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Assessment of Health Risks Associated with the Presence of Antibiotic-Resistant *Staphylococcus aureus* in *Attiéké* Consumed in Burkina Faso

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Abstract

Attiéké, a popular food in Burkina Faso, is often produced under variable hygienic conditions, which favors the proliferation of pathogenic microorganisms such as methicillin-resistant *Staphylococcus aureus* (MRSA), a growing threat to the health of consumers. This study assessed the health risks associated with the presence of MRSA in *attiéké* consumed in Burkina Faso. A survey was carried out on 300 vendors to assess their sales conditions. Of the 225 samples analyzed using standardized microbiological analysis methods, 89 strains of *S. aureus* were identified, of which 37% were methicillin-resistant and 76.4% were multidrug-resistant. However, 77.53% of the strains were sensitive to linezolid. The survey findings indicated that a significant proportion (57.33%) of *attieké* sellers lack training in proper hygiene and modern food processing techniques. Key risk factors identified included inadequate hygiene practices, suboptimal fermentation methods, and the quality of water used in production. These results highlight the urgent need for an antibiotic resistance surveillance system and better awareness of good hygiene practices. Health authorities are called upon to strengthen controls throughout the production chain and to encourage producers and consumers to adopt safer practices to reduce the risks of antibiotic-resistant infections.

Keywords

Attiéké, *Staphylococcus aureus*, Health Risks, Public Health, Risk Factors

1. Introduction

Attiéké, a cassava-based fermented food in West Africa, including Burkina Faso, faces growing concerns about its potential to harbor harmful bacteria. The emergence of antibiotic-resistant strains, such as methicillin-resistant *Staphylococcus aureus* (MRSA), poses a significant threat to public health. MRSA, classified as a high-priority pathogen by the World Health Organization (WHO) [1], can cause a range of infections, from mild skin infections to life-threatening systemic diseases [2]. Food handlers can act as carriers of virulent *S. aureus* strains, potentially contaminating food products like *attiéké*. While studies in West Africa, notably in neighboring countries such as Benin and Côte d'Ivoire, have highlighted the presence of pathogenic bacteria and antimicrobial resistance in *attiéké* [3]-[5], data on the prevalence of MRSA in Burkina Faso remain poorly available. *S. aureus* thrives in food environments and produces toxins that can cause foodborne illnesses [6]. The combination of antibiotic resistance, contaminated food, and socioeconomic factors intensifies public health challenges [7]. Many Burkina Faso people rely on these fermented foods for their livelihoods. Antimicrobial properties could support local food systems and contribute to economic development. This study aimed to assess the health risks associated with the contamination of *attiéké* with MRSA in Burkina Faso and contribute to the development of effective prevention and control strategies.

2. Materials and Methods

2.1. Study Areas

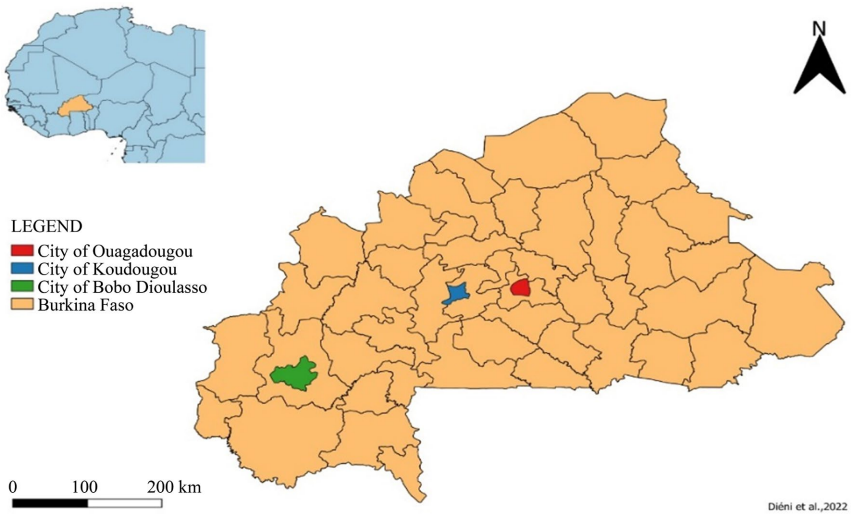

Figure 1. Location sites.

This cross-sectional study was conducted from February to March 2023 in three major cities in Burkina Faso: Ouagadougou (12˚21'58" N, 1˚31'05" W), Bobo-Dioulasso (11˚11'00" N, 4˚17'00" W), and Koudougou (12˚15'04" N, 2˚22'28" W). These cities are located in the Central (Kadiogo Province), Hauts-Bassins (Houet Province), and Central West (Boulkiemdé Province) regions, respectively (**Figure 1**).

2.2. Characterization of the *Attiéké* Production and Marketing Circuit

To identify potential risk factors and assess hygiene practices in the *attiéké* production and distribution chain in Burkina Faso, a field study was conducted. Three hundred (300) vendors were interviewed face-to-face using structured questionnaires, complemented by direct observation of production, processing, distribution, and sales sites. The sample size was estimated by the simple random sampling method performed by [8] using ε = 1.96 for an accuracy α = 5%, the formula is as follows:

$$N = \frac{\varepsilon^2 \times p \times Q}{i^2}$$

Q = 1 − p, i being the precision. The prevalence (p) is estimated to be 68% among sellers [9]. With this method, 318 vendors were obtained. The required sample sizes for all the 3 cities were 367 vendors with 10% relative precision. The sample sizes were further adjusted as indicated above.

2.3. Data Collection

A total of 225 *attiéké* samples, each weighing 500 g, were collected in a reasoned manner from various public markets in Ouagadougou, Bobo-Dioulasso, and Koudougou (**Table 1**). The samples, representing individually sold portions, were labeled, placed in freezer bags, stored in coolers with ice, and transported to the laboratory for microbiological analysis.

Table 1. Sampling procedures and data collected.

Sample type	Bobo-Dioulasso	Ouagadougou	Koudougou
Imported *attiéké*	50	50	25
Attiéké sold at retail	25	50	25
Total	75	100	50

2.4. Microbiological Analysis

Staphylococcus aureus was isolated from *attiéké* samples following [10]. Serial dilutions (10^{-1}, 10^{-2}, 10^{-3}) were prepared and spread-plated onto Chapman selective medium (Mannitol Salt Agar, Liofilchem, Italy) at pH 7.4 ± 0.2. Plates were incubated at 37˚C for 24 - 48 hours, and small yellow colonies (0.5 - 2 mm) were selected for further analysis. Suspected *S. aureus* colonies were subcultured onto Mueller-Hinton (MH) agar and subjected to standard microbiological tests, in-

cluding Gram staining, catalase and coagulase tests. A total of 89 *S. aureus* isolates were identified.

Antibiotic Susceptibility Test

Antibiotic susceptibility testing was performed using the disk diffusion method (Kirby-Bauer method) according to EUCAST guidelines [11]. The following antibiotics were tested: cefoxitin (FOX), trimethoprim-sulfamethoxazole (SXT), chloramphenicol (C), fosfomycin (FOS), fusidic acid (FC), clindamycin (CD), penicillin G (P), linezolid (LNZ), ofloxacin (OFX), gentamicin (GEN), and erythromycin (E). *S. aureus* ATCC 29213 was used as a quality control strain. Multidrug resistance was defined according to [12] as resistance to at least three antibiotics from three different classes. Reading of antibiotic disks was performed by measuring the diameters of the inhibition zone or clear halo and interpretation was performed according to [11]. The diameter of the zones or diameter of inhibition is proportional to the antibacterial activity of the antibiotic. Thus, these diameters of inhibition were measured using a caliper, which also made it possible to define three categories of strains: sensitive (S), intermediate (I) and resistant (R). Phenotypic identification of methicillin-resistant *S. aureus* (MRSA) strains was made using cefoxitin disks (30 µg).

2.5. Statistical Analyses

Descriptive statistics were performed for all variables using the statistic software package (SPSS) version 20.0 and Microsoft Excel version 2016.

3. Results

3.1. Contamination Factors

The characteristics of the surveyed vendors are presented in Table 2. The results show that over 42% of the participants received no training in food hygiene. Selling conditions are extremely precarious, characterized by unsanitary environments, direct handling of food without handwashing and inadequate packaging. Vendors often operate in crowded areas, exposing food to multiple sources of contamination. These findings highlight the high risk of food contamination associated with the sale of *attiéké* under current conditions. Urgent measures must be taken to improve hygiene practices in this sector.

Table 2. Socio-demographic characteristics.

Characteristics		Vendors (n = 300)
Sex	Man	34 (11.33%)
	Woman	266 (88.67%)
Food hygiene and technology training	Yes	128 (42.67%)
	No	172 (57.33%)
Cleanliness of sales premises	cleaning done	270 (90%)
	cleaning not done	30 (10%)

3.2. Antibiotic Resistance

S. aureus resistance varies across regions according to antibiotic use and hygiene conditions. High antibiotic use and poor hygiene are correlated with increased resistance to ofloxacin, clindamycin, and trimethoprim-sulfamethoxazole. Improved hygiene and responsible antibiotic use are essential to combat these problems. The antibiogram showed that the strains of *S. aureus* isolated from the food were predominantly resistant to several antibiotics, while maintaining some susceptibility to penicillin G and fusidic acid. This multiple resistance is particularly pronounced for ofloxacin, clindamycin, and trimethoprim-sulfamethoxazole (Figure 2). Multiplex PCR showed that 7.86% of the *S. aureus* strains expressed *sea* enterotoxins. This finding highlights the risk of enterotoxin-mediated food poisoning because *sea* is a common and potent staphylococcal enterotoxin.

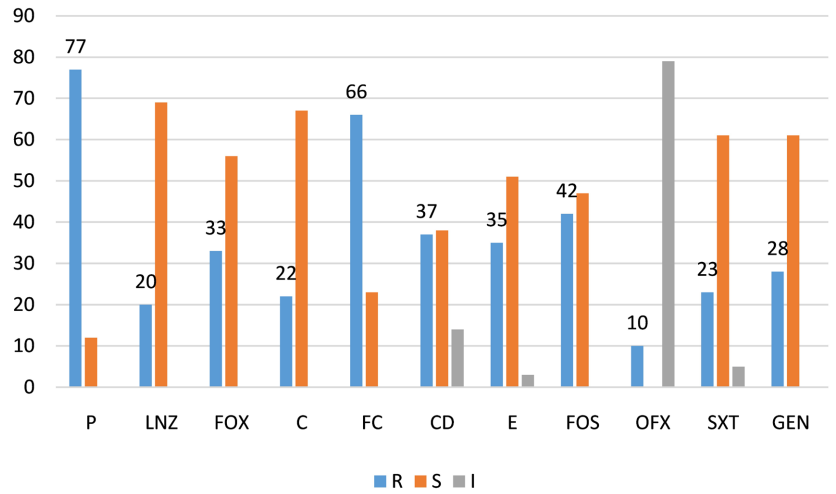

Figure 2. Susceptibility of *S. aureus* strains to antibiotics. R: Resistant; I: Intermediate; S: Sensible, FOX: Cefoxitin; P: Penicillin G; CD: Clindamycin; FC: Fusidic acid; FOS: Fosfomycin; E: Erythromycin; LNZ: Linezolid; OFX: Ofloxacin; GEN: Gentamicin; SXT: Trimethoprim-Sulphametoxazole and C: Chloramphenicol.

4. Discussion

Attiéké is an affordable and easily prepared street food that is widely consumed in Burkina Faso. However, our study revealed significant hygiene issues associated with its production and sale. Many vendors operate in unsanitary conditions and lack proper hygiene training, creating a conducive environment for the growth and spread of foodborne pathogens [13]. A major concern identified in this study was the high prevalence of antibiotic-resistant *S. aureus* strains in the *attiéké* samples. These results are consistent with global trends of increasing antibiotic resistance. The widespread use of antibiotics in both human and veterinary medicine, coupled with poor hygiene practices, has contributed to the development of these resistant strains [14]-[16]. Specifically, we observed high resistance to penicillin G, a common antibiotic. This finding is similar to those reported in other studies that examined street foods in West Africa [17] [18]. Additionally, nearly

all isolates were resistant to ofloxacin, highlighting the extent of antibiotic resistance among *S. aureus* strains associated with *attiéké* [17] [19]. The study found that more than 33% of the strains were MRSA, a prevalence comparable to the 32% reported by [20] in food sold on the Abomey Calavi campus in Benin. The public health implications of these findings are significant. Consuming foods contaminated with antibiotic-resistant bacteria can lead to foodborne illnesses that are difficult to treat. Furthermore, the spread of antibiotic-resistant bacteria in the community can contribute to the emergence of more serious infections that are resistant to multiple drugs [12]. Further research should address limitations like sample size and explore the link between vendor practices and contamination levels. The small sample size may limit the generalizability of the findings to all *attiéké* vendors in Burkina Faso; therefore, larger, more representative samples are needed to confirm the results.

5. Conclusion

This study revealed an alarming prevalence of antibiotic-resistant *S. aureus* strains in *attiéké* and fermented dough samples from Burkina Faso. Multidrug resistance poses a significant public health threat because it imitates the lack of treatment options for infections caused by these bacteria. Poor hygiene practices during the production and handling of *attiéké* appear to contribute to the spread of resistant bacterial strains. Rigorous measures must be taken to improve hygiene throughout the food chain. Although antibiotics such as linezolid, chloramphenicol, and trimethoprim-sulfamethoxazole are effective against the strains identified in this study, closely monitoring the evolution of bacterial resistance profiles is crucial. Such surveillance allows for the adaptation of treatment strategies and the prevention of new resistance. In conclusion, the findings of this study highlight the importance of strengthening health controls and promoting good hygiene practices in the production and sale of *attiéké* to protect consumer health and limit the spread of antibiotic-resistant bacteria.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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