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Review Article

Food Safety and Quality Control of Cassava Semolina (Attieke) in West Africa: Current Status and Prospects with a Focus on Mali

Sissoko Aminata[1, *], Maiga Boubacar Madio dit Aladiogo[1], Diabate Daouda[2], Dicko Amadou Hamadoun[3], Samake Fasse[2]

[1]Department of Quality Control, Central Veterinary Laboratory, Bamako, Mali

[2]Department of Applied Sciences, University of Sciences, Techniques and Technologies of Bamako, Bamako, Mali

[3]Department of Animal Health, University of Segou, Segou, Mali

Abstract

Attieke is a traditional West African food product made from fermented, partially dehydrated, and steamed cassava (*Manihot esculenta*) semolina. This fermented food, which is particularly popular in Côte d'Ivoire and other countries in the West Africa subregion, is valued for its digestibility, energy density, and ability to accompany a variety of dishes. Local production offers opportunities for cassava valorization, women's employment, and contributions to national food security. The research method used was based on open international databases and scientific publications (PubMed, AGRIS, Google Scholar, and AJOL), including studies that were the subject of scientific articles on Attieke in Côte d'Ivoire (more abundant), Burkina Faso, and other technical reports (FAO, CGIAR) to analyze studies conducted in several countries across the subregion. This literature review aims to assess current knowledge on the microbiological, physico-chemical, and socio-economic aspects of Attieke consumed in West Africa. The methodology involved a systematic consultation and critical analysis of previous studies conducted in West Africa countries between 2010 and 2025. Fermentation, which is generally spontaneous in artisanal practices, improves the bioavailability of nutrients. It contributes to the detoxification of cyanogenic compounds, while reducing anti-nutritional factors. However, Attieke has a low protein and lipid content, which is why it is consumed with complementary protein sources. From a socio-economic perspective, the production and marketing of Attieke constitute a structuring industry: they generate income (particularly for women), contribute to local food security, and promote the use of cassava. However, the majority of production remains artisanal, with limited infrastructure and insufficient health controls, which poses challenges in terms of standardization and safety. From a physicochemical point of view, studies show that the pH of the final Attieke is acidic (around 4.5), as a result of the action of lactic acid bacteria during fermentation. At the same time, the transformation process significantly alters parameters such as moisture content, dry matter, organic acid levels (lactic, acetic), and cyanide content: detoxification is important, but depends heavily on the rigor of the pressing and rinsing processes. With regard to microbiological quality, analyses have revealed populations of coliforms, *Staphylococcus aureus*, Bacillus spores, yeasts, and molds in commercial products. In particular, B. cereus spores can withstand steam cooking and reappear after packaging. These observations highlight the need to impose critical control points (CCPs) throughout the process from raw materials to packaging.

*Correspondence: Sissoko Aminata (sissokomi@yahoo.fr)

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Keywords

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1. Introduction

Attieke is a partially dehydrated fermented cassava (*Manihot esculenta Crantz*) semolina, steamed and agglomerated in appearance, widely consumed in West Africa, particularly in Côte d'Ivoire, Ghana, Togo, Burkina Faso and Mali [1, 2]. It is a staple food for a large part of the population, appreciated for its digestibility, energy value, and ability to accompany a wide variety of dishes [3]. Its artisanal preparation is based on a fermentation process that improves not only its taste but also its nutritional qualities and shelf life [4, 5].

Nutritionally, Attieke is an important source of complex carbohydrates and dietary fiber, and contains some vitamins such as vitamins C and B, as well as minerals such as calcium, magnesium, and potassium [5, 6]. Fermentation plays a key role in increasing the digestibility and bioavailability of nutrients, while reducing the content of antinutritional compounds present in raw cassava [7, 8]. However, Attieke is low in protein and fat, which is why it is most often consumed with protein sources such as fish, meat, or vegetables to make a balanced meal [9].

The importance of Attieke in the diet goes far beyond its nutritional value. It represents a food that is deeply rooted in the culinary practices of West African populations [1, 10]. Its consumption is associated with specific social and traditional contexts, such as family gatherings, ceremonies, and local festivities [11]. This cultural dimension is documented in several countries, notably Côte d'Ivoire, Ghana, and Burkina Faso, where Attieke is an essential part of the gastronomic heritage [2, 8].

Consumption of Attieke is growing steadily in urban areas of Mali, particularly in Bamako, Sikasso, and Segou, where it is sold in markets, grocery stores, and by street vendors [4]. This development can be explained by rapid urbanization, changing eating habits, and the search for foods that are easy to prepare and consume [6]. In cities, Attieke is often eaten for lunch or dinner, and its affordability contributes to its popularity among low-income households [12].

Furthermore, Attieke represents an important economic issue. Its production and marketing generate substantial incomes for producers, processors, and street vendors, particularly women, who play a central role in the value chain of this food [1, 2]. This phenomenon has been documented in several West African countries, where the Attieke industry contributes to job creation and local food security [8, 10].

However, despite its economic, nutritional, and cultural importance, Attieke can pose a risk of food poisoning to consumers and therefore a risk to public health when it is produced in artisanal conditions without strict hygiene controls [14]. Studies have highlighted the presence of pathogens such as *Bacillus cereus, Escherichia coli* and *Salmonella spp*. in samples of commercially available Attieke [4, 5, 13]. These findings highlight the need to develop modernized manufacturing processes that comply with health standards in order to ensure the quality and safety of this widely consumed product [6, 14].

Finally, with population growth, urbanization, and increased demand for convenient and nutritious food products, Attieke appears to be a strategic product in the West African food system. Its local production in Mali could meet this growing demand while contributing to economic development and national food security [1, 14].

2. Methodology

This systematic review was conducted in accordance with the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [15]. It aims to synthesize existing knowledge on the microbiological, physicochemical, and organoleptic quality of imported and locally produced Attieke in Mali, as well as on the socio-economic issues related to its consumption. The objective is to identify gaps in the literature in order to propose avenues for research and recommendations for health safety.

2.1. Inclusion Criteria

Eligibility criteria for study selection were established based on the PICOS methodology [16]. to define specific inclusion and exclusion parameters. The selected studies had to focus on Attieke or similar products resulting from the cassava fermentation process, in order to ensure the relevance of the research to this specific product.

Another important criterion was that the studies had to examine the microbiological, physicochemical, and nutritional quality of the products, thereby enabling an assessment of their safety and nutritional value.

The included studies had to address the production and marketing chain of cassava-based products, which is essential for understanding the economic and logistical aspects related to their availability on the market.

Finally, it was necessary for the publications to contain data concerning Mali or other West African countries in order to contextualize the research within a specific and relevant geographical framework.

2.2. Exclusion Criteria

Exclusion criteria for the sources in this study were defined, applied, and presented as follows. First, non-scientific documents were excluded because they do not meet the academic standards necessary to guarantee the reliability and rigor of the results.

In addition, abstracts without full text were discarded because they do not provide sufficient detailed information for an in depth analysis of the topics covered.

Studies focusing on other fermented products not directly related to attieke were also excluded in order to maintain the relevance of research specifically focused on this cassava based product.

Lack of microbiological, physicochemical, and nutritional quality: Finally, studies that did not examine microbiological, physicochemical, and nutritional quality were rejected, as these aspects are crucial for assessing the safety and harmlessness of cassava-based products.

2.3. Information Sources, Search Strategy, and Article Selection

The article selection process was carried out in three distinct phases following PRISMA guidelines.

The first phase, identification, involved locating relevant studies through keyword-based searches across selected databases. The search strategy combined carefully chosen keywords with Boolean operators. The keywords used included: "Attieke," "fermented cassava," "microbiological quality," "Food Safety," "West Africa," "Mali," "Fermentation," "Quality control," and "Nutrition".

During the screening phase, article titles and abstracts were reviewed to verify compliance with the inclusion criteria. In the eligibility and final inclusion phase, full-text articles were examined to extract relevant information. The data extracted included the characteristics of the samples analyzed, the analytical methods used, the microbiological, physicochemical, and organoleptic results, as well as socio-economic and regulatory aspects. These data were synthesized to produce an overall assessment and outlook for the safety and quality of Attieke in the West African region, including Mali.

3. Results and Discussion

The synthesis of information gathered from various sources led to its classification into three subheadings in the results. These subheadings cover: the socioeconomic role of Attieke in West Africa its composition, nutritional benefits, and finally, its physicochemical and microbiological qualities. This classification has helped to highlight the multiple dimensions of Attieke in West Africa as summarized in the table below.

Table 1. *Compiled Characteristics and Indicators of Attieke Quality.*

Characteristics	Parameters
Socio-economic	source of income, dietary diversity, food security, household economic security
Physical and chemical properties	pH, moisture, proximate composition, carbohydrates, proteins, lipids, and cyanide
Microbiological quality	microbial loads, pathogens, molds, antibiotic resistance

3.1. Socio-economic Role of Attieke in West Africa

Attieke plays a crucial role as a source of income for many families, particularly in rural areas where it is grown and processed. It also contributes to food security and dietary diversity [3]. The Attieke processing and marketing sector has significant socio-economic implications due to its contribution to food and nutritional security in West Africa. The value chain of this strategic tuber, known as cassava (*Manihot esculenta*), contributes effectively to food resilience and household economic security [2, 17]. The processing of cassava into Attieke is a lever for agro-industrial development, increasing local added value and reducing post-harvest losses [1, 18].

Although Attieke is not considered a traditional Malian product, its consumption and production have expanded rapidly over the past two decades, particularly in urban areas. This trend can be explained by the high demand for convenient, quick-cooking foods that are culturally valued in West Africa [4, 19]. In Mali, Attieke production is mainly artisanal and carried out by women's groups, often with limited resources, who see it as an opportunity for subsistence and economic empowerment [20, 21]. Socioeconomically, this activity plays an important role in job creation and income diversification, particularly in the urban markets of Bamako, Sikasso, and Segou, where demand remains strong [22]. The Attieke sold in these cities comes from both local production and imports, mainly from Côte d'Ivoire, which remains the main regional supplier [15].

However, artisanal production conditions in Mali remain pre-

carious: lack of suitable equipment, sanitation, processing standards, and systematic quality control, which limits the competitiveness and food safety of the product [20, 23]. The rise of Attieke in Mali, at the crossroads of economic, health, and food issues, highlights the need to structure the sector and strengthen the technical capacities of stakeholders to make it a real driver of food security and women's empowerment [14, 17].

3.2. Composition and Nutritional Benefits of Attieke

Attieke is rich in carbohydrates, but it also contains fiber, vitamins, and minerals. Its nutritional benefits make it an interesting food, especially for populations in need of energy and essential nutrients [5, 6]. Attieke is a food made from steamed cassava semolina that is whitish in color and has a slightly sour taste [24]. Its popularity is well known in countries in the West African sub-region and even in Europe, where it is exported [24]. This is due to its composition and nutritional value. A summary of information extracted from several studies concludes that 100 g of dry Attieke provides consumers with 1,552 kJ (371 kcal) of energy [24].

Its nutritional composition can vary depending on how it is prepared and the ingredients added. As a food source rich in complex carbohydrates (80-90%), Attieke is essential in local diets in West Africa, particularly in a context where food security is a major issue for these countries [17]. The results of the studies indicated that this high carbohydrate content helps meet the energy needs of populations, particularly in terms of supporting daily activities [5, 9, 28]. Urban populations in Africa are particularly dynamic and engaged in labor-intensive activities that require an energy-rich diet [17]. In this context, the nutritional composition of Attieke explains its popularity in these urban environments, where street food is booming [17, 25]. However, the low protein (2-3%) and fat (<1%) content highlights the need for complementary food sources, such as legumes and animal products, to ensure a balanced nutritional intake [6]. In addition, its low fat content makes it a light and easily digestible food, which makes it accessible to a wide range of consumers [5, 9]. Finally, its high fiber content contributes to digestive health, promoting good intestinal transit and overall well being [6].

3.3. Physicochemical and Microbiological Quality of Attieke

Assessing the physical and chemical properties of Attieke, such as its pH, texture, and water absorption capacity, is essential to guarantee its quality and safety. In addition, microbiological analysis ensures that it is free of pathogens, which is crucial for consumer health [25]. Data from the literature indicate strong demand for Attieke in cities in West African countries in general and in Mali in particular, linked to its cultural role, nutritional value, and practicality [22, 26].

3.3.1. Physicochemical Quality of Attieke

Attieke is a staple food made from cassava that is widely consumed in Côte d'Ivoire and found in several West African countries (Burkina Faso, Benin, Mali, etc.). Its physicochemical quality determines its safety (particularly with regard to cyanide), shelf life, nutritional value, and sensory acceptability. The traditional process (grating, spontaneous fermentation, pressing, sieving, steam cooking) leads to significant variability between producers and regions [4, 7, 26]. Most of the data comes from studies conducted in Côte d'Ivoire and Burkina Faso; specific studies for Mali are rare. The variations observed can be explained mainly by the variety of cassava, the duration/method of fermentation, rinsing/pressing, and post-fermentation practices.

pH and acidity: The pH of the finished product is generally acidic, with most studies indicating values between 3.8 and 4.8, with averages often around 4 to 4.6. This acidification results from the activity of lactic acid bacteria during the fermentation process. It plays a protective role by inhibiting the growth of undesirable microorganisms, thereby contributing to the safety and quality of the final product [26].

Humidity: The moisture content of cassava products is often between 50 and 65%, which corresponds to a dry matter content of approximately 35 to 50%. This moisture content may vary depending on the degree of cooking and drying. After cooking, water activity remains high enough to make the product susceptible to spoilage, especially if it is stored at room temperature and poorly packaged. It is therefore essential to use appropriate storage methods to preserve the quality and safety of the product [27].

Proximate composition (carbohydrates, proteins, lipids, ash)

Attieke is primarily an energy food, with carbohydrates and starch making up most of its composition, including a very high level of tuber starch in the dough. The carbohydrate content, based on fresh matter, generally varies between 35 and 48 g per 100 g, depending on moisture content. The protein content is generally low, ranging from 0.8 to 3.8 g per 100 g of fresh product. Lipids are also low, often less than 1 g per 100 g, except in cases of enrichment. Finally, ash and minerals have variable values, ranging from 0.14 to 0.78 g per 100 g, and are influenced by factors such as rinsing, mineral contamination, or the addition of ingredients [28, 29].

Table 2. *Average nutritional values for 100 g of dry Attieke.*

Nutriments	Quantity (g)
Carbohydrates	91.73
Dietary fiber	4.2
Protein	2.83
Fats	1.23
Salt	1

Nutriments	Quantity (g)
Total	100

Total cyanide (HCN): main chemical concern Cassava contains cyanogenic glycosides such as linamarin and lotaustralin. Traditional preparation methods, including scraping, fermentation, pressing, rinsing, and steaming, significantly reduce the cyanogen content. However, the quality of the final residues can vary considerably. Some studies indicate that if these processes are not carried out correctly, HCN levels can exceed recommended thresholds. Fermentation and pressing are therefore crucial steps in ensuring effective detoxification [30, 31].

Color and grain size: Color, ranging from ivory to yellow, and grain size, which refers to the size of the Attieke grains, are essential sensory criteria for assessing quality. These characteristics vary depending on the variety of cassava used, the duration of fermentation, and the sieving process. In addition, these parameters play a decisive role in consumer acceptance of the product [32]. In terms of organoleptic properties, consumer acceptance of Attieke depends heavily on its texture (cohesion, moldability), shine, and acidity [33].

Figure 1. *Attieke packaged in a plastic bag and on a plate [33].*

Table 3. *Synthetic table (typical values extracted from the literature).*

Parameters	Typical range	Comment/source
pH	3,8 – 4,8	Acidification by LAB [26]
Humidity (%)	50 – 65	Depends on drying/cooking; influences preservation [27]
Dry matter (%)	35 – 50	Moisture supplement [28]
Carbohydrates (%)	35 – 48	Main energy component [28]
Proteins (%)	0,8 – 3,8	Low opportunity for enrichment [29]
Lipids (%)	0,1 – 1	Low [28]
Ash (%)	0,14 – 0,78	Varies depending on contamination/minerals. [28]
Total cyanide (mg/Kg)	< 10 (GP) >50 (IP)	Depends on the effectiveness of fermentation, pressing, and rinsing. [30, 31]
Color/particle size	quality rating	important for acceptability (CIELab measurements sometimes used) [32]

The variations observed in cassava processing are determined by several key factors. First, the variety of cassava used, whether bitter or sweet, directly influences the initial level of cyanogenic glycosides, as well as the final texture of the product [31, 32]. In addition, the fermentation process, which encompasses parameters such as duration, temperature, and the use of controlled starters, plays a crucial role in modulating pH, acidification, and detoxification efficiency [26, 27, 31]. The rinsing, pressing, and cooking steps are also essential, as they extract and remove cyanogens while reducing moisture [31]. Finally, hygiene practices and the quality of the water used impact ash and mineral levels, which can indirectly affect the physicochemical quality of the final product by leading to contamination and residue risks [33, 34]. These various elements interact to determine the safety and quality of cassava derived products.

3.3.2. Microbiological Quality of Attieke

The main microorganisms encountered during fermentation include, first and foremost, lactic acid bacteria (LAB), which dominate this process and contribute to the organoleptic quality of the products. However, the presence of total and fecal coliforms, as well as *E. coli*, are indicators of poor hygiene, signaling potential health risks. In addition, contamination by

Staphylococcus aureus is often linked to improper handling during preparation. It is also important to note the presence of *Bacillus spp.,* some species of which, such as *B. cereus*, can be toxinogenic, representing an additional risk. Finally, the variety of yeasts and molds observed depends on storage conditions, which can also influence the safety and quality of fermented products. A summary of the key results is presented in the following table.

Table 4. *Synthetic table (typical values extracted from the literature).*

Reference and Location	Analytical methods	Key results	Risk identified
Côte d'Ivoire [37]	Microbial counts, pH, LAB identification	Dominant LAB, protective acidic pH	Low risk if good post-fermentation hygiene
Burkina Faso [38]	Coliformes, Salmonella, B. cereus	Presence of S. aureus; Salmonella absent	Post-cooking hygiene risks
Côte d'Ivoire [12]	Microbiology + total cyanide	Variable contamination; no Salmonella	Chemical + microbial risks
Burkina Faso [39]	Antibiogram	Multi-resistant S. aureus detected	AMR (antimicrobial resistance) risk
Burkina Faso [36]	Metals (Pb, Cd) ND	Traces detected	Environmental chemical risk
Côte d'Ivoire [35]	Coliforms, E. coli, S. aureus	High coliform loads in street vending	Fecal risks + handling

The absence of clear national standards and regular inspections exacerbates this risk. Imports, although they meet demand, do not fully guarantee sanitary quality. These findings justify the need for an integrated approach combining standardization, sanitary controls, producer training, and consumer awareness [3, 5, 6].

4. Conclusion and Recommendations

Based on information from existing literature, Attieke appears to be a staple food in West Africa, both nutritionally and economically. Its high carbohydrate content and low cost make it a mainstay of many households' diets, while its artisanal production provides incomes, particularly for women. However, this same artisanal production presents major challenges in terms of food safety. The variability of processes (fermentation, pressing, cooking), hygiene at production sites, and the lack of standardization are sources of microbiological and chemical risks. In terms of hygiene and fecal indicators, numerous studies reveal the frequent presence of total and fecal coliforms, with concentrations sometimes exceeding recommended standards. With regard to major pathogens, the results highlighted the frequent presence of *Staphylococcus aureus*, indicating poor food handling practices. In addition, *Bacillus spp*. were detected, often associated with cassava, soil, and storage conditions, with a potential risk of toxigenic *Bacillus cereus*. In contrast, Salmonella appears to be largely absent from the available studies. Finally, scientific research will need to support this initiative by evaluating fermentation processes, microbiological quality, and product traceability in order to guarantee safe, nutritious, and sustainable Attieke for consumers in Mali and West Africa. In order for Attieke to fully play its role as a vector for development, several actions are necessary:

Standardization and hygiene: development and adoption of quality standards, implementation of HACCP systems, training of producers (particularly artisanal producers) in good manufacturing practices.

Technological improvement: selection of high-performance microbial strains (lactic acid bacteria, yeasts) to optimize fermentation, reduce production times, and control risks.

Abbreviations

AGRIS	International Information System for the Agricultural Sciences and Technology
AJOL	African Journal Online
AMR	AntiMicrobial Resistance
CIELab	Color Space as an International Standard for Color Measurements
CGIAR	Consultative Group on International Agricultural Research
CVL	Central Veterinary Laboratory
HACCPs	Hazard Analysis Critical Control Point
HCN	Total Cyanide
FAO	Food and Agriculture Organization
LAB	Lactic Acid Bacteria
ND	Not Detected
PRISMA	Reporting Items for Systematic Reviews and Meta-Analyses
PICOS	Problem, Intervention, Comparator, Outcomes Study Design
pH	Hydrogen-Ion Concentration Measured at the Electrode *p*.

USTTB University of Sciences, Techniques and Technologies of Bamako

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Author Contributions

Sissoko Aminata: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing

Maiga Boubacar Madio dit Aladiogo: Investigation, Methodology, Writing – review & editing

Diabate Daouda: Methodology, Supervision, Writing – review & editing

Dicko Amadou Hamadoun: Supervision, Writing – review & editing

Samake Fasse: Supervision, Writing – review & editing

Data Availability Statement

The data supporting the outcome of this research work has been reported in this manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

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