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Bacteriological Quality of Fresh Raw Beef and Chevon Retailed in Lafia Metropolis, Nigeria

Aleruchi Chuku[1], Lawrence B. Etim[2], Godwin Attah Obande[1,*], Bassey Ernest Asikong[3], Bashir Eya Sani[1]

[1]Department of Microbiology, Faculty of Science, Federal University Lafia, Nasarawa State, Nigeria
[2]Department of Biological Sciences, Faculty of Science, Cross River University of Technology Calabar, Cross River State, Nigeria
[3]Department of Microbiology, Faculty of Science, University of Calabar, Cross River State, Nigeria

Abstract Raw beef and chevon retailed in Lafia were assessed to determine their bacteriological quality, following standard microbiological procedures. A total of eighty (80) samples comprising forty (40) raw beef and forty (40) raw chevon samples were randomly collected between June and August 2015, from three open markets and street vendors which serve as major sources of raw meat in Lafia metropolis. *Escherichia coli*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Proteus* species (sp), *Salmonella* sp, *Shigella* sp, *Pseudomonas* sp, and *Klebsiella* sp were identified as contaminants in the meat samples analyzed, with *Staphylococcus aureus* and *Salmonella* sp being the most (96.3%) and least (42.5%) isolated contaminants respectively. Mean bacterial counts ranged from 1.23 x 10^7 to 6.11 x 10^8 cfu/g in both meat types. Total staphylococcal count (TSC) was higher in beef than in chevon. Over-all total aerobic count (TAC), total coliform count (TCC) and total salmonella-shigella count (TSSC) revealed a higher contamination rate in raw chevon than in raw beef samples, although the differences were not statistically significant (p>0.05). Street vended beef samples and chevon from Lafia old market were most contaminated, with differences in the contamination rates between the locations sampled not statistically significant (p>0.05). The study reveals that raw beef and chevon retailed in Lafia are contaminated beyond acceptable limits. Hence the need for enforcement of hygienic practices among sellers and public awareness on healthy handling of raw meat among consumers so as to safeguard the health of the general public.

Keywords Raw, Beef, Chevon, Vendors, Market, Bacteriological, Market

1. Introduction

The term meat, refers to mammalian flesh consumed as food. Hence, raw meat refers to uncooked muscle tissue of animals that is used for food [1]. Recently however, meat has been broadly defined to include poultry, shellfish, fish, frogs and alligators [2]. Cattle and goat are very popular sources of beef and chevon respectively all over the world, Nigeria inclusive and Lafia in particular. Meat and meat products have increasingly become part of daily human diet because of its rich and nutritive composition. Beef and chevon have been reported to contain high quality proteins, minerals, vitamins and fat [3, 4].

Slaughtering of livestock continues to increase as a result of the increase in demand for meat and its products [5]. The highly nutritious nature of meat provides a suitable environment for the growth of pathogenic, nonpathogenic as well as spoilage organisms [6]. Its high consumption rate and popularity hence, makes contamination and its consequences an issue of concern, since raw meat and meat products have been identified as important vehicles of foodborne illnesses and implicated in food poisoning outbreaks [7-9]. Diseases spread through meat and meat products to humans by direct contact and ingestion of the finished product [8]. Food safety is a complex issue that has an impact on almost all segments of the society, from the public to the government, industry and academia. Diseases caused by foodborne pathogens constitute a worldwide public health problem [10]. *Escherichia coli, Clostrudium perfringens, faecal Streptococci*, *Klebsiella pneumoniae* as well as species of *Salmonella, Shigella, Bacillus, proteus, Staphylococcus, Salmonella* and *Listeria* have been reported as contaminants of raw meat in various studies within and outside Nigeria [3, 11-13].

The state of health of animals prior to slaughtering and the prevailing circumstances in the slaughter house can contribute to the quality of meat from such animals [14, 15]. Reports have indicated that slaughtering of animals in rural communities within Nigeria is usually done under unhygienic conditions. In most cases, potable water is unavailable, leaving butchers with unhealthy water sources for use. These aforementioned reasons in addition to high ambient temperature, humidity and poor handling practices dispose raw meat to deterioration and contamination [15, 16]. Other sources such as animal skin, hide and feet, faecal

* Corresponding author:
obandegodwins@gmail.com (Godwin Attah Obande)
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material and the hands, clothing and equipment of slaughter men have been identified as routes of contamination [17].

Despite the foregoing and the high consumption rate of raw beef and chevon in Lafia metropolis, there is little or no available information on their bacteriological quality. The dearth of information in this area has necessitated this research.

2. Methodology

2.1. Sample Collection

The major sources of raw meat in Lafia metropolis were identified from preliminary investigation as hawkers, open markets and slaughter houses (abattoir). The methods of [3] and [18] were adopted in the collection of samples. Forty (40) each of fresh beef and chevon samples (total = 80) were randomly collected from four (4) locations namely Shinge, Lafia old market, Lafia Modern market and street hawkers within Lafia, between the months of June and August, 2015. This period witnessed the slaughter of a lerge number of animals in Lafia owing to the Salah festivity (Eid-el-fitri) which held in July. The meat samples were bought and packaged as they are sold to other consumers, appropriately labeled and transported to the laboratory for analysis within two (2) hours of collection. Samples were collected in the morning hours to avoid the effect of changing temperatures on microbial population. Contact with the meat by collector's hands and other materials were avoided after packaging by the vendor, to prevent contamination from other sources.

2.2. Isolation of Bacterial Contaminants

Isolation of bacterial contaminants from the meat samples were based on the method described by [18]. Ten gram of each sample was homogenized in 90ml of 0.85% (w/v) sterile physiological saline in a blender (MasterChef) for 1 min and serially diluted using 0.85% physiological saline as blank. One milliliter (1ml) of the fifth dilution from each sample was inoculated by pour-plate method on Nutrient agar, Salmonella-Shigella agar, Mannitol Salt agar and MacConkey agar for total aerobic, Salmonella-Shigella, Staphylococcal and coliform counts respectively. Inoculated agar plates were incubated for at least 24 hours at 37°C.

2.3. Identification of Isolates

Identification of bacterial isolates followed standard microbiological methods as described [18]. Gram reaction, colonial and biochemical characteristics of pure isolates obtained from discrete colonies were noted. Biochemical tests carried out include catalase test, coagulase test, urease test, motility test, indole test, Methyl Red test, Voges-Proskauer test, citrate test, oxidase test, haemolysis test on blood agar and sugar fermentation on triple sugar iron agar. MRVP medium was used for methly red test and Voges-Proskauer test, while Simmons citrate agar was used for citrate utilization test. Motility Indole Urea (MIU) medium was used for the determination of motility, indole and urease production respectively. Identification of isolates was done by comparing the biochemical characteristics of isolates with those of known taxa, as described by [19].

2.4. Statistical Analysis

Data collated were analyzed using IBM SPSS Statistics version 20 (IBM Corporation, 2011). Simple means, percentages and frequencies were computed. Means were compared using Analysis of Variance (ANOVA) and Chi-squared test was used to determine associations.

3. Results

Table 1 shows the bacterial contaminants isolated and their frequency of occurrence in the meat samples. *Staphylococcus aureus* (92.3%) was the most isolated contaminant, followed by *Staphylococcus epidermidis* (88.8%). *Salmonella* spp had the lowest frequency of 43.0%.

Table 1. Frequency of bacterial isolates in raw beef and chevon samples

Bacterial contaminants	No. of samples (N=80)	Frequency of occurrence (%)
Staphylococcus aureus	77	96.3
Staphylococcus epidermidis	71	88.8
Escherichia coli	67	83.6
Klebsiella sp	64	80.0
Shigella sp	51	63.6
Pseudomonas aeruginosa	50	62.5
Proteus sp	49	61.3
Salmonella sp	34	42.5

Except for beef samples from Shinge where no *Pseudomonas aeruginosa* was isolated, all other bacterial contaminants were isolated and detected in other beef samples from the different locations and at high frequencies (Table 2). *S. aureus* had the highest frequency of 97.5%, followed by *E. coli* and *S. epidermidis* which both had frequencies of 90.0% and 87.5% respectively. *Salmonella* sp was the least isolated, with a frequency of 50.0%. Among the isolates, *E. coli* was the most isolated contaminant in samples from Shinge (100%), while *S. aureus* (100%) *and S. epidermidis* (100%) were the most isolated in samples from Lafia old market. Similarly, all samples from Lafia modern market were contaminated by *Staphylococcus aureus* (100%) and *Pseudomonas aeruginosa* (100%), while all samples from hawkers were contaminated by *S. aureus* (100%) and *S. epidermidis* (100%).

Table 3 shows the distribution and frequency of the bacterial isolates from chevon samples. High prevalence of *S. aureus* (95.0%), *S. epidermidis* (90.0%) and *Klebsiella* sp (82.5%) were observed in the chevon samples with *Salmonella* sp having the least prevalence rate of 35.0%. All chevon samples collected from Shinge and Lafia old market

were contaminated by *S. epidermidis* (100%) and *S. aureus* (100%) respectively.

The mean bacterial counts of beef samples from the different sites reveal that hawked samples were the most contaminated, having a mean total aerobic count of 2.30 x 10^7 cfu/g (Table 4). Samples from Shinge (6.1 x 10^8 cfu/g), hawkers (1.82 x 10^8 cfu/g) and Lafia old market (1.11 x 10^8 cfu/g) had the highest mean total coliform count (TCC), mean total salmonella-shigella count and mean total staphylococcal count respectively. Analysis of Variance (ANOVA) did not reveal significant differences in the rate of contamination within the sites and between the mean counts (p>0.05).

Chevon samples collected from Lafia old market had the highest level of contamination with a mean TAC of 7.58 x 10^7 cfu/g (Table 5). However, contamination with coliforms and *Staphylococci* was highest in chevon samples from Shinge (4.05 x 10^8cfu/g and 5.08 x 10^7 cfu/g respectively). The mean total salmonella-shigella count revealed a higher salmonella-shigella contamination rate in chevon samples from Lafia old market (2.19 x 10^8 cfu/g) than those from Shinge (3.06 x 10^7cfu/g). The rate of contamination both within the locations and between the locations were not statistically significant (p>0.05).

Table 2. Distribution and frequency of bacterial contaminants in raw beef samples from different sample sites

Bacterial contaminants	Collection sites (n=10)				Total (N=40) (%)
	Shinge (%)	Lafia old market (%)	Modern market (%)	Hawkers (%)	
Staphylococcus aureus	9(90.0)	10(100)	10(100)	10(100)	39(97.5)
Escherichia coli	10(100)	8(80.0)	9(90.0)	9(90.0)	36(90.0)
Staphylococcus epidermidis	7(70.0)	10(100)	8(80.0)	10(100)	35(87.5)
Klebsiella sp	8(80.0)	7(70.0)	8(80.0)	8(80.0)	31(77.5)
Proteus sp	6(60.0)	8(80.0)	8(80.0)	5(50.0)	27(67.5)
Pseudomonas aeruginosa	0(0.0)	8(80.0)	10(100)	8(80.0)	26(65.0)
Shigella sp	8(80.0)	3(30.0)	5(50.0)	7(70.0)	23(57.5)
Salmonella sp	4(40.0)	6(60.0)	6(60.0)	4(40.0)	20(50.0)

Table 3. Distribution and frequency of bacterial contaminants in chevon samples from different sample sites

Bacterial contaminants	Collection sites		Total (%)
	Shinge (%)	Lafia old market (%)	
Staphylococcus aureus	18(90.0)	20(100)	38(95.0)
Staphylococcus epidermidis	20(100)	16(80.0)	36(90.0)
Klebsiella sp	15(75.0)	18(90.0)	33(82.5)
Escherichia coli	17(85.0)	14(70.0)	31(77.5)
Shigella sp	16(80.0)	12(60.0)	28(70.0)
Pseudomonas aeruginosa	10(50.0)	14(70.0)	24(60.0)
Proteus sp	14(70.0)	8(40.0)	22(55.0)
Salmonella sp	8(40.0)	6(30.0)	14(35.0)

Table 4. Mean bacterial counts of beef samples

Location	TAC (cfu/g)	TCC (cfu/g)	TSSC (cfu/g)	TSC (cfu/g)
Shinge	2.08 x 10^7	6.11 x 10^8	2.82 x 10^7	1.36 x 10^7
Lafia old market	1.23 x 10^7	3.98 x 10^8	1.69 x 10^8	1.11 x 10^8
Lafia modern market	2.14 x 10^7	2.25 x 10^7	1.75 x 10^7	2.09 x 10^7
Street vendors	2.30 x 10^7	1.89 x 10^7	1.82 x 10^8	6.95 x 10^7
Over-all mean	1.94 x $10^7 \pm 4.8^a$	2.63 x $10^8 \pm 2.9^a$	9.92 x $10^7 \pm 8.8^a$	5.38 x $10^7 \pm 4.6^a$

TAC: total aerobic count; TCC: total coliform count; TSSC: total *Salmonella-Shigella* count, TSC: total staphylococcal count.
Over-all mean: Over-all mean ± standard deviation
The same superscripts in a row indicate no significant difference (p>0.05)

Table 5. Mean bacterial counts of chevon samples

LOCATION	TAC (cfu/g)	TCC (cfu/g)	TSSC (cfu/g)	TSC (cfu/g)
Shinge	2.20×10^7	4.05×10^8	3.06×10^7	5.08×10^7
Lafia old market	7.58×10^7	1.85×10^8	2.19×10^8	2.86×10^7
Over-all mean	$4.89 \times 10^{7a} \pm 3.8$	$2.95 \times 10^{8a} \pm 1.6$	$1.25 \times 10^{8a} \pm 1.3$	$3.97 \times 10^{7a} \pm 1.6$

TAC: total aerobic count; TCC: total coliform count; TSSC: total *Salmonella-Shigella* count, TSC: total staphylococcal count.
Over-all mean: Over-all mean ± standard deviation
The same superscripts in a row indicate no significant difference ($p>0.05$)

4. Discussion

Results of this study indicate that fresh raw beef and chevon sold in Lafia metropolis are contaminated with different bacteria types. Seven (7) different bacterial genera comprised of both Gram positive and Gram negative species were isolated from samples collected from the open markets, abattoir and hawkers. Out of this number, six (6) genera are Gram negative bacteria with each of them contaminating more than 30% of the meat samples. This is worrisome, considering that Gram negative bacteria have been reported to account for approximately 69% of bacterial food-borne diseases [20, 21]. Similar studies conducted within and outside Nigeria [4, 18, 22-23] also reported the presence of bacteria isolated in this study, namely *Escherichia coli, Staphylococcus aureus, Staphylococcus epidermidis*, *Klebsiella* sp, *Salmonella* sp*, Shigella* sp*, Proteus* sp and *Pseudomonas aeruginosa*. Some of these isolates are of medical and public health importance because of their disease causing abilities.

E. coli, Staphylococcus aureus, Salmonella sp*,* and *Proteus* sp were more prevalent in beef samples than in chevon samples, while chevon was more contaminated with *S. epidermidis*, *Klebsiella* sp and *Shigella* sp than beef samples. The high frequency of these organisms observed in this study is indicative of unhygienic handling of beef and chevon by the butchers. *Escherichia coli* has been associated with traveler's diarrheoa and hemorrhagic colitis. Its presence in food is therefore considered a threat to human health, and an indication of gross contamination by human and/or animal faecal matter [24, 25]. Faecal contamination may have been from slaughter surfaces and water sources used for washing of carcass. It was observed during this study that butchering of cows was done on slaughter slabs and bare floor littered with animal excreta. The high incidence of *Staphylococcus aureus* (96.3%) is also worrisome, considering the heat-stable toxin that it produces. This bacterium can withstand high sodium chloride concentration and also produce enterotoxins that can withstand high temperature and cause vomiting and diarrhea upon ingestion [26]. A staphylococcal toxin dose of less than 1 microgram in contaminated food can produce symptoms of staphylococcal intoxication [27]. The incidence of *Staphylococcus aureus* suggests excessive human handling, since the bacterium occurs as a normal flora of the human and animal skin [21].

The mean microbial counts observed in this present study indicate that beef and chevon sold in Lafia are contaminated beyond acceptable limit of $10^4 - 10^5$ cfu/g [28, 29]. The mean total aerobic count (TAC) which ranged from 1.23×10^7 cfu/g in beef to 7.58×10^7 cfu/g in chevon, is higher than earlier reports of similar studies in other parts of Nigeria [18, 23, 30]. The overall mean TAC for chevon samples ($4.89 \times 10^7 \pm 3.8$ cfu/g) was found to be higher than that for beef ($1.94 \times 10^7 \pm 4.8$ cfu/g), indicating that chevon was more contaminated than beef, although the differences were not statistically significant ($p>0.05$). This finding agrees with an earlier report by [31], but is contrary to other reports of beef being more contaminated [30, 32]. These high bacterial load could affect the average shelf life of the meats and increase the chances of spoilage. The mean TAC of beef samples show that hawked samples were the most contaminated. This is not surprising considering that hawked samples are usually uncovered as the hawker moves from street to street, thereby exposing it to unhygienic conditions. As at the time of this study, chevon was not being hawked or sold at the Lafia Modern market. However, chevon collected from Lafia old market was more contaminated than that from Shinge, although differences were not statistically significant ($p>0.05$). This may not be unconnected with the observation that the water source for washing of carcass was better and healthier at Shinge than the old market.

Except for the overall mean total staphylococcal count (TSC), the overall mean total coliform count (TCC) and the overall mean total salmonella-shigella (TSSC) count were also higher in chevon than in beef, although the differences were not statistically significant ($p>0.05$). This agrees with earlier reports of similar studies [3, 4, 31]. All the counts were however, higher than acceptable safety levels of 10^2 - 10^3cfu/g [27, 28] as well as those reported in earlier studies [30, 31]. The incidence of *Salmonella* sp in this study is quite worrisome, particularly because of its implication in foodborne salmonellosis in humans, caused by ingestion of salmonella cells. Approximately 40, 000 cases are said to be reported yearly, while several cases go unreported [33]. *Salmonella typhi* is most common and is known to cause typhoid or enteric fever [18, 34]. Species of *Salmonella*, especially *Salmonella typhi* is mostly associated with contaminated water, sewage, soil or workers who are carriers of the pathogen [18, 33]. The highest mean TSSC count was observed in chevon samples from Lafia old market, which was noted to have a very poor water supply system. Again,

hawked beef samples were more contaminated with salmonellae than those from the other locations.

The high overall mean TCC observed in this study is a clear indication of unhygienic handling and faecal contamination of the meat types, which may have come from the hand of butchers, or interaction between the carcass of the slaughtered animals and their bowel contents. It was observed that butchering of slaughtered animals is done on surfaces littered with animal faeces emptied from the intestine. Also, offal and muscles of slaughtered animals are displayed for sale on the same table, making cross contamination easy. Although differences in the mean total coliform counts were not statistically significant (p>0.05), the highest mean TCC was recorded in chevon samples from Shinge. Contamination with coliforms in beef was in the order Shinge>Lafia old market>Lafia modern market> Hawkers.

The high staphylococcal count observed in this present study agrees with the reports of earlier studies conducted within and outside Nigeria [30, 32]. The overall mean TSC was higher in beef than in chevon and is in line with the report of [30]. A similar work by [32] however reported a higher staphylococcal contamination rate in chevon than in beef. Contamination by *Staphylococci* could have arisen from the body of the butchers as well as the animals, since it is a normal flora of human and animal skin [21]. The wider surface area of cows and the fact that more hands are involved in the slaughtering and butchering of the animal, when compared with the smaller size of goats with consequent lesser human interaction, may be the reason for the higher staphylococcal presence in beef than in chevon.

The foregoing reveal that fresh, raw beef and chevon retailed in Lafia are contaminated, basically by unhygienic practices engaged in by butchers, unclean water used for washing of carcass, contaminated containers, as well as contaminated slabs and slaughter surfaces. This brings to the fore, the need for handlers of raw meat to be educated on the importance of adherence to personal hygiene both at the point of slaughter and retailing of meats. Since prolonged heating can kill the vegetative forms of the contaminants identified in this study, consumers of meat should be educated on the need to properly wash and cook meat before consumption. It is also important for the National Agency for Food and Drug Administration and Control (NAFDAC) to establish and enforce safety standards for raw meat and other foods retailed in Nigeria, and also strengthen the regulation of retailed meat by conducting periodic quality control checks to ensure compliance to established safety standards. These efforts could go a long way to reduce contamination of raw meat, and safeguard public health.

5. Conclusions

Findings of this study have revealed a high contamination rate in raw, fresh beef and chevon sold in open markets, abattoirs and by hawkers in Lafia metropolis, judging by the unacceptably high microbial counts recorded. The two meat types were also found to be contaminated with pathogenic bacteria which have been implicated in cases of foodborne illness. Contamination of the meats was observed to be related to unhealthy and unhygienic handling of slaughtered animals. The researchers therefore, recommend that urgent steps geared towards availing consumers within the metropolis with safer raw beef and chevon be taken by relevant authorities, so as to forestall possible outbreak of diseases arising from consumption of beef and chevon.

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REFERENCES

[1] Duffy G. Enda C., Padraig N, Stephen O., and Francis B. 2006, A review of quantitative microbial risk in the management of *Escherichia coli* O157:H7 on beef., Meat Science, 74 (1), 76 – 88.

[2] S. Nakai and W.H. Modler, Food proteins, 1st ed., New York, USA: Wiley-VCH, 2000.

[3] Iroha, I. R., Ugbo, E. C., Ilang D. C., Oji, A. E. and Ayogu, T. E., 2011, Bacteria contamination of raw meat sold in Abakaliki, Ebonyi State Nigeria, Journal of Public Health and Epidemiology, 3(2), 49-53.

[4] Francis, A. H., Abraham, A. and Victoria, A., 2015, Microbiological and parasitological quality of local beef retailed in Accra and radiation sensitivity of *Salmonella* sp., International Journal of Current Microbiology and Applied Science, 4(4), 86-96.

[5] P. D. Warris, Meat Science: An Introductory Text, 2nd ed., Cambridge, UK: Cambridge University press, 2010.

[6] Steinkraus, K.H., 1994, Nutritional significance of fermented foods, Foods Research International, 27, 259-267.

[7] Macrae, R., Robinson, R.K. and Sailer, M.J., 1993, Encyclopaedia of Science, Food Technology and Nutrition, 6, 4233-4236.

[8] Pépin, M., Russo, P., and Pardon, P., 1997, Public health hazards from small ruminant meat products in Europe, Revue scientifique et technique-Office International des Epizooties, 16 (2), 415-425.

[9] Bhandare, S. G., Sherikarv, A. T., Paturkar, A. M., Waskar, V. S., and Zende, R. J., 2007, A comparison of microbial contamination of sheep/goat carcasses in a modern Indian abattoir and traditional meat shops, Food Control, 18: 854-868.

[10] Maha, A. M. A., Mayada, M. G., and Khaled, H. A., 2014, Prevalence, Detection and Antimicrobial susceptibility of *Listeria monocytogenes* isolated from milk and soft cheeses and its zoonotic importance, World Applied Sciences Journal,

29(7), 869-878.

[11] R. A. Lawrie, and D. A. Ledward, Lawrie's Meat Science, 7th ed, Cambridge, UK: Woodhead publishing, 2006.

[12] Zweifer. C., Fischer, R., and Stephan, R., 2008, Microbiological contamination of pig and cattle carcasses in different small-scale Swiss abattoir, Meat Science, 78, 225-231.

[13] Eze, V. C., and Ivuoma, N., 2012, Evaluation of Microbial Quality of Fresh Goat Meat Sold in Umuahia Market, Abia State, Nigeria, Pakistan Journal of Nutrition, 11 (9), 782-786.

[14] Whyte, P., McGill, K., Monahan, C., and Collins, J.D., 2004, The Effect of Sampling time on the Levels of microorganisms recovered from broiler carcasses in a Commercial slaughter plant, Food Microbiology, 21, 59-65.

[15] Nnachi, A. U., Emele, F. E., Ukaegbu, C. O., Agah, M. V., Udu-Ibiam, O. E., Chukwu, O. S., and Agwu, M. M., 2014, Prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) in raw meat and meat handlers in Onitsha, Nigeria, European Journal of Preventive Medicine, 2(1), 9-15.

[16] Raji, A. I., 2006, Bacteriological Quality of dried sliced Beef (Kilishi) sold in Ilorin metropolis, Nigeria, Applied Science and Environmental Management, 10(1), 93-96.

[17] Adetunde, L. A., Glover, R. L. K., Oliver, A. W. O., and Samuel, T., 2011, Sources and distribution of microbial contamination on beef and chevon in Navrongo, Kassena Nankana district of upper East region in Ghana, Journal of Animal Production Advances, 1(1), 21-28.

[18] Ukut, I. O. E., Okonko, I. O., Ikpoh, I. S., Nkang, A. O., Udeze, A. O., Babalola, T. A., Mejeha, O. K., and Fajobi, E. A., 2010, Assessment of bacteriological quality of fresh meats sold in Calabar Metropolis, Nigeria, Electronic Journal of Environmental, Agricultural and Food Chemistry, 9(1), 89-100

[19] R. E. Buchanan and N. E. Gibbons, Bergey's Manual of Determinative Bacteriology, 8th ed., Baltimore USA: Williams & Wilkins Co., 1974.

[20] Adak, G. K., Meakins, S. M., Yip, H., Lopman, B. A., and O'Brien, S. J., (2005), Disease Risks from Foods, England and Wales, 1996-2000, Emerging Infectious Diseases, 3(4). Available: http://www.cdc.gov/ncidrod/EID/Vol1No03/04-0191.htm.

[21] Clarence, S. Y., Obinna, C. N., and Shalom, N. C., 2009, Assessment of bacteriological quality of ready to eat food (Meat pie) in Benin City metropolis, Nigeria, African Journal of Microbiological Research, 3(6), 390-395.

[22] Nafisa, H. A., Amber, F., Adnan, K., Ameera, Y. K., and Shahana, U. K., 2010, Microbial contamination of raw meat and its environment in retail shops in Karachi, Pakistan, Journal of Infection in Developing Countries, 4(6), 382-388.

[23] Mboto, C. I., Agbo, B. E., Ikpoh, I. S., Agbor, R. B., Udoh, D. I., Ambo, E. E. and Ekim, M.A., 2012, Bacteriological study of raw meat of Calabar Abattoir with public health and veterinary importance, Journal of Microbiology and Biotechnology Research, 2(4), 529-532.

[24] Tambekar, D. H., Jaiswal, V. J., Dhanorkar, D. V., Gulhane, P. B., and Dudhane M. N., 2008, Identification of microbiological hazards and safety of ready-to-eat food vended in streets of Amravati City, India, Journal of Applied Biosciences, 7, 195 – 201.

[25] Annan-Prah, A., Amewowor, D. H. A. K., Osei-Kofi, J., Amoono, S. E., Saka, S. Y. E., and Ndadi H. A., 2011, Street foods: Handling, hygiene and client expectations in a World Heritage Site Town, Cape Coast, Ghana, African Journal of Microbiology Research, 5(13), 1629-1634.

[26] F. B. Geo, C. C. Karen, S. B. Janet, and A. M. Stephen, Jawetz, Melnick, & Adelberg's Medical Microbiology, 24th ed., USA: McGraw-Hill Medical, 2008.

[27] Food and Drug Administration (2013) Bad Bug Book: Foodborne Pathogenic Microorganisms and Natural Toxins Handbook, *Staphylococcus aureus*. Available: http://www.fda.gov/Food/FoodborneIllnessContaminants/CausesOfIllnessBadBugBook/ucm070015.htm.

[28] Food Administration Manual, Microbiological reference criteria for food, Version 2.0, October 1995.

[29] Meat Standards Committee, Microbiological testing for process monitoring in the meat industry, Guidelines approved 30th October, 2002.

[30] Agwu, U. N., and Chisom, O. U., 2014, Microbial quality of raw meat sold in Onitsha, Anambra State, Nigeria, International Journal of Science and Research, 3(2), 214-218.

[31] Antwi-Agyei, P., and Maalekuu, B. K., 2014, Determination of microbial contamination in meat and fish products sold in the Kumasi metropolis (A Case Study of Kumasi central market and the Bantama market), Merit Research Journal of Agricultural Science and Soil Sciences, 2(3), 038-046.

[32] Ahmad, M. U. D., Sarwar, A., Najeeb, M. I., Nawaz, M., Anjum, A. A., Ali, M. A., and Mansur, N., 2013, Assessment of microbial load of raw meat at abattoirs and retail outlets, The Journal of Animal & Plant Sciences, 23(3), 745-748.

[33] P. K. Talaro and A. Talaro, Foundations in Microbiology, 4th ed., New York: McGraw Hill, 2002.

[34] L. Hu and D. J. Kopecko, Typhoid *Salmonella*, D. M. Marianne, and W. B. Jeffrey, Eds., International Handbook of Food Borne Pathogens, New York: Marcel Dekker, 2003.