

Research Article

Assessment of the Microbiological Quality of Attieke Marketed in the Urban Municipality of Macenta (Republic of Guinea)

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Abstract

Attieke is a traditional fermented cassava-based food widely consumed in West Africa, particularly in the Republic of Guinea, where it represents an important component of the daily diet. Its microbiological quality is strongly influenced by artisanal processing methods, post-fermentation handling practices, storage conditions, and marketing environments, which may affect product safety. This study aimed to evaluate the microbiological quality of attieke sold in the urban municipality of Macenta, Guinea. Sixteen samples were randomly collected from different retail outlets and analyzed using standard microbiological methods. The parameters investigated included total aerobic mesophilic flora, total and thermotolerant coliforms, *Staphylococcus aureus*, yeasts and molds, and *Salmonella spp.* The results showed total aerobic mesophilic counts ranging from 15 to 1,000 CFU/g. Total coliforms were detected in 62.5% of samples, while thermotolerant coliforms were present in 50%, indicating inadequate hygienic conditions during processing and distribution. *Staphylococcus aureus* and yeasts and molds were detected in 81.3% of samples, with maximum counts of 44 CFU/g and 310 CFU/g, respectively. *Salmonella spp.* was not detected in any sample (absence in 25 g). Overall, microbial loads were within acceptable limits for ready-to-eat foods. However, the presence of hygiene indicator microorganisms highlights the need to strengthen good hygiene practices throughout the production and distribution chain in order to improve food safety.

Keywords

Attieke, Microbiological Quality, Fermented Foods, Food Hygiene, Macenta

1. Introduction

Attieke is a traditional fermented cassava-based food produced from *Manihot esculenta* Crantz, originating from Côte d'Ivoire and widely consumed in West Africa, particularly in the Republic of Guinea. Appreciated for its high energy value,

affordability, ease of preparation, and granular texture similar to couscous, attieke is an essential ready-to-eat food in the daily diet of many populations in both urban and rural areas [1, 2].

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Attieke production is based on a predominantly artisanal process involving several successive steps, including fermentation, pressing, granulation, and steaming [2, 3]. Fermentation plays a central role from both technological and sanitary perspectives, contributing to the reduction of cyanogenic compounds naturally present in cassava and to the improvement of the product's organoleptic properties [4, 5].

However, the artisanal nature of processing, combined with often poorly controlled handling, packaging, and marketing conditions, exposes attieke to risks of microbiological contamination, particularly during post-fermentation stages [6]. Several studies conducted in West Africa have reported the presence of hygiene indicator microorganisms, such as total coliforms, reflecting inadequate hygienic conditions, and *Staphylococcus aureus*, generally associated with human-origin contamination. More rarely, major regulated pathogens such as *Salmonella* spp have also been detected in attieke sold on local markets [7]. In this context, assessing the microbiological quality of ready-to-eat foods, especially those produced through artisanal value chains, is of critical importance in developing countries, where sanitary control and microbiological surveillance systems often remain limited.

In the Republic of Guinea, particularly in the urban municipality of Macenta, attieke is widely produced, marketed, and consumed in local markets. However, unlike other countries in the sub-region such as Côte d'Ivoire or Burkina Faso, scientific data on the microbiological quality of attieke in this locality are scarce or nonexistent. Therefore, the present study aims to evaluate the microbiological quality of attieke marketed in Macenta by determining the levels and prevalence of major hygiene indicator and pathogenic microorganisms, and by comparing the results with recommended microbiological criteria for ready-to-eat foods. This study seeks to provide baseline data to support improvements in hygienic practices, sanitary risk management, and food safety at the local level.

2. Materials and Methods

2.1. Study Area

The present study was conducted in the urban municipality of Macenta, located in the administrative region of Nzerekore in Forest Guinea (Figure 1). This area was selected due to its central role in the production, marketing, and distribution of attieke at the local level. Its economic and nutritional importance makes it a relevant setting for assessing the microbiological quality of this widely consumed food product among local populations.



Figure 1. Geographical location of the urban municipality of Macenta, Republic of Guinea.

2.2. Sampling

Sixteen (16) attieke samples were collected from sixteen (16) vendors selected based on the high customer traffic at their selling points in the market of the urban municipality of Macenta in October 2025 (Figure 2). Each sample, weighing 1,000 g, was obtained from a different vendor, aseptically packaged, and transported in an insulated cooler to the laboratory of the National Quality Control Office (ONCQ) in Conakry for analysis.



Figure 2. Marketing conditions of attieke in the market.

2.3. Microbiological Analyses

Total aerobic mesophilic flora (TAMF) were enumerated by the plate count method following decimal dilutions and incubation at 30°C for 48 h [8]. Total and thermotolerant coliforms were enumerated on Compass ECC agar after incubation at 37°C and 44°C for 24 h, respectively [9]. *Staphylococcus aureus* was enumerated in accordance with ISO 6888-1: 2021 using Baird-Parker agar, with incubation at 37°C for 48 h [10, 11]. Yeasts and molds were enumerated according to the NF ISO 6611 standard using Sabouraud and potato dextrose agar (PDA) media [11]. The detection of *Salmonella* spp, was performed in accordance with ISO 6579-1: 2017 [12].



Figure 3. Microbiological analysis of samples in the laboratory.

2.4. Statistical Analysis

Data were analyzed using STATA software (version 15.1) with descriptive statistical methods. Inferential statistical analyses were also performed to compare microbial loads among samples. A one-way analysis of variance (ANOVA) was used to assess significant differences between groups, followed, where appropriate, by Tukey’s post hoc test for pairwise comparisons. A significance level of $p < 0.05$ was

adopted. In addition, the obtained results were compared with the relevant sanitary standards in order to identify any potential non-compliance.

3. Results

The Figure 4 presents the distribution of microbial loads of the analyzed attieke samples according to six (6) microbiological parameters. The Figure highlights a marked inter-sample variability, reflecting the heterogeneity of processing, handling, and marketing conditions of attieke within the single market of the urban municipality of Macenta.

The observed microbiological loads showed inter-sample variability. Total aerobic mesophilic flora ranged from 10 to 10^3 CFU/g, with maximum values remaining below the acceptable limits for ready-to-eat foods. Total and thermotolerant coliforms were detected at moderate levels. Staphylococcus aureus counts ranged between 10 and 10^2 CFU/g. Yeasts and molds reached levels of up to 10^3 CFU/g in some samples. No Salmonella was detected in any of the analyzed samples.

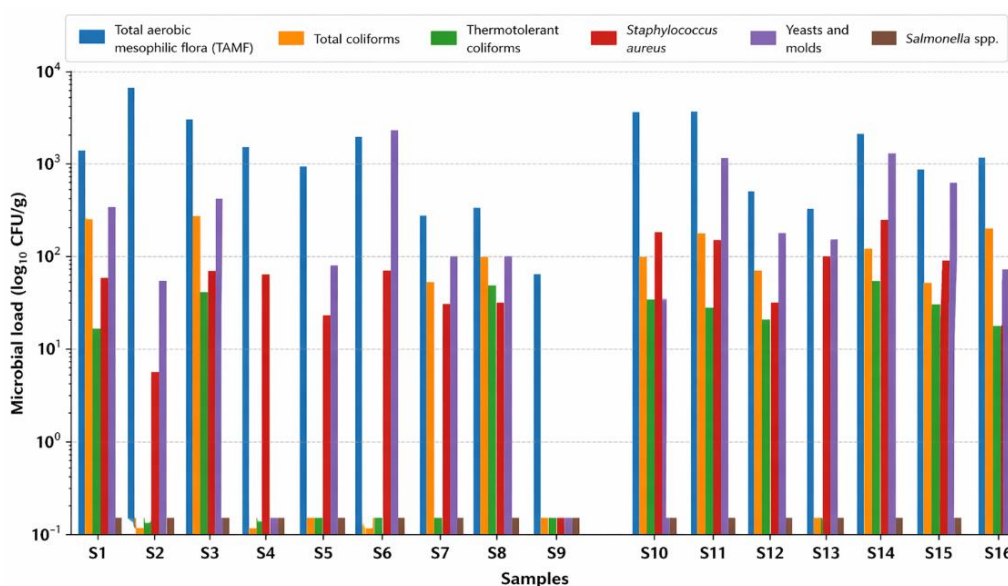


Figure 4. Distribution of the microbial load of the sixteen attieke samples.

The Table 1 presents the minimum and maximum values of the main microbiological parameters analyzed in sixteen (16) attieke samples marketed in the urban municipality of Macenta. The results highlight significant variability in microbial

loads, reflecting the heterogeneity of processing, handling, and marketing conditions of this traditional fermented product.

Table 1. Statistical description of the microbiological parameters of attieke (n = 16).

Microbiological parameters	Units	n	Minimum	Maximum
Total aerobic mesophilic flora (TAMF)	CFU/g	16	15	1,000

Microbiological parameters	Units	n	Minimum	Maximum
Total coliforms	CFU/g	16	0	53
Thermotolerant coliforms	CFU/g	16	0	15
<i>Staphylococcus aureus</i>	CFU/g	16	0	44
Yeasts and molds	CFU/g	16	0	310
Salmonella	CFU/25 g	16	Absence	Absence

The Table 2 presents the proportion of samples positive for the different microbiological parameters analyzed in sixteen (16) attieke samples marketed in the urban municipality of Macenta. The results reveal a high prevalence of certain microorganisms, reflecting the influence of artisanal processing, handling, and marketing conditions on the microbiological quality of the product.

Table 2. Prevalence of microbiological parameters.

Microbiological parameters	Number of positive samples	(%)
Total aerobic mesophilic flora (TAMF)	16	100
Total coliforms	10	62.5

Microbiological parameters	Number of positive samples	(%)
Thermotolerant coliforms	8	50.0
<i>Staphylococcus aureus</i>	13	81.3
Yeasts and molds	13	81.3
Salmonella (25 g)	0	0

The Table 3 presents the distribution of microbial loads of attieke samples according to three concentration classes (< 10 CFU/g, 10–10² CFU/g, and > 10² CFU/g). This approach provides a concise sanitary interpretation and facilitates the assessment of the product's contamination level in relation to microbiological thresholds commonly used for ready-to-eat foods.

Table 3. Distribution of microbiological parameters according to contamination levels.

Parameters	< 10 CFU/g n (%)	10–10 ² CFU/g n (%)	> 10 ² CFU/g n (%)
Total aerobic mesophilic flora (TAMF)	1 (6.3)	8 (50.0)	7 (43.7)
Total coliforms	6 (37.5)	10 (62.5)	0 (0)
Thermotolerant coliforms	8 (50.0)	8 (50.0)	0 (0)
<i>Staphylococcus aureus</i>	3 (18.7)	11 (68.8)	2 (12.5)
Yeasts and molds	3 (18.7)	7 (43.8)	6 (37.5)

The Table 4 presents the assessment of the microbiological compliance of the analyzed attieke samples with respect to the reference criteria of the Codex Alimentarius applicable to

ready-to-eat foods. This approach allows a direct normative evaluation of the potential health risk associated with consumption of the studied product.

Table 4. Microbiological compliance with ready-to-eat food criteria.

Parameters	Reference criteria (Codex Alimentarius)	Non-compliant samples n (%)
Total aerobic mesophilic flora	≤ 10 ⁵ CFU/g	0 (0)
Total coliforms	≤ 10 ² CFU/g	0 (0)

Parameters	Reference criteria (Codex Alimentarius)	Non-compliant samples n (%)
Thermotolerant coliforms	≤ 10 CFU/g	4 (25.0)
<i>Staphylococcus aureus</i>	≤ 10 ² CFU/g	0 (0)
Yeasts and molds	≤ 10 ³ CFU/g	0 (0)
Salmonella (25 g)	Absence	0 (0)

4. Discussion

The total aerobic mesophilic flora counts observed in the present study were generally lower than those reported in previous studies. For example, a microbial load of 4.8×10^6 CFU/g was reported in garba, a street food widely consumed in Côte d'Ivoire Anoman, A. T., et al., (2019) [13]. Similarly, a microbial concentration of 1.7×10^6 CFU/kg was found in a study investigating residual hydrocyanic acid content and the microbiological quality of attiéké in the Abidjan region Koffi, L., et al., (2009) [14]. Furthermore, a study conducted in Burkina Faso on artisanal attiéke produced in Dedougou at the local processing unit "Burkina Journalier" reported microbial loads ranging from 3.73 to 4.52 log CFU/g, which were also higher than those measured in the present study Dembele, R., et al., (2018) [15]. In the same vein, higher total aerobic mesophilic flora counts (8.2×10^7 CFU/g) were reported in a study on the characterization of the microflora of attiéke during traditional small-scale preparation Coulin, P., et al., (2006) [16].

These differences may be attributed to variations in processing conditions, handling practices, storage methods, and production environments specific to each study area. Additionally, differences in the application of hygienic practices during post-fermentation stages may have contributed to the lower microbial loads observed in attiéke samples analyzed in Macenta.

The results of the present study highlight total coliform loads that were generally lower than those reported in several similar studies conducted in West Africa. Thus, Kouassi, K. B., et al., (2025) [9], in their study on the quality characteristics of attiéke produced in the lagoon areas of Côte d'Ivoire, did not detect any total coliforms in samples collected from different production sites, in contrast to the findings from Macenta, where a moderate presence of coliforms was observed in some samples. Conversely, Kouadio-Yapo C. G., et al., (2018) [17] reported markedly higher contamination levels, with microbial loads reaching 8.6×10^7 CFU/g in samples collected in Lobia, indicating a significantly higher degree of contamination than that measured in the present study. The total coliform colony counts observed in this study were lower than those reported by Flibert G., et al., (2021) [18], who investigated the lactic acid bacteria and yeasts involved in cassava fermentation for attiéke production in Burkina Faso and their technological properties, reporting a microbial load of

0.98 log CFU/g. These discrepancies may be attributed to differences in processing conditions, handling practices, and storage methods specific to each production area.

The thermotolerant coliform counts observed in the present study were lower than those reported by Koffi, L., et al., (2009) [14], who highlighted an average concentration of 1.6×10^3 CFU/g in their analysis of residual hydrocyanic acid levels and the microbiological quality of attiéke produced in the Abidjan region. The thermotolerant coliform counts observed in this study were lower than those reported by Assanvo JB., et al., (2006) [19] in their study on the microflora of traditional cassava starter used for attiéke production in Dabou, Côte d'Ivoire, which were 8.0×10^3 CFU/g. These differences may be explained by variations in production conditions, hygienic practices, as well as the analytical protocols employed.

The yeast and mold counts observed in the present study were markedly lower than those reported by Kouadio-Yapo C. G., et al., (2018) [17], who, in their investigation on the identification of yeast species present in attiéké marketed in Abidjan markets, recorded an average concentration of 1.01×10^6 CFU/g. In an assessment of the microbiological quality of attiéké (steamed cassava) sold in Côte d'Ivoire, a microbial load of 2.7×10^6 CFU/g was reported by Nazo Edith K-K et al. (2020) [6]. These differences may be explained by variations in processing conditions, hygienic practices, storage methods, and marketing channels specific to the geographical areas studied.

The *Staphylococcus aureus* counts observed in the present study were lower than those reported by Alfred, K. K., et al., (2019) [20], who assessed the microbiological and chemical risks associated with commercial attiéke produced in southern Côte d'Ivoire. In that study, microbial concentrations ranged from $(1.8 \pm 0.4) \times 10^2$ CFU/g in Jacquville to $(4.3 \pm 1.8) \times 10^3$ CFU/g in Abidjan. The *Staphylococcus aureus* load enumerated in the present study is comparable to that reported by Akmel, D. C., et al., (2017) [21], who also observed values below 10^2 CFU/g across all the zones or cities studied, in the context of the quantitative assessment of microbiological risk associated with the consumption of attiéke in Côte d'Ivoire. These discrepancies may be attributed to regional variations in production, handling, and storage conditions, as well as differences in hygienic practices, which directly influence microbial loads and, consequently, the sanitary quality of the product.

The results regarding *Salmonella spp* in the present study are consistent with those reported by Alfred, K. K., et al., (2019) [20], who demonstrated the absence of *Salmonella* in

all analyzed samples during their evaluation of microbiological and chemical risks associated with commercial attieke produced in southern Côte d'Ivoire. Similarly, Krabi Ekona, R., et al., (2015) [1], in their study on the production of attieke (fermented cassava couscous) in Abidjan, also reported the absence of *Salmonella*, regardless of the cassava variety used. These convergent findings suggest that, despite the artisanal nature of processing, certain production practices effectively contribute to limiting contamination by this pathogen.

5. Conclusions

The present study assessed the microbiological quality of attieke marketed in the urban municipality of Macenta, Republic of Guinea. Overall, the results indicate that the measured microbial loads were largely compliant with the recommended microbiological criteria for ready-to-eat foods, reflecting a generally satisfactory sanitary quality of the analyzed product. The absence of *Salmonella* in all samples constitutes a reassuring indicator from a food safety perspective. However, the detection of total and thermotolerant coliforms, as well as the relatively frequent presence of *Staphylococcus aureus*, highlights hygiene deficiencies that may occur during post-fermentation stages, particularly during handling, packaging, and marketing. In addition, yeast and mold counts, although characteristic of traditional fermented products, may contribute to product deterioration and reduced shelf life when present at high levels. These findings underscore the need to strengthen the implementation of good hygiene and manufacturing practices through-out the attieke production chain. Actions such as training of stakeholders, improvement of handling and selling conditions, and the establishment of regular microbiological monitoring could contribute to sustainably enhancing the sanitary quality of the product. Finally, further studies involving a larger number of samples and the evaluation of physicochemical parameters would help deepen the understanding of factors influencing the microbiological quality of attieke and better guide improvement strategies.

Abbreviations

TAMF	Total Aerobic Mesophilic Flora
TC	Total Coliforms
TTC	Thermotolerant Coliforms
Stap Aureus	Staphylococcus Aureus
YM	Yeasts and Molds
Sal	Salmonella
CFU	Colony Forming Unit
g	Gram
e	Number of Samples

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and Veterinary Medicine (ISSMV) of Dalaba for its financial support, as well as the staff and laboratory technicians of the National Office for Quality Control in Matoto, Conakry, for their technical assistance.

Author Contributions

Sekou Kouyate: Conceptualization, Funding acquisition, Project administration, Writing – original draft

Ndeye Adiara Ndiaye: Validation, Writing – review & editing

Modou Dieng: Validation, Writing – review & editing

Vamougna Soumaoro: Data curation, Supervision

Mama Guilavogui: Data curation, Funding acquisition, Investigation, Methodology

Data Availability Statement

The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

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Biography



Sekou Kouyate is an Assistant Researcher in the Department of Food Technology and Product Control (TCPA) at the Higher Institute of Veterinary Science and Medicine. He obtained his Master's degree in Quality Management in Bio-Industries from the Higher Polytechnic School (ESP), Cheikh Anta Diop University, in 2024. Recognized for his commitment, rigor, and dedication, Eng. Kouyate, currently a PhD candidate, has been appointed Head of the Physicochemical and Microbiological Laboratory of the institute. He has actively contributed to the microbiological and physicochemical analysis of food products for numerous undergraduate and graduate theses at ISSMV Dalaba, playing a key role in the practical training and scientific development of future professionals in the agri-food sector.



Ndeye Adiara Ndiaye is a Lecturer-Researcher at the Higher Polytechnic School, Cheikh Anta Diop University of Dakar (Senegal). She holds a PhD in Plant and Microbial Biotechnology, specializing in plant breeding. Her multidisciplinary background includes microbiology, biotechnology, quality management, and biological engineering. Her research focuses on applied microbiology, particularly microbiota characterization, food quality, and safety. She uses molecular and analytical techniques to study microbial dynamics in food systems. Her work aims to improve food safety, address public health issues, and promote sustainable agri-food systems. She is actively involved in teaching, research, and supervision of future engineers and researchers.

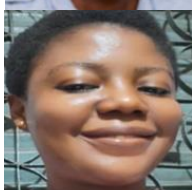


Modou Dieng was born in Pékesse, Thiès region (Senegal). He completed his secondary education at the Military Prytanée of Saint-Louis, obtaining a baccalaureate in natural and physical sciences with honors. He pursued higher education at ENSUT (now ESP), earning a DUT in Biological Analyses and a Technologist Engineering diploma in Sanitary Engineering. He later obtained an AEA and a DEA with honors from the Institute of Environmental Sciences. In 2009, he completed a PhD in Animal Production and Biotechnology at the Inter-State School of Veterinary Sciences and Medicine, graduating with highest honors. He is currently a Lecturer-Researcher at Cheikh Anta Diop University. His teaching includes food microbiology, general microbiology, and waste management. He also serves in key

laboratory management roles and has authored around forty scientific publications.



Vamougna Soumaoro, born on May 2, 1989, in Nzerekore (Guinea), is a food science specialist with a solid academic background in nutrition and food technology. He holds an Engineering Technologist diploma in Food Products from the Higher Institute of Veterinary Science and Medicine (ISSMV) of Dalaba, Republic of Guinea. He also earned a Master's degree in Nutrition and Food Sciences, with a specialization in International Nutrition, from the University of Montpellier, France. His training combines expertise in food processing, nutrition, and food quality, contributing to the improvement of food systems and nutritional outcomes.



Mama Guilavogui graduated from the Department of Food Technology and Quality Control. She has a solid background in food microbiology, quality control, and food safety. Her research interests focus on assessing the microbiological quality of food products, preventing foodborne health risks, and improving agro-food processing methods. She is particularly interested in the safety of locally marketed food products and in developing strategies to reduce contamination. Through her work, she contributes to enhancing food safety and protecting public health within communities.

Research Field

Sekou Kouyate: Food quality control, physico-chemical analysis of food, microbiological analysis of food, laboratory management and research, food preservation technology, bio-industrial process management, food product development

Ndeye Adiara Ndiaye: Microbiology and food safety

Modou Dieng: Food microbiology, General microbiology, Solid waste management and recovery, Sanitary engineering and environment, Biotechnology applied to bio-industries

Vamougna Soumaoro: Food Formulation, Microbial Biotechnology, Food Fermentation, Nutrition – Health

Mama Guilavogui: Microbiological analysis of foods, techniques for counting microorganisms, food formulation