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Detection of Multidrug-Resistant *Staphylococci* in Beef Processing Line

Sığır Eti İşleme Hattında Çoklu İlaç Dirençli *Stafilokokların* Belirlenmesi

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ABSTRACT

Some *Staphylococcus* species are zoonotic and the non-zoonotic species may harbor antibiotic-resistance genes for transmission to humans via the food chain. The study aimed at determining the staphylococci contamination of beef processed for human consumption and the antibiogram of the organisms. Isolation and identification of *Staphylococcus* from beef and the meat contact surfaces were done following standard microbiological protocols, including the Application Programmed Interface. Disc diffusion method was used to test the susceptibility of the staphylococci to 14 commonly used antimicrobial agents. The mean staphylococci load of the beef before processing was $5.0 \times 10^9 \pm 1.0 \times 10^5$ and $7.1 \times 10^9 \pm 1.0 \times 10^6$ cfu/cm^2 after. Of the 200 samples tested, *Staphylococcus* spp. were isolated in 25 (12.5%). The isolates were *Staphylococcus aureus* (12%), *Staphylococcus xylosus* (56%), *Staphylococcus cohnii* (16%), *Staphylococcus saprophyticus* (12%), and *Staphylococcus hominis* (4%). Twenty-two (88%) of the isolates were resistant to antimicrobials, including those listed in World Health Organization's list of "*high*" and "*highest*" priority antibiotics. Eighteen isolates (81.8%) were multidrug resistant while 4 (21%) were resistant to at least 1 antimicrobial agent. Isolation of multidrug-resistant *Staphylococcus* from beef and the meat contact surfaces portends significant food safety and public health risks as the organisms or their resistance determinants are transmissible to humans via the food chain. This emphasizes the need for the adoption of the "farm to fork" concept of food safety in beef production and processing lines to forestall staphylococci meat contamination and hence the untoward public health and economic consequences thereof.

Keywords: Beef, contact surfaces, multidrug-resistant *Staphylococcus*, Kwata slaughterhouse, Nigeria

ÖZ

Bezelye İşleme Hattında Çoklu İlaç Dirençli Stafilokokların Belirlenmesi Bazı Staphylococcus türleri zoonotiktir ve zoonotik olmayan türler de antibiyotik direnci genlerini barındırabilir ve gıda zinciri yoluyla insanlara iletebilir. Bu çalışmanın amacı, insan tüketimi için işlenen sığır etindeki stafilokok kirliliğini ve organizmaların antibiyogramını belirlemektir. Sığır eti ve et temas yüzeylerinden Staphylococcus izolasyonu ve tanımlaması yapılması için Aplikasyon Programlı Arayüz gibi standart mikrobiyolojik protokoller kullanıldı. Stafilokokların 14 yaygın olarak kullanılan antimikrobiyal ajanlara duyarlılığı disk difüzyon yöntemiyle test edildi. İşlemden önceki ortalama stafilokok yükü 5.0 x 109 ± 1.0 x 105 idi ve işlemden sonra 7.1 x 109 ± 1.0 x 106 cfu/cm2 oldu. Test edilen 200 örnekten 25'inde (%12,5) Staphylococcus spp. izole edildi. İzolatlar Staphylococcus aureus (%12), Staphylococcus xylosus (%56), Staphylococcus cohnii (%16), Staphylococcus saprophyticus (%12) ve Staphylococcus hominis (%4) idi. İzolatların 22'si (%88) Dünya Sağlık Örgütü'nün "yüksek" ve "en yüksek" öncelikli antibiyotiklerinin listesinde yer alanlar da dahil olmak üzere antimikrobiyallere dirençliydi. On sekiz izolat (%81,8) multidrug-resistant iken 4'ü (%21) en az bir antimikrobiyal ajana dirençliydi. Sığır eti ve et temas yüzeylerinden çoklu ilaç dirençli Staphylococcus izole edilmesi, organizmaların veya direnç belirleyicilerinin gıda zinciri yoluyla insanlara taşınması bakımından önemli gıda güvenliği ve halk sağlığı riskleri taşımaktadır. Bu sonuç da, sığır üretimi ve işleme hatlarında gıda güvenliği "çiftlikten çatala" kavramının benimsenmesinin stafilokok et kirliliğini önlemek ve buna bağlı olarak olumsuz halk sağlığı ve ekonomik sonuçları engellemenin gerekliliğine vurgu yapmaktadır.

Anahtar Kelimeler: Sığır eti, temas yüzeyleri, çoklu ilaca dirençli Staphylococcus, Kwata mezbahası, Nijerya

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INTRODUCTION

Foodborne pathogens are the leading causes of illnesses and death globally, costing billions of dollars in medical care and social costs.[1] Although foodborne diseases affect persons of all ages, the burden is more in children below the age of 5, immunologically compromised individuals and people residing in developing and low-income countries.[2] Globally, many foodborne disease outbreaks have been associated with the consumption of contaminated foods of animal origin. Of these outbreaks, staphylococcus food diseases (staphyloenterotoxicosis or staphyloenterotoxemia) are prominent,[3] although campylobacteriosis and salmonellosis are also in the front burners.[4]

In developing counties, majority of meats consumed are slaughtered at homes or in clandestine slaughterhouses.[5] This makes the bacteriological qualities of these meats uncertain due to poor sanitary conditions of the staff, equipment, meat contact surfaces, and the environment in most slaughterhouses.[6] Further meat contamination occurs in the slaughterhouses as a result of poor planning during the construction of slaughterhouse, lack of required amenities, and non-adherence to rules guiding food animal slaughter or processing for human consumption.[7]

Consequently, quite a good number of bacterial meat contaminants have been reported in Nigerian slaughterhouses.[8-10] Most of these contaminants may be zoonotic, pathogenic, or harbor antimicrobial-resistance determinants transmissible to humans via the food chain. Of all bacterial meat contaminants, emphasis has been on the *Staphylococcus* species, especially coagulase-positive staphylococci (*Staphylococcus aureus* and *Staphylococcus pseudintermedius*) due to their zoonotic and pathogenic potentials. However, the coagulase-negative *Staphylococcus* (CoNS) species are equally important. Their importance lies in the fact that CoNS cause opportunistic infections which may degenerate into severe diseases in immune-compromised hosts.[3] Additionally, the CoNS are reservoirs of antimicrobial resistance genes, due to frequent exposure to low doses of antimicrobials occasioned by the imprudent use of the drugs in medical and veterinary practices.[11]

Meats contaminated with *Staphylococcus* species are major causes of foodborne disease outbreaks as the moisture and nutritional contents of meat facilitate bacterial growth and proliferation.[3] In addition, the organisms are capable of surviving as commensals on the skin and nares of meat processors and food handlers, as well as on inanimate surfaces like clothing, meat contact surfaces, and meat processing equipment.[12]

Staphylococcus ranks high as a major cause of foodborne intoxication globally because most toxigenic species are capable of elaborating toxins. Some of these toxins are heat stable, resistant to the activities of proteolytic enzymes and can cause intoxication even at low doses.[13] Unfortunately, the ambient temperature in most tropical climates, including Nigeria, favors the proliferation of *Staphylococcus* and the production of toxins in the toxigenic species.[3] In both *Staphylococcus* food poisoning and intoxication, the onset of clinical manifestations depends on the immune status of the host and includes nausea, vomiting, stomach aches, chills, fever, and diarrhea as well as cause abscess, fatal sepsis, endocarditis, meningitis, and toxic shock.[14,15]

Considering the state of some slaughterhouse facilities and the role of slaughterhouse workers in the spread of zoonotic pathogens in the meat supply chain in Nigeria;[6,16] meat processed for human consumption in Anambra State, Nigeria, may be contaminated with *Staphylococcus* species in view of the ubiquitous nature of the organisms. Detection of drug-resistant *Staphylococcus* in the meat and abattoir environment could provide a scientific basis for improvement in sanitary conditions of the facilities which will bring about great economic and public health gains to humanity. In addition, the antimicrobial resistance profile of the staphylococci contaminants could guide empirical antibiotic treatment in cases of suspected *Staphylococcus* foodborne diseases or intoxication.

Published data on staphylococcal contamination of beef and or the meat contact surfaces, as well as the antibiogram of the bacteria in Anambra State are sparse and far between. Therefore, this study determined *Staphylococcus* contamination of beef and meat contact surfaces in Anambra State, Nigeria, and also the antimicrobial-susceptibility profile of the isolates in order to recommend appropriate and implementable public health action.

MATERIALS AND METHODS

Study Area

The study was conducted in Kwata slaughterhouse (KSH), Anambra State, Nigeria. The KSH is an open system with neither roof nor doors. Therefore, visitors as well as scavenging animals and birds have unrestricted access to the facility. The slaughterhouse is the major source of meat supply to Awka, the capital city of Anambra State. The demographics of the state have been published,[17] and the geographical location of Awka is shown in Figure 1.

Study Design and Sampling

The study adopted a cross-sectional study design. Using the prevalence of 9.4% earlier recorded,[3] a minimum sample size of 72 was calculated as earlier described.[18] However, 200 samples were used in this study for buoyancy and accuracy of data. Swab samples were collected from 2 cm^2 of the groin skin before processing and from the same site of the meat carcass after processing and different meat contact surfaces (before and after contact with dressed beef) in the slaughterhouse using sterile swab sticks moistened with 0.1% peptone water. A systematic random sampling (1 in 5) was used in the selection of beef and the contact surfaces for swab sample collection. The surfaces sampled were slaughter floor, meat dressing table, washing bucket, bleeding knife, butchers' footwear, knife sharpener, wheelbarrow, washing water, and meat display table. In all, 200 samples were collected over a period of 10 weeks.

Determination of *Staphylococcus* Contamination

The *Staphylococcus* load of the beef and the contact surfaces were determined by aerobic bacterial count (enumeration) as described.[19] Briefly, swab samples were transferred aseptically into a sterile stomacher bag containing 225 mL of 0.85% sterile saline solution and homogenized in a stomacher (Stomacher® 400 Circulator, Seward, Ltd., UK) for 2 minutes at room temperature to achieve a 10-1 dilution. Microbial extracts were serially diluted in sterile distilled water. Each diluted 1 mL sample was plated individually and spread thoroughly on mannitol salt agar and incubated at 37°C for 48 hours for staphylococcal counting. Glistening whitish/creamy and yellow colonies were recorded and counted as Staphylococcus. All analyses were performed in triplicate, and results were expressed as the logarithm of colony-forming units per cm^2 (Log CFU/cm^2). Plate counts were determined and converted to $\log_{10}$ CFU values using standardized plate count

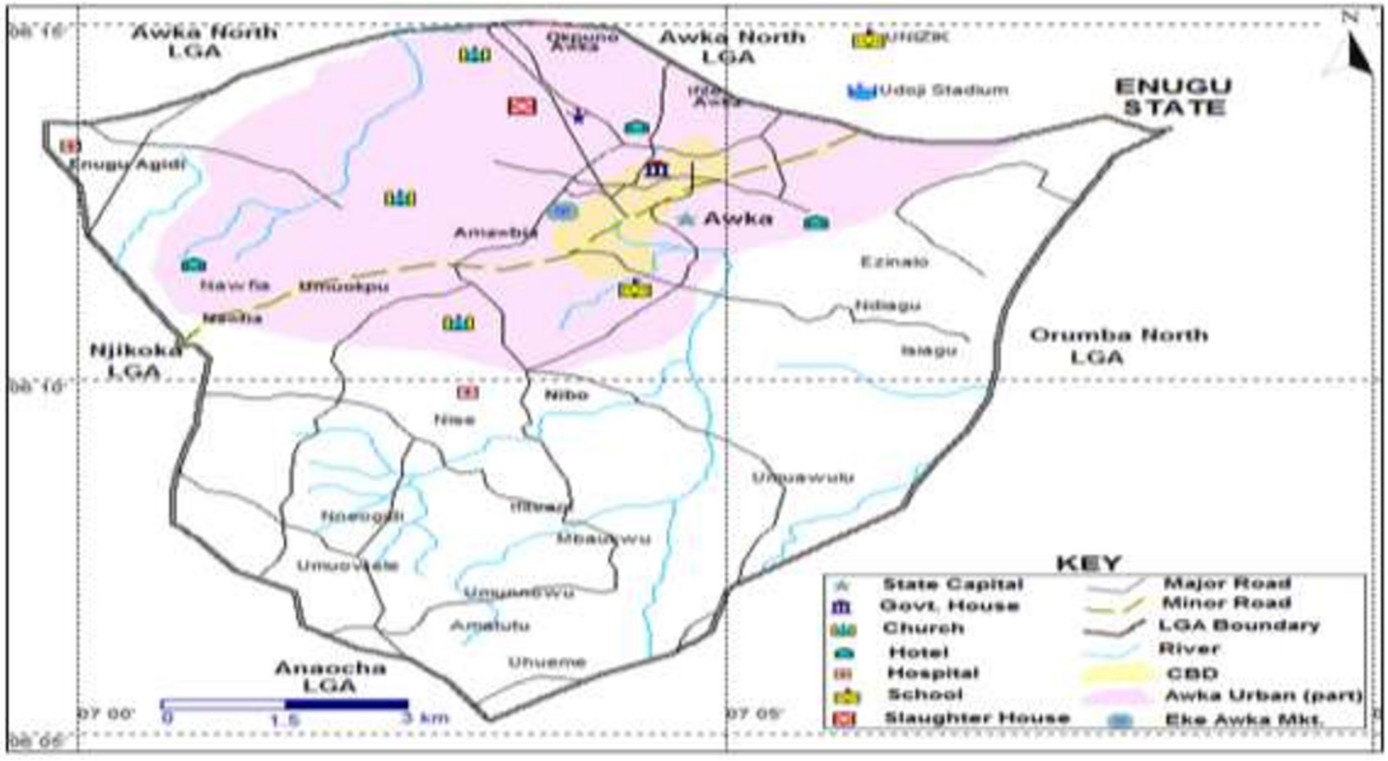

Figure 1. Map of Anambra State showing the study area.

rules.[19] Isolation of *Staphylococcus* species was done using mannitol salt agar (Oxoid, Basingstoke, UK) according to the method of Cheesbrough.[20] At first, the swab samples were pre-enriched in nutrient broth supplemented with 7.5% NaCl for 24 hours at 37°C. Thereafter, a loop full of the pre-enriched samples was streaked on mannitol salt agar and incubated at 37°C for another 24 hours. In plates that yielded growth, 1 or 2 whitish/creamy and yellow colonies on the agar were purified on nutrient agar (Oxoid, Basingstoke, UK). Putative *Staphylococcus* colonies, appearing cream on nutrient agar, were further subjected to Gram-staining and catalase tests. Gram-positive cocci in bunches that produced vigorous bubbles on emulsification with 3% H_2O_2 were subjected to further characterization and speciation using the Application Programmed Interface Staph kit (Biomerieux®, France) according to the manufacturer's instruction.

Antimicrobial Resistance Profiling

Antimicrobial susceptibility testing of the staphylococcal isolates was performed by disc diffusion method according to the guidelines of the Clinical Laboratory Standards Institute[21] with discs (Oxoid Hampshire England) impregnated with the following 13 antimicrobial agents belonging to 6 classes: β-lactam—ceftriaxone (30 µg), cefixime (5 µg), ampicillin (10 µg), and amoxicillin (10 µg), macrolides—erythromycin (15 µg), fluoroquinolones—ciprofloxacin (5 µg), levofloxacin (5 µg), norfloxacin (10 µg), and ofloxacin (5 µg), aminoglycosides—gentamicin (10 µg) and streptomycin (10 µg), ansamycin—rifampicin (5 µg), and phenicols—chloramphenicol (30 µg). *Staphylococcus aureus* ATCC 25923 was used as a quality-control strain for susceptibility. Inhibition zone diameters were interpreted in accordance with the breakpoints for *Staphylococcus*.[21] An isolate resistant to at least 1 antimicrobial agent in 3 or more classes/categories of antimicrobial agents was considered multidrug-resistant.

Statistical Analyses

Data bothering on the prevalence and antimicrobial resistance profile of the isolates were analyzed descriptively. Results obtained for the bacteria count were summarized as mean ± standard error of mean. Mean values of the bacterial load for beef and the various contact surfaces were compared using a 1-way analysis of variance. Duncan's multiple range test was used to separate variant means. Values were considered significant at $P < .05$. All the statistical analyses were performed using IBM® Statistical Package for Social Sciences statistics version 23 (SPSS Inc., Chicago, Ill, USA).

Ethical Approval

The research was conducted in accordance with the guidelines laid down by local laws and regulations, and the swab samples used for the study were collected from surfaces of carcasses, floors, and materials used for their processing in the slaughterhouses. The University of Ibadan Animal Care and Use Research Ethics Committee gave ethical permission for the work with the number UI-ACUREC/APP/2015/047 issued on 15/11/2015.

RESULTS

The mean staphylococci load of the beef before and after contact with processing equipment and surfaces were $0.50 \times 10^{10} \pm 0.10 \times 10^{6}$ and $0.71 \times 10^{10} \pm 1.0 \times 10^{6}$ cfu/cm^2, respectively. Results on the bacterial loads of the different beef contact surfaces are presented in Table 1. There was a significant ($P < .05$) increase in the *Staphylococcus* load in the washing water after beef immersion. Also, there was a significant ($P < .05$) increase in *Staphylococcus* contamination of the beef after processing.

Out of 200 samples processed, *Staphylococcus* species were isolated in 25 (12.5%) samples. The isolates were *S. aureus*, 3

Table 1. Mean *Staphylococcus* Counts in Different Beef Contact Surfaces (n=20 Each) Collected from Kwata Slaughterhouse, Anambra State, Nigeria

Contact Surfaces	Number of Samples that Yielded Growth (%)	*Mean Staphylococcus* Count (cfu/cm²)	
		Before Beef Contact	After Beef Contact
SF	3 (15)	$1.1 \times 10^9 \pm 1.1 \times 10^{6a}$	$1.0 \times 10^9 \pm 1.1 \times 10^{5b}$
MDT	4 (20)	$1.1 \times 10^9 \pm 1.0 \times 10^{6a}$	$1.1 \times 10^9 \pm 1.0 \times 10^{6a}$
WBu	2 (10)	$1.1 \times 10^9 \pm 1.1 \times 10^{5a}$	$1.0 \times 10^9 \pm 1.0 \times 10^{5b}$
BK	2 (10)	$1.1 \times 10^9 \pm 1.1 \times 10^{5a}$	$1.0 \times 10^9 \pm 1.0 \times 10^{6b}$
BFW	2 (10)	$1.0 \times 10^9 \pm 1.1 \times 10^{5a}$	$1.1 \times 10^9 \pm 1.0 \times 10^{6b}$
KS	2 (10)	$1.0 \times 10^9 \pm 1.1 \times 10^{5a}$	$1.0 \times 10^9 \pm 1.1 \times 10^{5b}$
WB	3 (15)	$1.1 \times 10^9 \pm 1.1 \times 10^{5a}$	$1.0 \times 10^9 \pm 1.0 \times 10^{5b}$
BDT	3 (15)	$6.0 \times 10^9 \pm 1.1 \times 10^{5a}$	$7.1 \times 10^9 \pm 1.1 \times 10^{6b}$
WW	1 (5)	$7.1 \times 10^9 \pm 1.0 \times 10^{5a}$	$1.1 \times 10^{10} \pm 1.0 \times 10^{5b}$

BDT, beef display table; BFW, butchers footwear; BK, bleeding knife; CFU, colony-forming unit; KS, knife sharpener; MDT, meat dressing table; SF, slaughter floor; WB, wheelbarrow; WBu, washing bucket; WW, washing water.
Different superscripts across the rows (within contact surfaces) indicate statistical significance.

(12%); *S. xylosus*, 14 (56%); *S. cohnii sub-species cohnii*, 4 (16%); *S. saprophyticus*, 3 (12%); and *S. hominis*, 1 (4%). The only *S. hominis* isolated was resistant to ceftriaxone, cefixime, ofloxacin, and clindamycin. Three isolates (2 *S. xylosus* and 1 *S. saprophyticus*) were susceptible to all the 14 antimicrobial agents used in the susceptibility testing. Details on the resistance profile of the other 22 isolates are presented in Table 2.

Results on the susceptibility of the *Staphylococcus* species to each of the antimicrobials are shown in Table 3. Of the 25 isolates, 18 (81.8%) were multidrug-resistant, following their non-susceptibility to at least 1 antimicrobial agent in 3 or more classes or groups of antimicrobials. Four isolates (21%) were resistant to at least 1 antimicrobial agent used in the susceptibility test. The resistance of the isolates to the antimicrobials in decreasing order were ofloxacin (14/25, 56%) > clindamycin (13/25, 52%) > norfloxacin (12/25, 48%) > ceftriaxone (10/25, 40%) > amoxicillin and rifampicin (9/25, 36%) > ampicillin and cefixime (8/25, 32%) > streptomycin (7/25, 28%) > chloramphenicol (6/25, 12%) > erythromycin (3/25, 12%) > ciprofloxacin (2/25, 8%). All the isolates were susceptible to levofloxacin and gentamicin (Table 3).

Twenty-two resistance patterns/phenotypes were observed for the antimicrobial-resistant isolates (Table 4). The patterns ranged from 1 to 10 antimicrobials and none had the same resistant pattern as the other. The resistance phenotypes indicated that 7, 10, and 5 isolates exhibited resistance to 8-10, 3-6, and 1-2 antimicrobials, respectively (Table 4).

Table 2. Antimicrobial Resistance Profile of *Staphylococcus* species (n=25) Isolated from Beef and Meat Contact Surfaces and Processing Equipment at Kwata Slaughterhouse, Nigeria

Antibiotics	Number of Resistant *Staphylococci* Species (%)			
	S. aureus (n=3)	*S. xylosus* (n=14)	*S. cohnii* (n=4)	*S. saprophyticus* (n=3)
Erythromycin	0 (0.0)	2 (14.3)	1 (25.0)	0 (0.0)
Ceftriaxone	2 (66.7)	3 (21.43)	3 (75.0)	2 (66.7)
Ampicillin	0 (0)	6 (42.9)	1 (25.0)	1 (33.3)
Cefixime	2 (66.7)	2 (14.3)	3 (75.0)	1 (33.3)
Levofloxacin	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Norfloxacin	2 (66.7)	5 (35.7)	3 (75.0)	2 (66.7)
Ciprofloxacin	0 (0.0)	1 (7.1)	1 (25.0)	0 (0.0)
Gentamicin	0 (0)	0 (0.0)	0 (0.0)	0 (0.0)
Ofloxacin	3 (100.0)	6 (42.9)	3 (75.0)	2 (66.7)
Clindamycin	3(100.0)	5 (35.7)	4 (100.0)	1 (33.3)
Amoxicillin	0 (0.0)	5 (35.7)	3 (75.0)	1 (33.3)
Streptomycin	0 (0.0)	4 (28.6)	1 (25.0)	2 (66.7)
Rifampicin	0 (0.0)	5 (35.7)	2 (50.0)	2 (66.7)
Chloramphenicol	1(33.3)	3 (21.43)	1 (25.0)	1 (33.3)

Table 3. Susceptibility of *Staphylococcus* Species (n=25) Isolated from Beef and Meat Contact Surfaces at Kwata Slaughterhouse to Different Antimicrobial Agents

Antimicrobials (μg)	Number of resistant isolates (%)
Ofloxacin (5)	14 (56)
Clindamycin (2)	13 (52)
Norfloxacin (10)	12 (48)
Ceftriaxone (30)	10 (40)
Amoxicillin (10)	9 (36)
Rifampicin (5)	9 (36)
Ampicillin (10)	8 (32)
Cefixime (5)	8 (32)
Streptomycin (10)	7 (28)
Chloramphenicol (30)	6 (24)
Erythromycin (15)	3 (12)
Ciprofloxacin (5)	2 (9)
Levofloxacin (5)	0
Gentamicin (10)	0

Table 4. Antimicrobial Susceptibility Profile of *Staphylococcus* Species (n=25) Isolated from Beef and Meat Contact Surfaces and Processing Equipment at Kwata Slaughterhouse, Nigeria

Antimicrobial Resistance Phenotypes	Number (%) of Isolates Exhibiting the Pattern
E	1 (4)
OF	1 (4)
CE	1 (4)
AP	1 (4)
O-CD	1 (4)
N-S-RD	1 (4)
AP-S-RD	1 (4)
N-OF-CD	1 (4)
E-AP-N-AMX	1 (4)
CT-CE-OF-CD	1 (4)
CT-CE-OF-CD-S	1 (4)
CE-OF-CD-AMX-RD	1 (4)
CT-N-OF-CD-S-RD	1 (4)
CT-CE-N-OF-CD-CH	1 (4)
CT-AP- N-OF-CD-AMX	1 (4)
CT-AP-CIP-OF-CD-AMX-CH	1 (4)
AP-N-OF-CD-AMX-S-RD-CH	1 (4)
CT-CE-N-CIP-OF-CD-AMX-RD	1 (4)
E-CE-N-CIP-O-CD-AM-RD-CH	1 (4)
E-CE-N-CIP-OF-CD-AMX-RD-CH	1 (4)
CT-AP-CE-LV-N-OF-AMX-S-R-CH	1 (4)
CT-AP- CE-N-OF-CD-AMX-S-RD-CH	1 (4)

AMP, ampicillin; AMX, amoxicillin; C, chloramphenicol; CD; clindamycin, CE, cefixime; CIP, ciprofloxacin; CN, gentamicin; CRO, ceftriaxone; E, erythromycin; LEV, levofloxacin; N, norfloxacin; OF, ofloxacin; RD, rifampicin; S, streptomycin.

DISCUSSION

The high *Staphylococcus* contamination of beef and the processing facilities found may be attributed to poor hygienic practices at farm and slaughterhouse levels.[22] Non-adherence to hygiene practices in all stages of meat production causes adverse health effects on animal health and decreases the microbial quality of the meat,[23] thereby raising serious food safety and public health concerns. In developing countries, poor hygiene practices in livestock farms or during transportation, marketing, or processing of animal is very common.[22,24] Moreover, the unsanitary conditions in which cattle in transit or those awaiting slaughter in lairage

could also have contributed to the meat contamination with *Staphylococcus*.

Additionally, the practices of flaying and evisceration on cattle carcasses on the bare floor, immersion in beef in water of unproven bacteriological quality, and lack of routine decontamination of slaughterhouses and slaughter equipment may have contributed to the high bacterial loads found in the beef, contact surfaces, and processing equipment. In the KSH disposal of wastes into streams and the use of water from the same streams to wash carcasses are common practices. This may have also accounted for the high staphylococcal counts found, which were higher than the recommended maximum permissible limits as cited by Edward et al.[25]

In addition, the colony counts of *Staphylococcus* in this study are higher than that recorded in Abuja and Aba abattoirs.[25,26] The high counts found are of public health significance as consumption of meat heavily contaminated with *Staphylococcus* species, may overwhelm the host immune defense system, and hence the onset of staphylococcal diseases, especially in immune-deficient individuals.[27]

Furthermore, the contaminated meat or meat processing equipment can contaminate ready-to-eat foods in the kitchens of food vendors and meat buyers. This may enhance further transmission of the *Staphylococcus* species through ingestion of the contaminated foods. The infection can also spread via contact with abraded skin. This is of great public health importance knowing that most abattoir workers in Nigeria, including KSH workers, do not use protective equipment during routine duties.[28]

Although the toxigenic potentials of the isolates were not determined, the isolation of known toxigenic staphylococcal species from the meats and the contact surfaces casts aspersion on the toxicological safety of the beef. While most Africans have the culture of proper meat cooking (heating at 80-100°C for over 30 minutes) which may be sufficient to kill off most pathogens in meats,[29] it does not deactivate heat-labile toxin if present, no matter the heating temperature or duration of cooking.[3]

The multidrug resistance noted in the isolates as well as the non-susceptibility to vital antibiotics such as quinolones and ceftriaxone portends great public health problems. The resistance may be due to large-scale indiscriminate use of antibiotics in medical practice and animal agriculture as antimicrobial use is not well regulated in Nigeria.[3] Although some of the isolates were not pathogenic species, their ingestion could result in the compromise of antimicrobial therapy in individuals colonized by them.

As a result of the observations of the study, the clinical importance and pathogenic potentials of different *Staphylococcus* isolates found are noteworthy. The recovery of *S. saprophyticus*, *S. xylosus*, *S. aureus*, and *S. homini* from beef and slaughterhouse contact surfaces in this study calls for serious concern since these staphylococcal species have been implicated in a wide range of diseases, especially in immunocompromised persons.[33] Infections with *S. aureus* usually result in a large range of clinical manifestations including infertility, food poisoning and intoxication, skin and soft tissue diseases, surgical site abnormalities, pleuro-pneumonia, and several other life-threatening conditions that resulted in a large number of deaths annually.[30] Cognizant that human immunodeficiency virus burden and other immune-modulating infections are high in Nigeria,[31] the synergy of these infections and Staphylococcosis could overwhelm the health of immune-deficient individuals and further pressurize the already precarious health facilities in Nigeria.

Beef processed for human consumption in Anambra State was contaminated with multidrug-resistant *Staphylococcus*, and this may pose deleterious health effects on the meat consumers. The contamination may be due to unhygienic practices in the meat production and processing lines hence the need for the adoption of the farm-to-fork concept of food safety. In the meantime, proper cooking of the meat is recommended to limit the odds of bacterial infection and the untoward health and economic effects thereof.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of University of Ibadan (Date: November 15, 2015, Decision No: UI-CUREC/APP/2015/047).

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – C.U.O., U.M., J.A.N., G.O.E.; Design – U.M., J.A.N., G.O.E.; Supervision – J.A.N., G.O.E.; Resources – C.U.O., S.C.O.; Materials – C.U.O., S.C.O.; Data Collection and/or processing – C.U.O., S.C.O., U.M.; Analysis and/or Interpretation – A.J.O., U.M., J.A.N.; Literature Search – C.U.O., E.O.N., A.J.O., U.M.; Writing Manuscript – A.J.O., E.O.N.; Critical Review – A.J.O., E.O.N., U.M.

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