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Microbiological Assessment of Fresh Beef from Bwari and Kubwa Abattoirs: Focus on Staphylococcus Aureus Isolation and Identification

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Abstract

Staphylococcus aureus is a Gram-positive bacterium widely recognised for its role in both clinical infections and foodborne illnesses. Its presence in meat products poses a considerable public health risk due to its ability to contaminate food and produce harmful enterotoxins. This study aimed to isolate and identify S. aureus from fresh meat samples obtained from slaughterhouses in Bwari and Kubwa, Abuja, Nigeria. A total of 100 meat samples were randomly and aseptically collected. The sample size was determined using the single proportion formula described by Lwanga and Lemeshow (1991), based on an assumed prevalence of 30%, a 95% confidence level, and a 10% margin of error. This number also aligns with international microbiological food safety guidelines, such as those of the International Commission on Microbiological Specifications for Foods (ICMSF), which recommend 60–100 samples for microbial quality assessments. Standard microbiological methods were employed for the preliminary identification of S. aureus, including culturing on Mannitol Salt Agar, Gram staining, and biochemical characterisation. Confirmation was performed using the coagulase test, a well-established diagnostic marker for pathogenic S. aureus. Results showed that 36% of the samples exhibited growth typical of S. aureus on selective media, while 18% were confirmed as coagulase-positive S. aureus. These findings underscore the potential public health hazards linked to meat contamination at the abattoir level and highlight the urgent need for improved hygiene practices during meat processing and handling.

Keywords: Staphylococcus Aureus, Foodborne Pathogens, Coagulase-positive, Meat Contamination, Abattoir Hygiene, and Microbial Isolation.

1. Introduction

Meat is a nutritionally rich food source valued worldwide for its high-quality protein, essential amino acids, and micronutrients such as vitamin B12, iron, and zinc, elements crucial for growth, immune function, and cognitive development (Hoffman & Falvo, 2004). In developing countries like Nigeria, meat plays a central role in cultural, economic, and dietary systems. Its nutrient bioavailability often surpasses that of plant-based foods, making it essential for addressing malnutrition in vulnerable populations such as children and pregnant women (Neumann et al., 2002).

However, meat is also a common vehicle for foodborne pathogens, especially when contamination occurs during slaughter, processing, storage, or retail. Organisms such as Staphylococcus aureus, Escherichia coli, Salmonella spp., and Listeria monocytogenes have been implicated in numerous foodborne outbreaks globally (Newell et al., 2010). Abattoirs are critical points in the meat production chain where hygiene practices directly impact the microbiological safety of meat. Ideally, abattoirs should operate under strict sanitary standards, with trained personnel, clean water, and effective waste disposal systems (WHO, 2008). In reality, however, many abattoirs in sub-Saharan Africa, including Nigeria, lack infrastructure and regulatory oversight, resulting in unhygienic practices such as evisceration on dirty surfaces or use of contaminated water (Adeyemo, 2002). Contamination sources in abattoirs are diverse. Human handlers, via inadequate hand hygiene or lack of protective equipment, are major contributors (Buncic et al., 2014; Bosilevac et al., 2009). Poorly cleaned equipment, such as knives, conveyor belts, and evisceration tools, can harbour bacteria, especially when biofilms form on damp or unclean surfaces (Nychas et al., 2008; Møretrø & Langsrud, 2017). Additionally, pest infestations and outdated facility designs create niches for microbial growth (Hathaway & McKenzie, 1991, Onyema et al, 2025). The implementation of Hazard Analysis and Critical Control Points (HACCP) remains a globally recognised approach for minimising such contamination risks (Motarjemi & Käferstein, 1999). Staphylococcus aureus, a Gram-positive, facultatively anaerobic bacterium, is a prominent foodborne pathogen that naturally colonises human skin and mucous membranes. Approximately 30% of the human population carries S. aureus asymptomatically (Tong et al., 2015). In abattoirs, it may be introduced via direct human contact or contaminated surfaces (Otto, 2010). Its pathogenicity stems from various virulence factors, including surface adhesins, tissue-invasive enzymes, and exotoxins such as staphylococcal enterotoxins (SEs), toxic shock syndrome toxin-1 (TSST-1), and Panton–Valentine leukocidin (PVL), which contribute to diseases ranging from food poisoning to life-threatening infections (Foster, 2005; Gordon & Lowy, 2008).

A growing concern is the rise of methicillin-resistant S. aureus (MRSA), which shows resistance to β-lactam antibiotics and is frequently multidrug-resistant. MRSA strains are no longer limited to healthcare settings; they are now found in the community and in livestock, raising concerns about zoonotic and foodborne transmission (Argudín et al., 2010; Smith & Wardyn, 2015). The presence of MRSA in retail meat highlights the potential role of the food chain in disseminating resistant pathogens (Waters et al., 2011). As such, a One Health approach is critical to addressing antimicrobial resistance at the interface of humans, animals, and the environment (WHO, 2017, Onyema, 2025).

To ensure meat safety and public health, routine microbial assessments in abattoirs are essential. Microbial risk assessment (MRA) supports hazard identification and helps guide food safety policy, particularly in light of emerging pathogens and antimicrobial resistance (FAO/WHO, 2006). Regular microbiological testing of carcasses, surfaces, and equipment verifies hygiene compliance and the effectiveness of Good Manufacturing Practices (GMPs) and HACCP systems (Liu et al., 2020; EFSA, 2019). Abattoir-based surveillance contributes not only to food safety enforcement but also to outbreak source tracking and public health intervention design. Surveillance data have played critical roles in controlling pathogens like Salmonella in Europe and North America (CDC, 2021). Given the global burden of foodborne S. aureus, particularly in underreported regions, local surveillance remains vital (Hennekinne et al., 2012, Onyema et al, 2025b).

This study investigates the occurrence and phenotypic characteristics of Staphylococcus aureus in fresh meat from abattoirs in Abuja, Nigeria. The findings aim to inform public

health strategies, strengthen food safety systems, and contribute to antimicrobial resistance monitoring efforts.

2. Statement of the problem

Staphylococcus aureus, a major foodborne pathogen renowned for its enterotoxin production, continues to be detected in raw and processed meats globally, even where food safety regulations exist (Bover-Cid & Casula, 2015; de Oliveira et al., 2019). In Nigeria, and specifically in the FCT Abuja abattoirs, contamination levels remain poorly documented, pointing to gaps in hygiene practices and surveillance (Huang et al., 2021; Bosch et al., 2018). The escalating occurrence of antimicrobial-resistant S. aureus, particularly MRSA, further complicates treatment and food safety responses (Bosch et al., 2018). Without a comprehensive localised assessment of S. aureus prevalence, contamination pathways, and contributing behaviours across the meat handling value chain, both public health and consumer trust remain at risk.

3. Purpose of the Study

The primary purpose of this study was to investigate the presence of Staphylococcus aureus in fresh meat samples collected from slaughterhouses in Bwari and Kubwa, Abuja. Specifically, the study aimed to:

1. Isolate Staphylococcus aureus from fresh meat samples obtained at the point of slaughter.
2. Identify the isolated strains using standard biochemical techniques.

4. Significance of the Study

The isolation and identification of Staphylococcus aureus from fresh meat in slaughterhouses carries substantial public health, industrial, and scientific relevance. This research addresses a key food safety concern by assessing the presence of a well-documented foodborne pathogen at a critical control point in the meat supply chain.

Slaughterhouses serve as a direct interface between livestock and consumer products; contamination at this stage can significantly affect public health and food industry outcomes. This study contributes to understanding the prevalence of S. aureus in local abattoirs, particularly where hygienic practices may be inconsistent or poorly enforced. Identifying and characterising bacterial isolates, including potential methicillin-resistant strains (MRSA), supports early detection and prevention efforts, reducing the incidence of foodborne illnesses and the associated public health burden. From an industrial perspective, the findings can inform stakeholders, including abattoir managers, meat processors, and food regulators, on strengthening hygiene protocols and implementing targeted interventions to reduce microbial contamination. This not only enhances product quality and consumer trust but also minimises economic losses from product recalls or non-compliance penalties.

Scientifically, the study contributes to the limited data on microbial contamination in Nigerian meat production environments. It offers a foundation for future research on antimicrobial resistance, pathogen transmission, and the evaluation of food safety interventions.

5. Scope of the Study

This study focuses on the isolation and identification of Staphylococcus aureus from fresh beef meat samples collected from the Bwari and Kubwa slaughterhouses in Abuja, Nigeria. A

total of 100 samples were obtained directly at the point of slaughter. The scope is geographically limited to these two abattoirs, providing a localised assessment of microbial contamination in fresh meat within the Federal Capital Territory (FCT).

6. Justification for the Study

The rising demand for beef in Nigeria, particularly in urban centres such as Abuja, underscores the need for stringent meat hygiene and food safety measures. Staphylococcus aureus poses a significant public health risk due to its ability to cause food poisoning via enterotoxin production and its increasing resistance to commonly used antibiotics.

Fresh beef is a known vehicle for S. aureus, especially when contamination occurs during slaughter, processing, or handling under unhygienic conditions. Bwari and Kubwa are two major abattoirs that supply meat to a large segment of Abuja's population, yet peer-reviewed studies on their microbiological safety are scarce. Observations of practices such as the use of untreated water, the absence of protective clothing, and cross-contamination between carcasses further raise concerns about foodborne pathogen transmission.

This study is justified on the following grounds:To assess the microbiological quality of meat entering the local food chain; to detect the presence and prevalence of S. aureus, including coagulase-positive, potentially pathogenic strains; to provide evidence-based data to inform public health surveillance, food safety policy, and abattoir hygiene regulation in Abuja and similar urban settings. Through these, the study aims to fill a critical knowledge gap and supports broader efforts to reduce foodborne illness and antimicrobial resistance in Nigeria.

7. Research Questions

The following research questions guided the study:

1. What is the prevalence of Staphylococcus aureus in fresh meat samples collected from the Bwari and Kubwa slaughterhouses in Abuja, Nigeria?
2. What proportion of Staphylococcus aureus isolates from fresh meat samples were confirmed as coagulase-positive, indicating pathogenic potential?
3. Can the appearance of yellow-colored colonies on Mannitol Salt Agar (MSA) reliably indicate the presence of Staphylococcus aureus in fresh meat samples?

8. Hypothesis

Although formal hypothesis testing was not conducted in this study, the research was guided by investigative assumptions consistent with empirical inquiry. These assumptions informed the data collection and analysis framework:

Staphylococcus aureus is present in varying proportions in fresh meat sourced from abattoirs, suggesting contamination during slaughter or processing.

Poor hygienic practices in abattoirs contribute to increased microbial loads, particularly of pathogenic organisms such as S. aureus.

The identification of S. aureus in fresh meat provides insight into contamination risks associated with meat consumption and supports the need for food safety interventions.

This study adopts a descriptive and exploratory approach, aiming to establish prevalence rates and contamination patterns. These findings provide a basis for future hypothesis-driven research and support public health decision-making.

9. Methodology

9.1 Study Area

The study was conducted at the Bwari and Kubwa abattoirs, located within the Federal Capital Territory (FCT), Abuja, Nigeria. Abuja, the capital city of Nigeria since December 12, 1991, is centrally located within the country. The city lies at approximately 9.0575° N latitude and 7.4950° E longitude, with GPS coordinates of 8°57′2.9988″ N and 7°4′36.2532″ E (LatLong.net, 2024). Abuja is a linguistically and ethnically diverse city, with English as the official language and other languages such as Hausa, Yoruba, Igbo, and Fulfulde also commonly spoken. The indigenous people of the region are the Gbagyi (Gwari).

Bwari and Kubwa are among the seven designated satellite towns within the FCT and fall under the Bwari Area Council. The seven satellite towns include:1. Bwari, 2. Kubwa, 3. Karshi, 4. Kuje, 5. Kusaki–Yanga, 6. Dobi, and 7. Anagada

9.2 Sample Collection

A total of 100 fresh beef samples were randomly and aseptically collected directly after slaughter at the abattoirs. Sampling was conducted over a four-week period to capture variability and ensure representativeness.

Samples were collected using sterile gloves and placed in sterile, labelledpolyethene bags. The samples were immediately stored in a portable icebox maintained at 4°C and transported to the microbiology laboratory for analysis.

9.3 Sample Size Determination

The sample size was calculated using the single population proportion formula by Lwanga and Lemeshow (1991), assuming a 30% prevalence of S. aureus, a 95% confidence level, and a 10% margin of error. This sample size aligns with international standards for microbial food quality studies, as recommended by the International Commission on Microbiological Specifications for Foods (ICMSF, 2002).

10. Materials and Methods

10.1 Pre-enrichment and Culture

Each meat sample (1 g) was aseptically transferred into 9 mL of 0.1% sterile peptone water in a sterile test tube. The mixture was thoroughly homogenised and incubated overnight at 37°C to allow bacterial resuscitation and enrichment (Cheesbrough, 2000).

Following incubation, a loopful of the pre-enriched suspension was streaked onto Mannitol Salt Agar (MSA) plates and incubated at 37°C for 18–24 hours to selectively isolate Staphylococcus species. Colonies showing yellow colouration on MSA, indicative of mannitol fermentation, were presumptively identified as Staphylococcus aureus. These were subcultured onto Nutrient Agar to obtain pure isolates.

Pure colonies were subjected to Gram staining. Colonies appearing as Gram-positive cocci in grape-like clusters were further analysed using catalase and coagulase tests for confirmatory identification.

10.2 Gram Staining

Gram staining was performed to differentiate between Gram-positive and Gram-negative bacteria based on their cell wall composition, following the method by Cappuccino and Sherman (2019). The steps were as follows:

1. Prepare and heat-fix a bacterial smear on a clean glass slide.

2. Stain with crystal violet (60 seconds).
3. Apply Lugol's iodine (60 seconds).
4. Decolourise briefly with acetone or ethanol.
5. Counterstain with safranin (30–60 seconds).
6. Rinse with distilled water between steps and allow to air-dry.

Slides were examined under a light microscope. Staphylococcus aureus appeared as purple-colored cocci in clusters, confirming its Gram-positive nature.

10.3 Materials used:

1. Bacterial cultures
2. Glass slides
3. Bunsen burner
4. Crystal violet
5. Lugol's iodine
6. Acetone (decolouriser)
7. Safranin (counterstain)
8. Distilled water
9. Inoculating loop
10. Light microscope

10.4 Biochemical Characterisation

10.4a Mannitol Fermentation Test

This test was conducted on MSA to identify Staphylococcus aureus based on its ability to ferment mannitol. Fermentation results in acid production, leading to a colour change in the medium from red to yellow. The high salt concentration in MSA inhibits non-staphylococcal growth (Forbes et al., 2007).

Pure isolates were streaked onto MSA plates and incubated at 37°C for 24 hours. Yellow colonies were considered presumptive S. aureus.

10.4b Catalase Test

The catalase test differentiates catalase-positive Staphylococcus from catalase-negative Streptococcus. A portion of a bacterial colony was transferred to a clean glass slide, and a drop of 3% hydrogen peroxide was added. The appearance of bubbles indicated a positive catalase reaction.

10.4c Coagulase Test

The coagulase test was used for the confirmatory identification of Staphylococcus aureus. Two drops of sterile human or rabbit plasma were placed on a clean glass slide. A loopful of the isolate was emulsified in the plasma and observed for clumping within 10–15 seconds. Visible agglutination indicated a positive result, confirming S. aureus.

11. Results

Research Question 1

What is the prevalence of Staphylococcus species in fresh meat samples collected from the Bwari and Kubwa slaughterhouses in Abuja, Nigeria?

Out of the 100 fresh meat samples analysed, 100% of the isolates were Gram-positive cocci and catalase-positive, indicating the presence of Staphylococcus species.36% of the samples exhibited colonial and biochemical characteristics consistent with Staphylococcus

aureus.18% of the isolates tested positive for the coagulase test, confirming them as pathogenic S. aureus strains.

These findings reflect a relatively high prevalence of Staphylococcus contamination in fresh meat, raising public health concerns. The detection of coagulase-positive strains suggests potential lapses in hygiene during slaughtering and meat handling processes at the studied abattoirs.

Table 1: Prevalence of Staphylococcus aureus

SAMPLES	OPTIONS	FREQUENCY (PERCENTAGE)
GRAMSTAIN	Positive	100(100%)
	Negative	0(0%)
CATALASE	Positive	100(100%)
	Negative	0(0%)
COAGULASE	Positive	18(18%)
	Negative	82(82%)

Research Question 2

What proportion of Staphylococcus aureus isolates from fresh meat samples were confirmed as coagulase-positive, indicating pathogenic potential?

Among the total samples analysed, 18% tested positive for the coagulase enzyme, confirming the presence of coagulase-positive Staphylococcus aureus. Since coagulase is a critical virulence factor, this finding indicates a considerable risk of foodborne illness and underscores the need for stricter hygiene controls in the abattoir environment to minimise contamination by pathogenic strains.

Table 2: Biochemical test for catalase and coagulase test

Coagulase	**Percentage**
Negative	82%
Positive	18%
Catalase	**Percentage**
Negative	0%
Positive	100%

This test was critical for identifying Staphylococcus aureus which shows that 82% are negative indicating they are coagulase-negative staphylococci (CoNS) which are likely composed of species such as Staphylococcus epidermidis, Staphylococci saprophyticus, or other non-pathogenic staphylococci they are likely less virulent species that may not cause severe infections in healthy individuals but could be problematic in clinical settings involving medical devices or immunocompromised patient. The 18% of coagulase-positive samples indicate the presence of Staphylococcus aureus, which requires closer attention due to its higher pathogenic potential. This finding underscores the importance of monitoring for Staphylococcus aureus.

Research Question 3

Can the appearance of yellow-colored colonies on Mannitol Salt Agar (MSA) reliably indicate the presence of Staphylococcus aureus in fresh meat samples?

The development of yellow colonies on Mannitol Salt Agar suggests mannitol fermentation, a characteristic trait of Staphylococcus aureus. The fermentation process produces acidic by-products that lower the pH and cause a colour change in the medium from pink to yellow. While this is a useful presumptive indicator, confirmation through coagulase testing is necessary to reliably identify S. aureus.

Table 3: Frequency and percentage of the culture samples from Bwari and Kubwa Abattoir

Culture	Frequency
Milky	43(43)
Yellow	36(36)
Grey	19(19)
Reddish	2(2)
Total	100

The table shows the frequency and percentage by culture of the samples collected from the Bwari slaughterhouse and the Kubwa Abattoir. Out of 100 samples, 43% displayed milky colonies, 36% displayed yellow colonies, 19% displayed grey colonies, and 2% displayed reddish colonies. 36% of the colony indicated potential Staphylococcus aureus growth.

11. Discussion

In this study, the appearance of yellow colouration on specific quadrants of Mannitol Salt Agar (MSA) plates indicates the presence of bacterial colonies capable of fermenting mannitol, a distinguishing phenotypic trait of Staphylococcus aureus. MSA is both selective and differential: it inhibits the growth of non-halotolerant organisms due to its high sodium chloride content, while differentiating among staphylococcal species based on mannitol fermentation (Levinson, 2020). Fermentation of mannitol leads to acid production, lowering the pH of the medium and causing a phenol red indicator shift from red to yellow. This visual shift corroborates the findings of MacFaddin (2000), who emphasised the utility of MSA in presumptive identification of S. aureus.

From the 100 meat samples analysed, 36% yielded colonies with yellow halos on MSA, suggesting potential S. aureus presence. However, further biochemical characterisation revealed that all isolates were Gram-positive cocci and catalase-positive, traits consistent with the genus Staphylococcus. While catalase testing efficiently differentiates staphylococci from catalase-negative streptococci, it lacks the specificity to identify S. aureus from other staphylococcal species (Cheesbrough, 2006). Therefore, a confirmatory coagulase test was performed, which identified only 18% of the isolates as S. aureus. This result aligns with previous work by Kim et al. (2017), who reported the catalase test to have a high sensitivity and specificity (98.6% and 98.3%, respectively) in initial staphylococcal screening, but emphasised the necessity of coagulase testing for species-level differentiation.

The remaining 82% of the isolates were coagulase-negative staphylococci (CoNS), a group that includes species such as Staphylococcus epidermidis, Staphylococcus saprophyticus, and Staphylococcus haemolyticus. Although traditionally considered non-pathogenic commensals of human skin and mucosa, CoNS are increasingly implicated in nosocomial infections, particularly in immunocompromised patients and in association with indwelling medical devices due to their biofilm-forming capabilities (Otto, 2009; Becker et al., 2014). Their presence in meat samples may reflect contamination during processing or handling, underscoring lapses in hygiene protocols.

The detection of S. aureus in 18% of the meat samples is clinically and public health–relevant. S. aureus is a known foodborne pathogen capable of producing heat-stable

enterotoxins that cause staphylococcal food poisoning, a condition characterised by rapid-onset gastrointestinal symptoms such as nausea, vomiting, and abdominal cramps (Argudín et al., 2010). Even low levels of contamination can result in toxin production if conditions permit bacterial growth and replication, particularly under inadequate refrigeration or improper handling practices.

This prevalence of S. aureus in meat products raises concerns about food safety, particularly in settings with inadequate sanitation, such as abattoirs, where cross-contamination can occur through equipment, handlers, and surfaces. Studies have demonstrated that meat processing environments can serve as reservoirs for pathogenic bacteria, and poor hygiene practices can facilitate their transmission along the food chain (Kadariya et al., 2014; Røssvoll et al., 2020). Regular microbiological monitoring and implementation of Hazard Analysis and Critical Control Point (HACCP) systems are therefore crucial in mitigating the risk of S. aureus contamination. The findings from this study highlight the importance of accurate microbial identification in food safety surveillance. The combination of selective culturing, biochemical tests, and confirmatory assays provides a robust approach for distinguishing pathogenic S. aureus from other staphylococcal species. Moreover, the data underscore the need for stringent hygiene standards and routine surveillance in meat processing facilities to prevent foodborne illnesses and ensure consumer safety.

12. Conclusion

This study highlights the presence of Staphylococcus aureus in fresh meat samples from slaughterhouses, revealing an 18% confirmed prevalence rate. This finding underscores a critical public health concern, given the pathogen's potential to cause foodborne illness and its ability to survive under various environmental conditions. The observed contamination likely arises from poor hygienic practices during slaughtering and meat handling processes. These results emphasise the urgent need for improved hygiene and regulatory oversight in abattoirs. The presence of S. aureus in meat intended for human consumption reinforces the importance of rigorous sanitation protocols, regular microbiological monitoring, and food safety education for personnel involved in meat processing and distribution. To safeguard public health, it is essential to address the root causes of contamination at the abattoir level and promote best practices throughout the meat supply chain.

13. Recommendations

Based on the findings of this study, the following recommendations are proposed to mitigate contamination risks in slaughterhouses and enhance meat safety:

1. Modern, well-equipped slaughterhouses should be constructed to eliminate the use of open-air facilities, thereby reducing exposure to environmental contaminants.
2. Health authorities and relevant regulatory agencies should enforce routine inspections of abattoirs to ensure compliance with hygiene standards and food safety regulations.
3. Trained veterinary officers should be deployed to all slaughterhouses to examine animals before slaughter and certify them free of infectious or zoonotic pathogens.
4. Awareness programs should be implemented to educate meat handlers, sellers, and consumers on the risks associated with Staphylococcus aureus and the importance of reporting suspected cases of contamination.
5. Butchers and slaughterhouse workers must maintain strict hygiene, including proper disinfection of slaughtering tools and surfaces.
6. Proper disposal of animal waste, including deep burial of dead animals and treatment of sick animals, should be enforced to prevent cross-contamination and limit the proliferation of pathogenic organisms.

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