate bacteria from localised sites to the rest of the carcasses. All parts of the goat carcasses may then be similarly contaminated. Goats are usually sold in parts and carcasses are displayed over a long time at ambient temperatures during the day and are put in the refrigerator at night [25]. The storage temperature to which the carcasses are exposed may favour the proliferation of pathogenic bacteria which are transmitted to the consumers [24].

Salmonella is Gram-negative, enterobacteria which are chemoorganotrophs. *Salmonella* can survive outside the living body and had been reported alive in dried excrement after two and half years [26,22]. *Salmonella* infection can be prevented by heating ready-to-eat meal to 75°C for 10 minutes. *Salmonella* is not destroyed by freezing [27]. Antibiotics resistance is an emerging human health threat. Prescription of antibiotics such as chloramphenicol, amoxicillin, ciprofloxacin has increased the risk of acquiring antibiotics-resistant food-borne infections. Ceftriaxone-resistant *Salmonella* has been documented [28].

Escherichia coli are enterobacteria, gram-negative, anaerobic and non-sporulating cells. *E. coli* is now recognized as a major cause of diarrhoea, haemorrhagic colitis and haemolytic uremic syndrome worldwide. There are preventive measures for controlling food-borne pathogens in goat processing such as Hazard Analysis Critical Control Point (HACCP) system and Microbiological Risk Assessment (MRA) [29-32].

Bacterial infections have both health and economic implications in a population. The controls of diseases require the intervention of both the medical and veterinary practitioners especially in the presence of emerging and re-emerging diseases globally [33]. The study was aimed at isolating, characterizing and identifying *Salmonella* and *Escherichia coli* from raw goat meat in Uyo metropolis.

2. MATERIALS AND METHODS

Reagents: Dipotassium phosphate, potassium dihydrogen phosphate, hydrogen peroxide, indo-reagent, VP reagent, oxidase, tryptone water, 96% ethanol, Lysol.

Media: Nutrient broth, S.S. agar, Simon citrate agar, Urea agar

Equipment: Disposable petri dishes, aluminium foil, cotton wool, masking tape, marker, stock bottles, surgical gloves, glass wares, plastic wares, forceps, wire loop, pipette, test tubes, glass rod, scissors, needles.

Study area: The study was conducted in Uyo, the capital city of Akwa-Ibom state, Nigeria. Uyo

is situated 55kilometers inland from the coastal plain of Southeast Nigeria [34]. The area lies within the humid tropical rainforest zone with two district seasons, the rainy and short dry seasons. The annual precipitation ranges from 2000-3000 mm per annum with a yearly relative humidity range of 70-80%. The area is located between latitude 5°17N and 5°21N, longitude 7°21E and 7°58E and covers an area of about 35square kilometres. The area is known to have a temperature range of 26-28°C [35].

Sample collection: Fresh goat meat samples were collected from different locations within Uyo metropolis unnecessary goat meat collected at Itam junction market (GTI), Anua junction market (GTA), Ikot Okubo junction market (GTO), Itak Uyo market (GTU), Etuk market (GTE), Ndueh Otong market (GTN) and Mbiere Ebeh market (GTM). Two samples of goat meat were collected from each of the goat meat sellers which made a total of 14 goat meat samples. The samples were collected in sterilised polyethene bags previously prepared by washing and rinsing with 75% ethanol and dried. These samples were transported immediately within two hours of collection to the Animal Science Laboratory for microbiological analysis. The goat meat samples that were not used immediately were kept in the refrigerator immediately and were used within 24 hours of collection.

Sterilisation of materials: All glass wares, petri dishes, pipettes, test tubes, glass rods, were sterilised in a hot air oven at 180°C for 1 hour. Plastic wares, bags were sterilised in 75% ethanol. Metal wares such as forceps, wire-loops, scissors, and needles were sterilised using a bunsen flame.

Preparation of growth media: Commercially available growth media were used. *Salmonella Shigella* Agar (SSA) was used for isolation of *Salmonella* species, Eosin Methylene Blue Agar (EMBA) was used for isolation of *E. coli 0157:H7*. These were weighed according to manufacturer specification, sterilised and allowed to cool before used.

Isolation of bacterial species: The isolation method of Nester et al., 2005 was employed using pour plate technique [36]:

10 g of the meat sample was cut and macerated. The macerated meat was weighed and mixed with 9 ml of sterile water in a test tube to form the aliquot, 10^{-1} dilution factor. 1 ml of the aliquot was aseptically transferred to 8 ml of sterile water in another test-tube, 10^{-2}. Diluents were taken from 10^{-2} dilution tube into sterile petri dishes and labelled them according to the sample and medium. Sterile, lukewarm molten media were poured into their respective plates and were allowed to cool and were incubated. The cultured plates (EMBA) were incubated at 44±5°C for 24 hours and cultured plates (SSA) were incubated in 24 hours. All plates were enumerated after the incubation period.

2. IDENTIFICATION OF BACTERIAL SPECIES

Colonies enumerated were characterised and identified to species level based on their morphological characteristics, microscopic examination of the cell, biochemical characteristic and sugar fermentation.

2.1 Characterisation and Identification of Bacterial Isolates

Identification of bacterial isolates was done by comparing the morphological and biochemical characteristics of the isolates with known taxonomy using Cowan and Steel's Manual for Identification of Bacteria [37].

The following biochemical tests were carried out on the bacterial isolates:

Gram stain reaction: A drop of distilled water was placed on a clean, grease free dry slide, using a sterile wire loop, a smear of the test organism was made on the slide and allowed to air dry and then heat fixed [38]. The smear was flooded with crystal violet stain for one minute, covered with Gram's iodine (Lugol iodine) and allowed to react for 30 seconds. The slide was then washed in running tap water, the smear was counter stained with Safranin solution for 1 minute, rinsed with water and allowed to air dry. The smear was examined microscopically using oil immersion objective (X100). A blue-black or purple colour indicated gram positive *E. coli* while a red colour indicate gram negative *Salmonella*.

Indole test: This test was carried out to show the ability of bacteria to use tryptone to produce indole. The isolates were inoculated into 3 ml of tryptone water and incubated for 48 hours at 37°C. After incubation, 0.5 ml of Kovac's reagent was added to the medium and shaken gently. A red colouration at the point of contact of the test solution with the Kovac's reagent indicated indole

production and this is a positive result while the ones with yellow colour production indicated a negative result. Indole is one of the degraded products from the metabolism of amino acid tryptophan. Bacteria that possess the enzyme tryptophanase are capable of clearing tryptophan thus producing indole, pyruvic acid and ammonia.

Voges Proskauer (VP) test: This test was carried out to identify bacteria that can ferment glucose, leading to accumulation of the enzyme 2, 3-butanediol, 40% KOH solution, (a) and a 5% solution Alpha Naphtol in absolute ethanol (b) Barrette's reagents were carefully dropped to meet the test organism in broth solution in the test tube. Development of red colour in the colour medium 15 minutes after the addition of the Barrette's reagent indicated a positive result. While those with yellow colour indicated a negative result for both *Salmonella* and *E. coli*.

Oxidase test: Filter paper strips were impregnated with oxidase reagent (tetramethyl-p-phenylenediamine dihydrochloride), a drop of the broth culture of the isolate was made on the filter paper with a wooden applicator. A change in the colour of the filter paper from light pink to dark purple indicated positive oxidase reaction while light pink indicated a negative result for both *Salmonella* and *E. coli*. This test was carried out to identify organism that produce cytochrome oxidase enzyme.

Methyl red test: 2-3 drops of methyl red indicator was added to a 48 hours old broth culture of the isolates in a test tube, an immediate change in colour to red indicated a positive result. This implies that the organisms can produce acid in glucose solution. A change in colour to yellow was a negative result which indicated that the organism was incapable of producing acid in glucose solution.

Citrate utilisation test: 1 g of Simmons citrate agar was weighed and mixed in 100 ml of water in a conical flask. The solution was sterilised in the autoclave condition of temperature, pressure and time. The test organism was inoculated on the surface of the prepared Simmons Citrate agar and then incubated at 37°C for 24 hours. A change in colour from green to blue indicates a positive citrate test and green colour indicated negative citrate test.

Catalase test: This test was carried out to determine the ability of isolates to produce the enzyme catalase. A smear of the test organism from a 72 hours old plate culture was made on a clean slide using a sterile wooden loop, 3 drops of freshly prepared 3% hydrogen peroxide (H_2O_2) solution was added to the smear made on the slide and covered with a coverslip. The active production of gas bubbles almost immediately indicates a positive result for *E. coli*. No gas bubbles were considered as a negative result for *Salmonella*.

Urease test: The isolates were inoculated on a sterile medium containing urea as a base (urea agar) and incubated at 37°C for 24 hours. Purple colouration indicated positive urease test while no colouration indicated negative urease test.

Sugar fermentation test: 1 g of each of the sugars used was weighed and mixed with 90 ml of distilled water in a conical flask. 1 g of peptone water was weighed and placed in the same conical flask. 10 ml of phenol red solution was also added. A 10 ml of the solution was dispensed separately into three test tubes. Durham's tubes were placed in the test tubes in an inverted form. The mouths of the test tubes were plugged with cotton wool. The test tubes were sterilised at 121°C for 15minutes and allowed to cool. The test organisms were then inoculated and incubated at 37°C for 24 hours. A change in colour from red to yellow indicated acid production which is a positive result. Air bubbles in Durham's tube indicated gas production while no change indicated no acid production.

Motility test: The hanging drop method was used. The test organisms were inoculated in peptone water and incubated for 24 hours. A smear from the isolates was made on a cover slip; a clean slide was placed over the slip with a quick motion inverting the slip so that the culture drop will appear in a hanging position. It was then examined with X100 lens. Motile organisms were seen actively from one point to another. Non-motile organisms stood at a spot vibrating.

Lysine Liquefaction (Hydrolysis Test): 1 g of Lysine (Amino acid), 1 g of glucose and 0.5 g of bromo-cresol purple dye was introduced into a broth medium of each organism in a test tube and sterilised in the autoclave. Conditions of temperature, pressure and time were 121°C, 15 psi and 15 minutes respectively. The organisms were inoculated and incubated at 37°C for 24 hours. A change in colour from purple to yellow was indicated as positive *lysine decarboxylase*

(hydrolysis, that implies that the organism has *lysine decarboxylase*).

3. RESULTS AND DISCUSSION

The analysis of fresh raw goat meat in Uyo metropolis showed that the total viable count of bacterial load detected on the fresh raw goat meat samples ranged from $9.1X10^2$cfu/g to $1.07X10^4$cfu/g. The highest bacterial count for *E. coli* was obtained from raw goat meat obtained from GTA1 ($3.4X10^3$ cfu/g) followed by GTM2 ($3.2X10^3$ CFU/g). The highest bacterial count for *Salmonella* was obtained from raw goat meat obtained from GTO1 ($1.07X10^4$) followed by GTM 2 ($1.02X10^4$) (Table 1).

The colonial morphological characterization of the isolated microorganisms was fully described as shown in Table 2. The colonial biochemical characterization of all the isolated micro-organisms was explicitly illustrated in Table 3.

The result showed that in addition to *E. coli* (100%) that was found in all goat meat samples, the most common isolated microorganisms from the fresh raw goat meat samples was *Salmonella choleraesuis* (38.8%) followed by *Salmonella salaemae* (34.4%) and *Samonella kauffmanni* (9.5%) respectively (Table 4).

Evaluation of bacterial contamination of food is an important tool in Public Health which focuses on reducing the epidemic of food-borne infections and its economic burden.

This study has indicated a high occurrence of *Escherichia coli* and *Salmonella* in the raw goat meats sold at the selected junctions of Uyo metropolis which suggested a high level of contamination of raw goat meats consumed in Uyo metropolis. The previous study by South African Department of Health had indicated that gastrointestinal infectious diseases were responsible for 5% of annual deaths [39]. Nortje had also reported that there was onward declination of hygienic standards among the people [40]. Goat contaminated with *Salmonella* and *E. coli* at slaughter house was reported as a source of food-borne disease when consumed raw or inadequately cooked with other food [41]. Lack of control of food borne diseases caused by these pathogenic microorganisms will lead to widespread infection that would probably result in escalated mortality rate. In fact, many of the gastrointestinal infections which are reported at all the healthcare facilities in the country would be reduced if proper attention is given to hygienic practices at the abattoirs nationwide and in all homes where foods and meats are being prepared. The attempt at reducing hospital visits due to food borne diseases will also help to reduce the cost incurred by patients during treatment, overhead cost by the healthcare systems, lost of hours at workplaces and in the long run, would help boost the economy.

Table 1. Bacteria count in goat meat samples – express the counts as log numbers

Sample code	*E. coli* (cfu/g)	*Salmonella* count (cfu/g)
GTI 1	$2.5X10^3$	$7.9X10^3$
GTI 2	$2.1X10^3$	$8.0X10^3$
GTA 1	$3.4X10^3$	$7.3X10^3$
GTA 2	$3.0X10^3$	$6.7X10^3$
GTO 1	$1.7X10^3$	$1.07X10^4$
GTO 2	$1.2X10^3$	$9.9X10^3$
GTU 1	$8.0X10^2$	$4.3X10^3$
GTU 2	$1.1X10^3$	$3.9X10^3$
GTE 1	$1.4X10^3$	$2.6X10^3$
GTE 2	$9.1X10^2$	$1.5X10^3$
GTN 1	$1.8X10^3$	$3.8X10^3$
GTN 2	$2.3X10^3$	$6.1X10^3$
GTM 1	$2.6X10^3$	$6.1X10^3$
GTM 2	$3.2X10^3$	$1.02X10^4$

GTI: Goat meat from Itam junction, GTA: Goat meat from Anua junction, GTO: Goat meat from Ikot Okubo junction, GTU: Goat meat from Itak Uyo market, GTE: Goat meat from Etuk Market, GTN: Goat meat from Ndueh Otong, GTM: Goat meat from Mbiere Ebeh Market. Cfu/g: Colony forming unit per gram sample

Table 2. Morphological characterization of *Salmonella* and *E. coli* isolates

S/N	Isolate	No of colony	Edge	Colour	Elevation	Odour	Optical characteristics	Consistence	Cell shape	Name of organism
1	GTI 1	79	Circular	Creamy	Raised	Offensive	Translucent	Butyrious	Rod	*S. choleraesuis*
2	GTI 2	80	Circular	Milky	Flat	Offensive	Opaque	Butyrious	Rod	*S. kauffmanni*
3	GTA 1	73	Circular	Creamy	Flat	Offensive	Opaque	Butyrious	Rod	*S. salaemae*
4	GTA 2	67	Circular	Creamy	Flat	Offensive	Opaque	Butyrious	Rod	*S. typhi*
5	GTO 1	107	Circular	Creamy	Flat	Offensive	Opaque	Butyrious	Rod	*S. choleraesuis*
6	GTO 2	99	Circular	Creamy	Flat	Offensive	Opaque	Butyrious	Rod	*S. salaemae*
7	GTU 1	43	Circular	Creamy	Flat	Offensive	Opaque	Butyrious	Rod	*S. salaemae*
8	GTU 2	39	Circular	Creamy	Flat	Offensive	Opaque	Butyrious	Rod	*S. arizonae*
9	GTE 1	26	Circular	Creamy	Flat	Offensive	Opaque	Butyrious	Rod	*S. choleraesuis*
10	GTE 2	15	Circular	Creamy	Flat	Offensive	Opaque	Butyrious	Rod	*S. salaemae*
11	GTN 1	38	Circular	Creamy	Flat	Offensive	Opaque	Butyrious	Rod	*S. choleraesuis*
12	GTN 2	41	Circular	Creamy	Flat	Offensive	Opaque	Butyrious	Rod	*S. pollurum*
13	GTM 1	61	Circular	Creamy	Flat	Offensive	Opaque	Butyrious	Rod	*S. salaemae*
14	GTM 2	79	Circular	Creamy	Raised	Offensive	Opaque	Butyrious	Rod	*S. choleraesuis*
15			Circular	Milky	Raised	Offensive	Opaque	EMBA	Rod	*Escherichia coli*

Table 3. Biochemical characterization of *Salmonella* and *E.coli* isolates

Isolates	Gram reaction	Indole test	VP test	Oxidase test	Methyl red test	Citrate test	Catalase test	Urease test	Glucose test	Lactose test	Maltose test	Motility test	Lysine test	Name of organism
GTI 1	-	+	-	-	-	-	+	-	+	+	+	-	+	*S. choleraesuis*
GTI 2	-	+	-	-	-	-	+	-	+	+	+	+	+	*S. kauffmanni*
GTA 1	-	+	-	-	-	-	+	+	+	+	+	+	-	*S. salaemae*
GTA 2	-	-	-	-	-	-	+	-	+	+	+	+	+	*S. typhi*
GTO 1	-	+	-	-	-	-	+	-	+	+	+	-	+	*S. choleraesuis*
GTO 2	-	+	-	-	-	-	+	+	+	+	+	+	-	*S. salaemae*
GTU 1	-	+	-	-	-	-	+	+	+	+	+	+	-	*S. salaemae*
GTU 2	-	+	-	-	-	-	+	-	+	+	+	+	+	*S. arizonae*
GTE 1	-	+	-	-	-	-	+	-	+	+	+	-	+	*S. choleraesuis*
GTE 2	-	+	-	-	-	-	+	-	+	+	+	+	+	*S. salaemae*
GTN 1	-	+	-	-	-	-	+	-	+	+	+	+	+	*S. choleraesuis*
GTN 2	-	+	-	-	-	-	-	-	+	-	+	+	+	*S. pollurum*
GTM 1	-	+	-	-	-	-	+	+	+	+	+	+	+	*S. salaemae*
GTM 2	-	+	-	-	-	-	+	-	+	+	+	+	+	*S. choleraesuis*
	-	+	-	-	+	-	+	-	+	+	+	+	+	*Escherichia coli*

Table 4. Total bacterial count of isolated microorganisms

Name of isolated microorganisms	No of colonies	Percent (%)	No off meat samples containing isolate	Mean±SD	Name of isolated microorganisms	Percent (%)
Salmonella choleraesuis	329	38.8	5	65.8±33.2	*Escherichia coli*	100
Salmonella kauffmanni	80	9.5	1	80		
Salmonella salaemae	291	34.4	5	58.2±31.6		
Salmonella typhi	67	7.9	1	67		
Salmonella arizonae	39	4.6	1	39		
Salmonella pullurum	41	4.8	1	41		
Total	847	100				

The presence of isolated microorganisms in the fresh raw goat meats suggested poor hygienic practice by the fresh raw goat meat handlers during the processing stage. The lack of sterilization of utensils and working surface was assumed as a source of contamination of fresh raw goat meat. This was also reported by Atanassova [42]. It is therefore important to rejuvenate various established environmental health policies to ensure that both standard and non-standard abattoirs nationwide adhere to safety standards regarding animal slaughter, meat handling, and processing. This is the only means to ensure food safety and good health for the Society at large. In developed countries, improved and advanced hygienic practices aided by innovations and technology have helped to reduce microbial contamination of food and meat during processing [43].

4. CONCLUSION

This study has indicated the presence of *Salmonella* and *E. coli* in the fresh raw goat meat sold at selected areas of Uyo metropolis.

5. RECOMMENDATION

Standardization of market facilities for sale of raw goat meat and proper education of goat meat sellers by Public health officers are hereby recommended.

CONSENT

Consent of participants was not required for this study.

ETHICAL APPROVAL

Ethical approval was not obtained for the study because there was no presence of the Institutional Review Board at this area at the time of the study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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