MICROBIOLOGY ARCHIVES
Original Research Article | ISSN: 3041-590X
Journal homepage: https://microjournal.researchfloor.org/

Assessment of Hygiene Practices and Their Impact on the Quality of Raw Cow Milk from Producers and Resellers in Korhogo, Côte d'Ivoire

Traore Moumouny*[1], Kouame N´Zebo Desire[2], Yoro Thierry Dezay[1], Kone Drissa[1], and N'guessan Amoin Elyse[1]

[1]*Department of Biochemistry and Genetics, Laboratory of Biotechnology and Agro-Food Valorisation, Peleforo Gon Coulibaly University, BP 1328 Kohogo, Côte d'Ivoire*
[2]*Departement of Biosciences, Laboratory of Biotechnology Agriculture and Valorization of Biological Resource, Félix Houphouët-Boigny University, 22 BP 582 Abidjan 22, Côte d'Ivoire*

ARTICLE INFO

Citation: Traore Moumouny, Kouame N´Zebo Desire, Yoro Thierry Dezay, Kone Drissa, and N'guessan Amoin Elyse (2026). Assessment of Hygiene Practices and Their Impact on the Quality of Raw Cow Milk from Producers and Resellers in Korhogo, Côte d'Ivoire.
Microbiology Archives, an International Journal.
DOI: https://doi.org/10.51470/MA.2026.8.2.05

Received 07 April 2026
Revised 09 May 2026
Accepted 10 June 2026
Available Online July 05, 2026

Corresponding Author: **Traore Moumouny**
E-Mail: **traoremoumouny@yahoo.fr**

Copyright: *© The Author(s) 2026. This article is Open Access under a Creative Commons Attribution 4.0 International License, allowing use, sharing, adaptation, and distribution with appropriate credit. License details: http://creativecommons.org/licenses/by/4.0/. Data is under the CC0 Public Domain Dedication (http://creativecommons.org/publicdomain/zero/1.0/) unless otherwise stated.*

ABSTRACT

The transmission of diseases through milk is more frequent among people who consume it raw. This study aims to evaluate the microbiological quality of raw cow's milk, with the goal of contributing to the preservation of consumer health. To achieve this, a survey was first conducted among 20 farmers, 45 vendors, and 70 consumers. Physicochemical and microbiological analyses were then carried out using conventional methods on 45 samples from farms and 27 from markets. Results show that 60% of the cows milked were between 4 and 6 years old. Sixty percent of the cows were fed with grass and organic matter. Milking was entirely manual, with volumes ranging between 6 and 10 litres (60%). Boiling milk is the most commonly used preservation technique (80%). More than 70% of respondents preferred raw milk for its taste (40%) and nutritional quality (25%). Samples taken from farms showed better compliance with standards for pH, titratable acidity, total dry matter and density. An increase in microbial loads was observed from farm to market: 6.8 to 8.7 × 10^4 CFU/mL; 1.2 to 1.5 × 10^3 CFU/mL; 2.8 to 5.2 × 10^2 CFU/mL; 1.5 to 1.7 × 10^3 CFU/mL, respectively for FAMT, CT, E. coli and S. aureus. ASR and Salmonella were not detected, which complies with standards. Training in hygiene and food safety is necessary to ensure the hygienic quality of raw milk.

Keywords: *milk cow, quality, microbiological, physicochemical, Côte d'Ivoire.*

INTRODUCTION

Milk is a highly nutritious food. It is rich in proteins, carbohydrates, fats, vitamins and minerals. It contains nearly all nutrients essential for humans and represents an important source of dietary energy. Its consumption can significantly contribute to meeting recommended nutritional needs [1].

Milk plays an essential role in dietary habits worldwide and holds an important place in the culinary traditions of many African countries. It is consumed as a hot or cold beverage and is used in the preparation of many food products (cheese, butter, yogurt, etc.). [2].

West African milk production is about 2.8 million tons, representing around 7% of Africa's total production. More than 64% of this production comes from Mali (28%), Niger (23%) and Mauritania (13%) [3]. In Côte d'Ivoire, production is mainly from cattle and was estimated at 34,000 tons in 2025, covering only 15% of national milk consumption. The northern region of Côte d'Ivoire is the main production area. Each year, the country imports more than 85% of its milk consumption to meet domestic demand [4].

In addition to the production deficit, challenges of preservation and microbiological quality arise. Milk is highly perishable due to its chemical composition, high water content, and near-neutral pH, making it an ideal medium for microbial growth. Raw, unpasteurized milk is susceptible to contamination from environmental or animal sources during milking, especially in artisanal production systems [5, 6]. Raw milk can therefore be a potential vector of foodborne diseases. Symptoms after consuming contaminated milk include diarrhea, vomiting, fever and stomach cramps [7].

In Côte d'Ivoire, data on hygiene practices from milking to consumption and microbial contamination of milk are limited, hindering rigorous risk assessment. Yet, consumers—especially in production zones like the Poro region—prefer raw milk for socio-cultural reasons, taste and perceived health benefits [8, 9]. Under these conditions, consumption may pose a danger to consumers.

It is therefore important to ensure raw milk of good hygienic quality. This study, conducted in Korhogo, one of Côte d'Ivoire's main milk-producing areas, aims to evaluate the physicochemical and microbiological quality of raw cow's milk to help preserve consumer health.

MATERIALS AND METHODS

Study Area

This study was conducted in Korhogo (Latitude: 9.4580°N, Longitude: -5.6295°W) from April 2 to June 10, 2025. Korhogo is the main city in northern Côte d'Ivoire and the capital of the Poro region. Its area is 12,500 km^2 and its population is estimated at 440,926 (Figure 1) [10]. It is one of the country's main cow's milk production centres.

Biological Material

The biological material consisted of raw cow's milk collected from three farms and three markets (Dem, Koko, and Delafoss) (Figure 2).

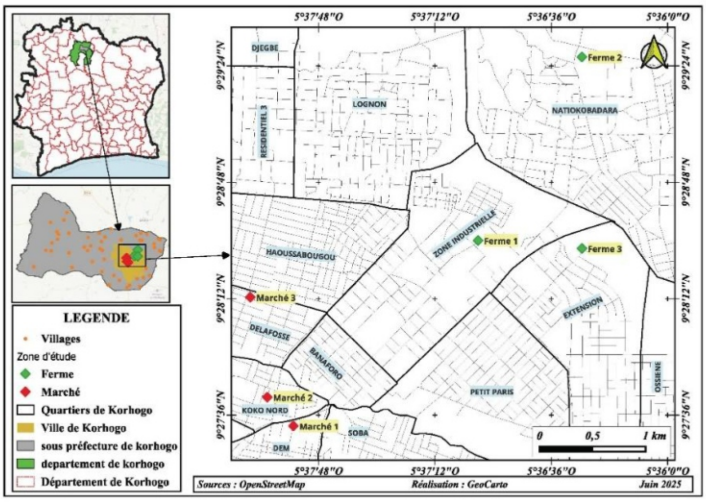

Figure 1 : Map of the Korhogo department with the sampling sites

Figure 2: Photographs of raw cow's milk during milking and sale on the market

Methods

Surveys of Farmers, Vendors and Consumers

Surveys were conducted through interviews using a questionnaire with open-ended questions. Topics included hygiene conditions and other factors affecting milk quality during milking, sale, and consumption. Respondents were selected using purposive sampling. Data collection was done with the Kobotoolbox application via Kobocollect on mobile phones. In total, 70 consumers, 45 vendors (15 per market), and 20 farmers participated.

Sampling

Sampling was also purposive. A total of 45 samples were collected during manual milking in three farms (15 per farm) and 27 samples from vendors in three markets (9 per market). Samples were collected in sterile 150 mL screw-cap bottles, in duplicate: one for physicochemical analysis and one for bacteriological analysis. Samples were taken under real milking and selling conditions, labelled, placed in ice-filled coolers, and transported to the laboratory within 30 minutes.

Physicochemical Analyses

The physico-chemical analyses focused on determining pH, density, titratable acidity and total dry matter content.

An electronic pH meter (HI 8010) was used to measure the pH of the samples. After calibration with buffer solutions of pH 4 and 7, the electrode was rinsed with sterile water and then immersed in the milk sample. The pH value was read directly from the pH meter dial once the data had stabilized [11].

The determination of titratable acidity (TA) was based on the titration of lactic acid with sodium hydroxide (NaOH) (1/9N) in the presence of phenolphthalein (1%) as a color indicator. The result was determined by applying formula 1.

The total dry matter content (TDM) was determined according to the method described by Otmane *et al*. (2022) [12]. A volume of 5 mL of milk was introduced into a pre-weighed capsule, then dried at 105 °C for 2 hours in an oven until a constant mass was obtained. After cooling, the capsule was weighed again. The TDM content, expressed in g/L, was calculated using formula 2.

The density of the milk was determined using a thermo-lactodensimeter according to Lankri, (2024) [11]. Measurements were carried out at 20 °C after immersing the instrument in a milk sample free of foam and air bubbles.

$$\text{Titrable acidity} = V \times 10 \ (D°) \qquad (1)$$

A : titrable acidity, **V** : volume in mL of sodium hydroxide solution (Dornic soda).

$$EST = (M' - M0) / M \times 1000 \qquad (2)$$

EST: Total Dry Extract, $\mathbf{M_0}$: the mass of the empty capsule, **M**: the mass of the milk before oven-drying (without the capsule), $\mathbf{M'}$: the mass of the capsule with the milk after oven-drying.

Microbiological Analyses

Serial decimal dilutions were performed according to ISO 6887/2017. Enumeration of total mesophilic aerobic flora (TAMF) was carried out on PCA agar according to ISO 4833-2:2013, and enumeration of total and fecal coliforms was performed on VRBL agar according to ISO 4832-1:2006.

Yeasts and molds were enumerated by surface spreading on Sabouraud agar with chloramphenicol, following NF ISO 6611:1996. Enumeration of presumptive *Staphylococcus aureus* strains was performed by surface spreading according to NF-V08-057-1 on Baird Parker medium enriched with egg yolk and potassium tellurite.

Detection of sulfite-reducing anaerobes (SRA) was carried out according to ISO 15213:2003 in tubes containing TSN medium. Selective chromogenic TBX agar was used for enumeration of β-D-glucuronidase-positive *Escherichia coli* according to NF ISO 16649-1.

For *Salmonella* detection, chromogenic RAPID'Salmonella agar was used according to ISO 16140-2:2016.

Calculation of Microbial Load

The microbial load was determined using formula 3 of ISO 7218

$$N=\sum C/V.d\ (n1+0{,}1n2) \qquad (2)$$

ΣC : sum of colonies on all plates from the two successive dilutions ; **V**: volume of the inoculum applied to each plate in milliliters; **n1** and **n2**: number of plates respectively for the first and second dilution considered; **d**: dilution factor of the first dilution taken into account.

Statistical Treatment of Data

Analysis of variance (ANOVA) was performed using Statistica software version 7.1 to evaluate differences in physico-chemical parameters and microbial loads. When a significant difference was observed between the values of the studied parameter, mean ranking (homogeneous groups) was carried out using the Newman–Keuls test. The significance threshold (α) was set at 0.05.

RESULTS

Survey Results

Among Farmers

The data from the survey conducted among farmers are presented in Table **I**. More than 60% of the cows milked were between 4 and 6 years old. They were mainly fed with grass and organic matter (60%). Milking was carried out entirely by hand, with only one milking per day (80%). The daily volume of milk obtained ranged between 6 and 10 litres in 60% of cases. In more than half of the farms (65%), milk from different cows was mixed. All cows had received doses of antibiotics (100%), and 90% were vaccinated.

Table I: Data from survey among farmers

Parameters	Category	Number (N=20)	Percentage (%)
Farmer's age	20 – 29	12	60
	Above 30	**08**	**40**
Age of cows	1 – 3	04	20
	4 – 6	**12**	**60**
	6 – 9	04	20
Feeding	Grass only	04	20
	Organic matter only	04	20
	Grass + organic matter	**12**	**60**
Number of milkings per day	**Once**	**16**	**80**
	Twice	04	20
Milking Volume (Litres)	2 – 5	04	20
	6 – 10	**12**	**60**
	10 – 20	04	20
Mixing of milk	**YES**	**20**	**100**
	Same species	13	65
Type of milk	Manual	20	100
	Industrial	00	00
Medical treatment administration	**Antibiotic**	**20**	**100**
	Vaccine	**18**	**90**
	Antibiotic and Vaccine	**19**	**95**

Among Market Vendors

The data from the survey conducted among vendors was presented in Table II. More than 80% of the vendors were supplied by farmers or their wives. For unsold milk, boiling is the most commonly used preservation technique (80%). The selling price applied is 600 FCFA per litre in 70% of cases. Milk is stored in jerrycans and displayed in basins or calabashes during sale.

Table II: Data from survey among vendors

Parameters	Category	Number (N=45)	Percentage (%)
Age (years)	18 – 24	09	20
	25 – 34	**27**	**60**
	Above 35	09	20
Supply source	Farm	09	20
	Market	**36**	**80**
Supply date	**Date of sale**	**27**	**60**
	Previous day	18	40
Storage during sale	Jerry can, basin or calabash	41	**91.1**
	Others	04	08.9
Preservation technique for unsold milk	**Boiling**	**36**	**80**
	Refrigeration	05	11.1
	Fermentation	04	08.9
Price per litre	500	14	31.2
	600	**31**	**68.8**

Among Consumers

The surveyed consumers were predominantly female (66%). The age group 20 to 29 years represented 43%. More than 70% of respondents preferred raw cow's milk to industrially processed fresh milk. This preference was motivated by taste (40%) and nutritional quality (25%). The majority (60%) reported consuming raw cow's milk at least once a week (Table III).

Table III: Data from the survey among consumers

Parameters	Category	Number (N=70)	Percentages (%)
Gender	**Feminine**	**46**	**65.7**
	Masculine	24	34.3
Ages (years)	10 – 19	25	35.7
	20 – 29	**30**	**42.9**
	Above 30	15	21.4
Type of milk	**Raw milk**	**49**	**70**
	Industrial milk	21	30
Reasons for consuming raw milk	**Taste**	**28**	**40**
	Quality	17	24.2
	Availability	11	15.7
	Price	14	20.1
Type of treatment before consumption	None	**39**	**55.7**
	Boiling	31	44.3
Frequency of consumption	Day	21	30
	Week	**42**	**60**
	Month	7	10

Physicochemical parameters of the samples

The physicochemical parameters of the samples are presented in Table IV. The mean pH values of samples from Farm 2 (6.57), Market 1 (6.50), and Market 3 (6.57) were lower than the standard (6.6–6.8). A significant difference at the 5% threshold was observed between the pH of samples from Farm 2 and Market 1 compared to the other samples.

The mean titratable acidity of samples from Market 1 (23.5 °D) and Market 3 (28.5 °D) were well above the standard values (16–18 °D). Only the samples from Market 2 showed a titratable acidity value significantly different at the 5% threshold. Overall, the titratable acidity of market milk was higher than that of farm milk ($p > 0.05$).

The total dry matter (TDM) content of the samples ranged between 14.13% and 29.84%. These values were higher than the standard, which is set at 13% for raw milk TDM.

The density values ranged between 1.02 and 1.226. Samples from Market 1 and Market 3 had mean densities of 1.22 and 1.21, respectively. These values were higher than those of quality cow's milk (1.028–1.035). No significant difference at the 5% threshold was observed between the TDM and density values of the analyzed samples.

Table IV: Physicochemical parameters of the analyzed milk samples

	pH	Titrable acidity (°D)	EST (%)	Density
Farm 1	6.66±0.02[a]	18.16±2.02[a]	20.7±3.43[a]	1.02±0.008[a]
Farm 2	6.57±0.04[b]	17.5±2.5[a]	28.1±1.77[a]	1.08±0.,09[a]
Farm 3	6.66±0.01[a]	16.16±3.88[b]	22.67±5.8[a]	1.03±0.009[a]
Market 1	6.50 ± 0.07[b]	23.5 ± 3.77[ab]	2.96 ± 11.41[a]	1.226 ± 0.282[a]
Market 2	6.68 ± 0.02[a]	16.5 ± 1.73[b]	14.13 ± 1.19[a]	1.049 ± 0.004[a]
Market 3	6.57 ± 0.03[ab]	28.5 ± 3.04[a]	29.84 ± 6.83[a]	1.214 ± 0.203[a]
Standard values	**6.6 – 6.8**	**16 - 18**	**10 - 13**	**1.028 – 1.035**

Means assigned the same letter in the same column are not statistically different at the 0.05 threshold.

Microbiological loads

Farm samples

The microbiological loads of samples from the farms are presented in Table V. The loads ranged between 4.45×10^3 and 8.2×10^3 CFU/mL. Samples from Farm 1 had the highest mean load of total mesophilic aerobic flora (TMAF) at 8.2×10^3 CFU/mL. A significant difference ($p < 0.05$) was observed between the mean TMAF load of Farm 2 (4.45×10^3 CFU/mL) and those of Farms 1 and 3. The TMAF loads were below the threshold set by microbiological criteria (10^5 CFU/mL).

The total coliform loads ranged between 9.86×10^2 and 1.44×10^3 CFU/mL. Samples from Farm 3 were the most contaminated with total coliforms (1.44×10^3 CFU/mL). Samples from Farms 2 and 3 exceeded the guideline value (10^3 CFU/mL). For *E. coli*, samples from Farm 3 had the highest mean load (4.22×10^2 CFU/mL), but this was below the guideline value (10^3 CFU/mL).

The mean loads of *Staphylococcus aureus* ranged between 1.12×10^3 and 1.83×10^3 CFU/mL. These values were above the threshold (10^2 CFU/mL). Samples with the highest yeast and mold counts came from Farm 3 (1.48×10^3 CFU/mL). Only samples from Farm 1 complied with the microbiological criteria (10^3 CFU/mL).

Anaerobic sulfite-reducing bacteria and *Salmonella* were not detected. These absences are consistent with microbiological standards.

No significant difference ($p > 0.05$) was observed among the three farms for total coliforms, *E. coli*, *Staphylococcus aureus*, and yeast and mold loads.

Samples from markets

The results of microbiological analyses of raw milk samples collected from markets are presented in Table VI.

The total mesophilic aerobic flora (TMAF) loads ranged between 7.14×10^3 and 1.06×10^4 CFU/mL. These values were below the threshold set by the standard (10^5 CFU/mL).

The total coliform loads ranged between 1.32×10^3 and 1.65×10^3 CFU/mL; these values were above the limit of 10^3 CFU/mL. Samples from Market 2 were the most contaminated with total coliforms (1.65×10^3 CFU/mL).

The *E. coli* contamination loads (4.49×10^2 to 6.27×10^2 CFU/mL) were below the guideline value (10^3 CFU/mL) set by microbiological criteria.

For *Staphylococcus aureus*, contamination loads ranged between 1.5×10^3 and 1.81×10^3 CFU/mL. None of the samples complied with the threshold (10^2 CFU/mL).

For yeasts and molds, Market 2 samples were the most contaminated, with a mean load of 1.46×10^3 CFU/mL. Only samples from Market 3 had loads below the microbiological criteria (10^3 CFU/mL).

No significant difference ($p > 0.05$) was observed among the markets for total coliforms, *E. coli*, *Staphylococcus aureus*, and yeasts/molds, except for yeasts and molds where differences were noted. Anaerobic sulfite-reducing bacteria and *Salmonella* were not detected in the analyzed samples.

Table V: Microbial load of samples from farms

UFC/mL	Farm 1	Farm 2	Farm 3	CM
FAMT	8.2 x10³ ± 1.65x10²[a]	4.45x10³ ± 1.81x10²[b]	7.86x10³ ± 1.50x10³[a]	**10⁵**
CT	9.86x10² ± 3.22x10²[a]	1.17x10³ ± 4.59x10²[a]	1.44x10³ ± 7.04x10²[a]	**10³**
E. coli	2.40x10² ± 1.04x10²[a]	1.86x10² ± 4.5[a]	4.22x10² ± 2.86x10²[a]	**10³**
S. aureus (	1.,68x10³ ± 4.77x10²[a]	1.12x10³ ± 1.04x10²[a]	1.83x10³ ± 5.77x10²[a]	**10²**
Lev and M	9.54x10² ± 1.36x10²[a]	1.41x10³ ± 2.27x10²[a]	1.48 x10³ ± 2.95x10²[a]	**10³**
ASR	ND	ND	ND	Absent
Salmonella	ND	ND	ND	Absent

FAMT: *Total Mesophilic Aerobic Flora;* ***CT***: *Total Coliforms;* ***E. coli***: *Escherichia coli;* ***Yeasts & Molds***: *Yeasts and Molds; ASR: Anaerobic Sulfite-Reducing bacteria;* ***CM***: *Microbiological Criteria;* ***ND***: *Not Detected. In the same row, means assigned the same alphabetical letter are not statistically different at the 5% threshold.*

Table VI: Microbial load of samples from market

UFC/mL	Mark 1	Mark 2	Mark 3	CM
FAMT	1.06x10⁴ ± 7.27x10²[a]	8.54x10³ ± 3x10³[a]	7.14x10³ ± 2.23x10³[a]	**10⁵**
CT	1.32x10³ ± 1.72x10²[a]	1.5x10³ ± 1.77x10²[a]	1.47x10³ ± 2.59x10²[a]	**10³**
E. coli	4.49x10² ± 3.1x10¹[a]	6.27x10² ± 3.18x10²[a]	4.69x10² ± 2.49x10²[a]	**10³**
S. aureus	1.81x10³ ± 5.86x10²[a]	1.5x10³ ± 3.18x10²[a]	1.66x10³ ± 4.95x10²[a]	**10²**
Lev et M	1.32x10³ ± 9.5x10¹[a]	1.46x10³ ± 8.6x10¹[a]	9.34x10² ± 1.16x10²[b]	**10³**
ASR	ND	ND	ND	Absent
Salmonella	ND	ND	ND	Absent

Means assigned the same letter in the same row are not statistically different at the 0.05 threshold

Comparison of physicochemical parameters of samples from farms and markets

The samples from the farms had mean values of pH (6.63), titratable acidity (17.40 °D), and density (1.04) that were consistent with the guideline values for quality raw milk. Overall, the physicochemical parameters of the market samples did not meet the criteria for quality raw milk (Table VII).

Table VII: Comparison of physicochemical parameters of samples from farms and markets

	pH	AT	EST	Density
Farm	6.63	17.42	23.89	1.04
Market	6.58	22.83	23.97	1.163
Standard values	6.6-6.8	16-18	10-13	1.028-1.035

Comparison of contamination levels between farm and market samples

The samples from the markets had higher levels of contamination in TMAF, total and thermotolerant coliforms, and Staphylococcus aureus compared to the samples from the farms (Figure 3). An increase in loads was observed from 6.8×10^4 to 8.7×10^4 CFU/mL; 1.2×10^3 to 1.5×10^3 CFU/mL; 2.8×10^2 to 5.2×10^2 CFU/mL; and 1.5×10^3 to 1.7×10^3 CFU/mL respectively for TMAF, CT, E. coli, and S. aureus from farm to market.

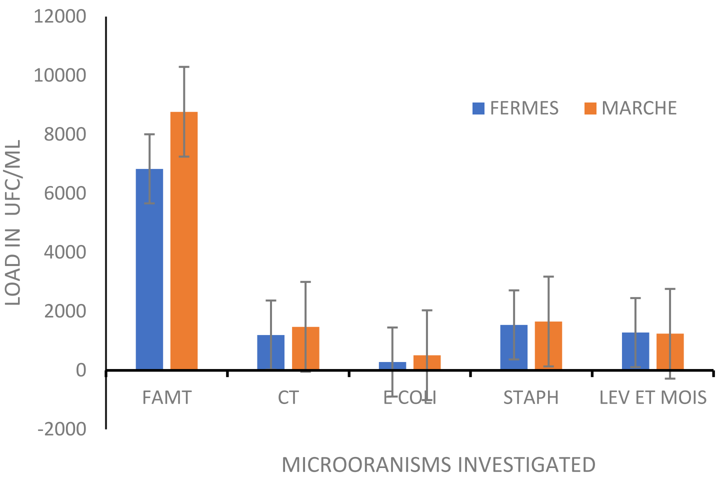

Figure 3: Comparison of contamination levels of samples from farms and markets

Frequency of contamination of samples by germs

The frequencies of contamination of the samples by germs are presented in Table VIII. All the samples analyzed were contaminated by TMAF. The contamination frequencies for total coliforms were 58% and 76% respectively for the samples from farms and markets. More than 81% of the samples from farms were contaminated by *Staphylococcus aureus*. *E. coli* (40% and 48%) and fungal flora (33% and 34%) were present in less than half of the samples.

Table VIII: Frequency of contamination of samples by germs

	Farm (%)	Mark (%)
FAMT	100	100
CT	58	76
E. coli	40	48
S. aureus	54	81
Lev et M	33	34
ASR	00	00
Salmonella	00	00

DISCUSSION

Knowledge of certain physicochemical parameters and the microbial load of raw milk makes it possible to assess its preservation and quality.

The pH of samples from farm 2 and markets 1 and 3 are lower than the pH values (6.66 – 6.8) of cow's milk considered fresh. The drop in pH in some samples could indicate the onset of fermentation. A study conducted by Gondimo *et al*. (2024) [13] on the physicochemical quality of milk in Moundo, Chad, showed that only 26.67% of the samples complied with the pH standard. The pH of raw milk is influenced by the lactation cycle, feeding, the health status of the cows, and the freshness of the milk, etc. [14].

The samples from the farms show better conformity with the values of titratable acidity (15–18°D) for fresh milk. The average titratable acidity of the samples from markets 1 (23.5°D) and 3 (28.5°D) is well above the standard. An increase in titratable acidity would indicate poor preservation of the milk. The titratable acidity values of the samples from the markets are of the same order of magnitude as those obtained by Gondimo *et al*., 2024 [13] (19,92°D - 27,42°D) in a similar study conducted in Chad. According to Lewis (2022) [15], there is no strict equivalence relationship between pH and the titratable acidity of milk. Indeed, two samples may present the same pH while having different titratable acidities, and vice versa. This lack of correspondence was also observed in the present study. For Lankri (2024) [11], an increase in the titratable acidity of milk indicates lactic fermentation, the presence of colostrum, or mastitis.

Regarding density, the samples from markets 1 and 3 have average densities higher than those of quality cow's milk (1.028 and 1.035) at 20 °C. The variation in density between the samples can be explained by the cows' diet and by fraudulent practices of the vendors. The density values obtained are close to those reported by Ambaye *et al*. (2026) [16], who found an average density of 1.029 in their study. The variability of milk density can also be explained by the breed of the animal and its diet [17].

The determination of Total Dry Extract (TDE) makes it possible to evaluate the quality of milk. It helps to identify whether there has been excessive addition of water to the milk [18]. The analyzed samples appear richer in dry matter since the values determined range between 14.13% and 29.84%. This richness in TDE can be explained by the low milking volumes, oscillating between 6 and 10 liters for 60% of the cows. According to Diao (2000) [19], an increase in the TDE content is explained by the cow's low milk production.

The microbiological analysis of cow's milk helps to prevent the risks of foodborne infections [20]. In this study, spoilage microorganisms (total mesophilic aerobic flora (TMAF), total coliforms (TC), yeasts, molds) and potentially pathogenic microorganisms (*Escherichia coli* (EC), *Staphylococcus aureus*, sulfite-reducing anaerobes (SRA), and *Salmonella*) were investigated.

Milk samples from the markets are more heavily loaded with microorganisms than those from the farms. The mixing of freshly milked milk and its transport in containers at inappropriate temperatures could explain the difference in microbial load between the farm and market samples. The results obtained are consistent with those of Yuen *et al*. (2012) [21], who reported a significant increase in total flora, rising from 5.08 ± 0.05 to 5.96 ± 0.12 log CFU/mL between the farm and the collection center. The authors attributed this increase to poor hygiene conditions of the containers used for milk collection and transport, as well as to storing the product at temperatures above 4–5 °C. Furthermore, Abd *et al*. (2009) [22]

suggest that mixing freshly milked milk with milk from the previous day is also a factor likely to increase bacterial proliferation in raw milk.

The TMAF loads are below the threshold value of 10^5 CFU/mL. The results are lower than those obtained by Niang *et al*. (2020) [23] (2.8×10^5 CFU/mL). TMAF provides information on the hygienic quality of raw milk, the hygiene conditions during handling, and the health status of the animal, particularly the udders [24].

The total coliform loads in the samples range from 9.86×10^2 to 1.44×10^3 CFU/mL for the farm samples and from 1.32×10^3 to 1.65×10^3 CFU/mL for the market samples. For most of the samples, these loads exceed the standard (10^3 CFU/mL). Inadequate preservation and exposure of milk during market sales may explain these contamination levels. The loads are similar to those reported by Sabrina and Selma (2020) [25], which were around 10^3 CFU/mL.

The *E. coli* loads are highly variable but remain below the standard of 10^3 CFU/mL. Aouadh *et al*. (2024) [26] reported average loads of 4.5 $\log_{10}$ CFU/mL of *E. coli* in raw milk.

The average *Staphylococcus aureus* load in all analyzed samples is above the standard. Contamination of raw milk could be attributed either to mastitis in the producing animals or to contamination occurring during milk handling. Sissoko *et al*. (2023) [6], in their study on milk quality in Bamako (Mali), found *Staphylococcus spp* contamination in 15.4% of the samples analyzed. In contrast to our results, *Staphylococcus aureus* was absent in all milk samples analyzed by Niang *et al*. (2020) [23]. *Staphylococcus aureus* is the pathogenic microorganism most often implicated in cases of collective foodborne intoxications (TIAC) from milk and dairy products. It causes nausea, vomiting, diarrhea, abdominal pain and headaches [27].

The fungal load ranged from 9.54×10^2 to 1.48×10^3 CFU/mL and from 9.34×10^2 to 1.46×10^3 CFU/mL for the farm and market samples, respectively. Poor hygiene during milking and market dust may explain this fungal presence. These values are higher than those found by Élysée *et al*. (2024) [28], which ranging from 05 CFU/mL to4.9.102CFU/mL. According to Kumar and Patyal (2024) [29], fungal flora originates from poor hygiene conditions during handling and from ambient air.

In this study, SRA and *Salmonella* were not detected, which is consistent with the standard. Our results corroborate those of Niang *et al*. (2020) [23]. These authors reported a total absence of *Clostridia* and *Salmonella* in the milk analyzed. The absence of these pathogenic germs is a positive indicator of the microbiological quality of milk, as *Clostridium* spp. and *Salmonella* spp. are frequently involved in cases of food poisoning [30].

The widespread use of antibiotics by farmers increases the risk of finding antibiotic residues and resistant microorganisms in milk [31]. Although appreciated, the consumption of raw milk presents major health risks. Indeed, without pasteurization, microorganisms present in milk or introduced during and after milking may pose a risk to consumer health. Pathogenic *Escherichia coli, Salmonella* spp., and *Staphylococcus aureus*, often present in milk, are implicated in severe gastrointestinal disorders [32].

CONCLUSION

This study aimed to evaluate the physicochemical and microbiological quality of raw cow's milk, with the goal of contributing to the preservation of consumer health. The samples collected from farms showed better conformity of physicochemical parameters compared to those from markets. These results reflect a possible degradation of quality in markets linked to handling and storage conditions along distribution circuits. All samples analyzed were contaminated by TMAF, total coliforms, *E. coli, Staphylococcus* spp., and yeasts and moulds. However, the market samples were more contaminated than those from farms. In this study, SRA and *Salmonella* were not detected, which is consistent with the standard. Raw milk deteriorates along the circuit from farm to consumer.

Conflict of Interest: The authors declare no conflict of interest.

Financial Disclosure: The authors declared that this study has received no financial support.

REFERENCES

1. Reyes-Jurado, F., Soto-Reyes, N., Dávila-Rodríguez, M., Lorenzo-Leal, A. C., Jiménez-Munguía, M. T., Mani-López, E. and López-Malo, A. (2023), Plant-based milk alternatives: Types, processes, benefits, and characteristics. Food Reviews International, 39(4), 2320-2351. doi :https://doi.org/10.1080/87559129. 2021.1952421 145.
2. Murtaza, G., Kalim, F., & Aafreen, A. (2025). Characterization of functional milk products. Handbook of Milk Production, Quality and Nutrition, 525–540. https://doi.org/10.1016/b978-0-443-24820-7.00022-5
3. FAOSTAT. (2025). Statistiques de la production mondiale de lait. Organisation des Nations Unies pour l'Alimentation et l'agriculture. https://www.fao.org/faostat/Consulté le 22/05/2025
4. MIRAH-DDP. (2025). Rapport annuel sur la filière lait en Côte d'Ivoire. Ministère de des Ressources Animales et Halieutiques – Direction de la planification et des statistiques. https://www.mirah.gouv.ci/ Consulté le 23/05 /2025
5. Amri D et Khelifa R. (2020). Etude de la qualité microbiologique du lait cru destiné à la consommation dans la région de Tizi-Ouzou (Algérie). Revue des bioressources,10(2), 25-33.
6. Sissoko A., Samaké F., Maïga B. M. D.A., Dembélé S., Koné F. et Tembely S. (2023). Évaluation de la qualité microbiologique du lait frais pasteurisé et du lait local transformé (Tiakry) vendus dans le district de Bamako, Mali. Agronomie Africaine. 35 (2), 323-332.
7. Pakbin, B., Rossen, J. W. A., Brück, W. M., Montazeri, N., Allahyari, S., Dibazar, S. P., Abdolvahabi, R., Mahmoudi, R., Peymani, A., & Samimi, R. (2022). Prevalence of foodborne and zoonotic viral pathogens in raw cow milk samples. FEMS Microbiology Letters, 369(1). https://doi.org/10.1093/femsle/fnac108
8. Vijaya Kumar, V. (2018). Aflatoxins: Properties, Toxicity and Detoxification. Nutrition &Amp; Food Science International Journal, 6(5). https://doi.org/10.19080/nfsij.2018.06.555696
9. Nyokabi, S. N., de Boer, I. J., Luning, P. A., Korir, L., Lindahl, J., Bett, B. and Oosting, S. J. (2021). Milk quality along dairy farming systems and associated value chains in Kenya: An analysis of composition, contamination and adulteration. Food Control, 119, 107482.doi : https://doi.org/10.1016/j.foodcont. 2020.107482.
10. Institut National de la Statistique. (2021). Recensement général de la population et de l'habitat de Cote d'Ivoire. https://plan.gouv.ci/assets/fichier/ RGPH2021-RESULTATS-GLOBAUX-VF.pdf

11. Lankri, E., Boudour, K., Belabdi, I., Bouhroum, N., & Aichouni, A. (2024). Effect of Shelf Life on Physicochemical and Biochemical Parameters of Camel Milk. Asian Journal of Dairy and Food Research, (Of). https://doi.org/10.18805/ajdfr.drf-337
12. Otmane Rachedi, K., Remadni, M., & Badi, Y. (2022). Etude comparative des caractéristiques physico-chimiques des différents laits crus (chamelle, chèvre et vache) de la région d'El-Oued et Bougous (Wilaya d'El-Tarf). Synthèse, 28(2), 1-11.
13. Gondimo, E. G., Doutoum, A. A., Nazal, A. M., Djamalladine, D. M., N'djekouanodji, S., & Tidjani, A. (2024). Évaluation de la qualité physico-chimique du lait cru produit et commercialisé à Moundou (Tchad). International Journal of Biological and Chemical Sciences, 18(2), 430–438. https://doi.org/10.4314/ijbcs.v18i2.9
14. Matallah S., Matallah F., Djedidi I., Mostefaoui K. N. et Boukhris R. (2019). Qualités physico-chimiques et microbiologiques de laits crus de vaches élevées en extensif au Nord -Est Algérien. Livestock Research for Rural Development 29(11), 6-4.
15. Lewis, M. J. (2022). Physical and Physicochemical Properties of Milk and Milk Products. Advanced Dairy Chemistry, 493–551. https://doi.org/10.1007/978-3-030-92585-7_12
16. Ambaye, G., Hailu, T., Weldegebriel, M., Reda, M., & Bsrat, A. (2026). Assessment of physicochemical properties and bacteriological quality of raw cow milk along the Dairy Value Chain in Mekelle City, Tigray, Ethiopia. Scientific Reports, 16(1). https://doi.org/10.1038/s41598-026-49677-8
17. Aleli, A. T. (2024). Effect of Ground Nut Cake Supplement on Milk Production Performances and Economic Return of Dairy Cows. International Journal of Animal Science and Technology. https://doi.org/10.11648/j.ijast.20240801.11
18. Kaouche S. et Mati A. (2017). Effets des pratiques d'élevage sur la variation de la qualité hygiénique et nutritionnelle du lait cru dans la région médio-septentrionale d'Algérie. Revue de Médecine Vétérinaire, 168(7-9), 151-163, 13p
19. Diao M. (2000). Qualité hygiénique et valeur nutritionnelle du lait. Institut Sénégalais de recherches Agricoles (ISRA).7p
20. Dash, K. K., Fayaz, U., Dar, A. H., Shams, R., Manzoor, S., Sundarsingh, A., Deka, P., & Khan, S. A. (2022). A comprehensive review on heat treatments and related impact on the quality and microbial safety of milk and milk-based products. Food Chemistry Advances, 1, 100041. https://doi.org/10.1016/j.focha.2022.100041
21. Yuen SK, Yee CF, Yin FH. (2012). Microbiological quality and the impact of hygienic practices on the raw milk obtained from the small-scale dairy farmers in Sabah, Malaysia. Int J Agric Fd Sci.; 2(2):55-59.
22. Abd Elrahman, S. M., Ahmad, A. M., El Owni, A. O., & Ahmed, M. K. (2009). Microbiological and physicochemical properties of raw milk used for processing pasteurized milk in blue nile dairy company (Sudan). Australian Journal of Basic and Applied Sciences, 3(4), 3433-3437.
23. Niang, I., Ayessou, N., NDiaye, M. A., Beye, C., & Diop, A. (2020). Qualité microbiologique des fromages de chèvre au Sénégal. Afrique SCIENCE, 16(4), 114-122.
24. Sassi, E. (2019). L'étude de la variation saisonnière des paramètres biochimiques et microbiologiques du lait cru de vache à la traite dans l'Ouest Algérien (Doctoral dissertation, Université de Mostaganem-Abdelhamid Ibn Badis).
25. Sabrina B. et Selma H. (2020). Évaluation de la qualité microbiologique du lait cru de vache distibué dans les marchés de la ville de Batna. Revue science et Technologie C,51,35-40, p72
26. Aouadhi, C., Trakhna, F., & Maaroufi, A. (2024). Prévalence des bactéries pathogènes dans les produits laitiers. Revue de la Faculté des Sciences de Bizerte, 22, 209-218.
27. Seddaoui, I. (2020). Variations saisonnières et diversité du microbiote des laits réceptionnés dans les laiteries de l'Ouest Algérien (Doctoral dissertation, Université de Mostaganem-Abdelhamid Ibn Badis).
28. Élysée, G. G., Doutoum, A. A., Nazal, A. M., Aristide, K., Fadeunbo, K., Tidjani, A., & Nicolas, N. Y. (2024). Microbiological Quality of Raw Cow's Milk Produced and Marketed System in the Town of Bongor, Chad. Journal of Advances in Microbiology, 24(10), 76–85. https://doi.org/10.9734/jamb/2024/v24i10859
29. Kumar, A., & Patyal, A. (2024). An insight on microbial flora of milk and milk products. The Microbiology, Pathogenesis and Zoonosis of Milk Borne Diseases, 69–94. https://doi.org/10.1016/b978-0-443-13805-8.00004-1
30. Maiwore, J., Baane, M. P., Ngoune, L. T., Fadila, J. A., Yero, M. Y., & Montet, D. (2018). Qualité microbiologique et physico-chimique des laits fermentés consommés à Maroua (Cameroun). International Journal of Biological and Chemical Sciences, 12(3), 1234. https://doi.org/10.4314/ijbcs.v12i3.13
31. Virto, M., Santamarina-García, G., Amores, G., & Hernández, I. (2022). Antibiotics in Dairy Production: Where Is the Problem? Dairy, 3(3), 541–564. https://doi.org/10.3390/dairy3030039
32. Aprea, G., & Mullan, W. M. A. (2022). Raw milk: benefits and hazards. Dairy Foods, 19–46. https://doi.org/10.1016/b978-0-12-820478-8.00003-1