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Research Article

Evaluation of the Physicochemical and Microbiological Quality of Honey Marketed in the Urban Commune of Macenta, Guinea

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Abstract

This study aimed to evaluate the physicochemical and microbiological quality of honey marketed in the urban commune of Macenta (Guinea). A total of twenty-six (26) honey samples were collected and analyzed using standardized methods. Physicochemical results showed that moisture content ranged from 14.09% to 17.95%, generally complying with the recommended limit (<18%), indicating good storage stability. The pH values, ranging from 3.63 to 5.04, reflect the acidic nature of honey, which is favorable for preservation. Sugar content (62.50%-76.25%) indicates a good energy value, although lower values in some samples may suggest incomplete ripening. Total ash content (0.24%-1.21%) reflects variability related to botanical origin or possible external contamination. From a microbiological perspective, most samples exhibited low to moderate total aerobic mesophilic flora counts (10^1-10^2 CFU/mL), indicating overall acceptable quality. However, some samples showed high microbial loads (≈10^4 CFU/mL), associated with the presence of total and thermotolerant coliforms, suggesting environmental contamination and inadequate hygienic practices. High levels of yeasts and molds were also observed in these samples, indicating a potential risk of spoilage. In contrast, sulfite-reducing anaerobes and Salmonella were absent in all samples. In conclusion, honey marketed in Macenta shows generally satisfactory physicochemical quality but heterogeneous microbiological quality. Strengthening good hygienic practices and improving storage conditions are necessary to ensure product safety and quality.

Keywords

Honey, Physicochemical Properties, Microbiological Quality, Food Safety, Guinea

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1. Introduction

Honey is a natural apicultural product produced by bees from floral nectar. It is widely valued for its nutritional, therapeutic, and economic properties. Its quality depends on several factors, including botanical origin, as well as conditions of production, harvesting, processing, and storage [1, 2]. Honey is recognized for its numerous health benefits, particularly its antibacterial, antioxidant, anti-inflammatory, antimutagenic, and anticarcinogenic properties [3, 4]. These properties are associated with its complex chemical composition, predominantly consisting of simple sugars—mainly glucose and fructose—but also including minor constituents such as enzymes, minerals, amino acids, vitamins, and polyphenols [5, 6]. The water content of honey (generally ≤ 20%) plays a critical role in its stability, influencing its viscosity, crystallization, fermentation, and microbiological quality [7].

Other parameters, such as reducing sugar content, sucrose content, and hydroxymethylfurfural (HMF) concentration, are also essential indicators of honey quality and authenticity [2, 8]. Furthermore, honey is characterized by an acidic pH (ranging from 3.2 to 4.5), which also limits the growth of microorganisms [9, 10].

Despite these intrinsic properties that are unfavorable to microbial proliferation, honey may harbor a microbiota of diverse origin. This microbiota derives from primary sources, such as nectar, pollen, and the bees' own microbiota, as well as from secondary sources related to extraction, handling, and storage conditions [3, 11]. Inadequate hygiene practices during extraction, handling, and packaging can lead to contamination by various microorganisms, thereby compromising honey quality [10].

The major honey-producing countries include China, the United States, and Argentina [12]. In addition, during the same period, countries such as Turkey, Iran, Ethiopia, Argentina, the United States of America, Russia, Ukraine, India, and Mexico ranked among the top ten global honey producers [10]. However, in developing countries such as Guinea, the apiculture sector remains largely traditional. Artisanal methods of production and marketing, often characterized by a lack of standardization and control, may affect honey quality, particularly in terms of physicochemical deterioration and microbiological contamination.

In the Macenta region, where honey production represents an important economic activity, few scientific studies have been conducted to assess its quality. A better understanding of the physicochemical and microbiological characteristics of locally produced honey is therefore necessary to ensure its safety, enhance its value, and facilitate market access. Thus, a key question arises: what is the physicochemical and microbiological quality of honey produced and marketed in Macenta, and to what extent does it comply with international food safety standards?

In this context, the present study aimed to evaluate the physicochemical and microbiological quality of honey produced and marketed in Macenta, in order to assess its compliance with existing standards and contribute to improving its sanitary quality.

2. Materials and Methods

2.1. Study Area

This study was conducted in the urban municipality of Macenta, located in the Nzérékoré Region in Forest Guinea (Figure 1). This area was selected due to its significant role in the local production and commercialization of honey. Its geographical location, combined with high consumption of the product by the population, justifies the relevance of assessing the physicochemical and microbiological quality of honey marketed in the region.



Figure 1. *Location of Macenta Prefecture, Guinea.*

2.2. Sampling

A stratified random sampling approach was implemented to ensure the representativeness of samples according to production volume and the attendance of sales points. A total of 26 honey samples, each weighing approximately 500 g, were collected from various retail outlets in the urban municipality of Macenta in September 2025. Sampling was carried out aseptically using sterile containers. The samples were then transported in an insulated cooler (Figure 2) to preserve their physicochemical and microbiological characteristics until analysis at the laboratory of the National Office for Quality Control (ONCQ) in Conakry.



Figure 2. *Collection and packaging of honey samples.*

2.3. Physicochemical Analysis

Physicochemical analyses of honey were performed using standard methods. Moisture content was determined by weight loss after drying in an oven at 100-105 ℃ until constant weight was achieved. The pH was measured using a pH meter directly immersed in the sample [13]. Sugar content was measured using a portable refractometer [8]. Protein content was determined using the Kjeldahl method [2]. Total ash content was obtained by incineration at 650-850 ℃ [1]. This methodology allowed for a comprehensive characterization of the physicochemical properties of honey samples.

2.4. Microbiological Analysis

Microbiological analyses of honey were performed using standard methods adapted to each target microorganism (Figure 3). Total aerobic mesophilic flora (TAMF) was incubated on Plate Count Agar (PCA) at 30 ℃ for 72 h. Total coliforms (TC) and thermotolerant coliforms (TTC) were enumerated on Violet Red Bile Lactose Agar (VRBL) at 37 ℃ and 44 ℃, respectively, for 24 h. Yeasts and molds (YM) were enumerated on Potato Dextrose Agar (PDA) at 30 ℃ for 72 to 120 h. Sulfite-reducing anaerobes (SRA) were cultured on VRBL at 46 ℃ for 24 h. Isolation of *Salmonella spp*. was carried out using the classical steps of pre-enrichment, selective enrichment, and isolation [14].

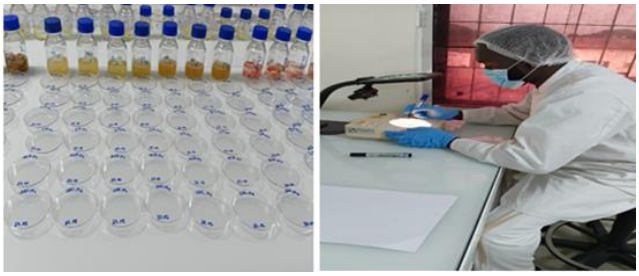


Figure 3. *Microbiological analyses of honey.*

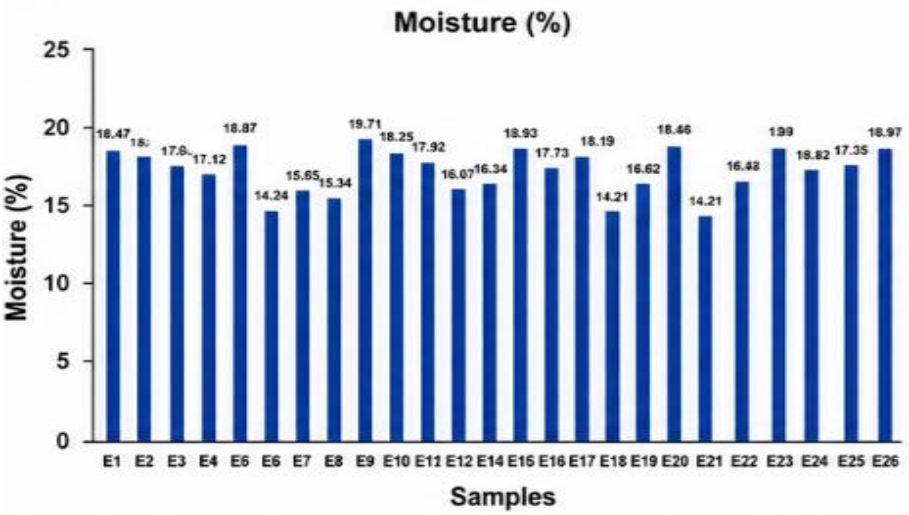
2.5. Statistical Analysis

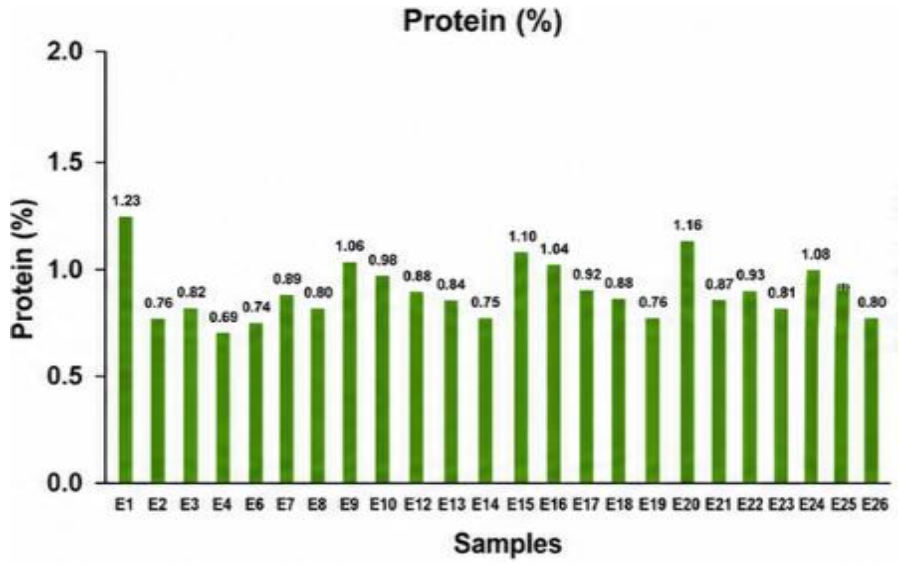
Data from physicochemical and microbiological analyses were processed using STATA software (version 15.1). Measured parameters were described using descriptive statistics, including means, standard deviations, minimum, and maximum values. To assess the compliance of samples with WHO standards, statistical comparison tests were performed, with a significance level set at $p < 0.05$. This approach enabled the identification of significant variations and highlighted non-compliant parameters that may pose a risk to food safety.

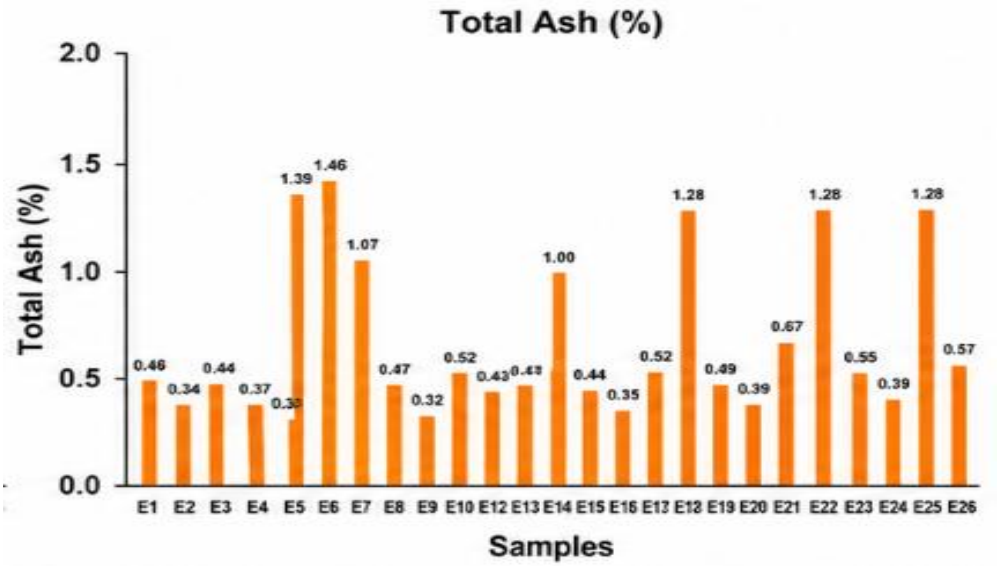
3. Results

3.1. Physicochemical Parameters

Figure 4 presents the physicochemical characteristics of twenty-six (26) honey samples collected in Macenta (Guinea). Moisture content ranged from 14.09% to 17.95%, remaining within international standards (< 20%), indicating good preservation potential. However, the highest values could, under inadequate storage conditions, favor fermentation processes. Protein content, ranging from 0.62% to 1.25%, reflects low variability related to floral origin while remaining within expected values for honey. Total ash content varied from 0.24% to 1.21%, indicating heterogeneity in mineral composition, likely influenced by botanical origin and environmental conditions. Sugar content, ranging from 62.50% to 76.25%, reflects a high carbohydrate concentration, which contributes to honey stability and preservation. Finally, pH values ranged from 3.63 to 5.04, confirming the acidic nature of honey, which contributes to microbial inhibition and overall product stability.


Moisture (%)
Moisture (%)
25
20
15
10
5
0
18.47
18.87
17.12
14.24
15.65
15.34
19.71
18.25
17.92
16.07
16.34
18.93
17.73
18.19
14.21
16.62
18.46
14.21
16.48
18.82
17.35
18.97
E1 E2 E3 E4 E6 E6 E7 E8 E9 E10 E11 E12 E14 E15 E16 E17 E18 E19 E20 E21 E22 E23 E24 E25 E26
Samples


Protein (%)
Protein (%)
2.0
1.5
1.0
0.5
0.0
1.23
0.76
0.82
0.69
0.74
0.89
0.80
1.06
0.98
0.88
0.84
0.75
1.10
1.04
0.92
0.88
0.76
1.16
0.87
0.93
0.81
1.08
0.80
E1 E2 E3 E4 E6 E7 E8 E9 E10 E12 E13 E14 E15 E16 E17 E18 E19 E20 E21 E22 E23 E24 E25 E26
Samples


Total Ash (%)
Total Ash (%)
2.0
1.5
1.0
0.5
0.0
0.46
0.34
0.44
0.37
1.39
1.46
1.07
0.47
0.32
0.52
0.43
1.00
0.44
0.35
0.52
1.28
0.49
0.39
0.67
1.28
0.55
0.39
1.28
0.57
E1 E2 E3 E4 E5 E6 E7 E8 E9 E10 E12 E13 E14 E15 E16 E17 E18 E19 E20 E21 E22 E23 E24 E25 E26
Samples

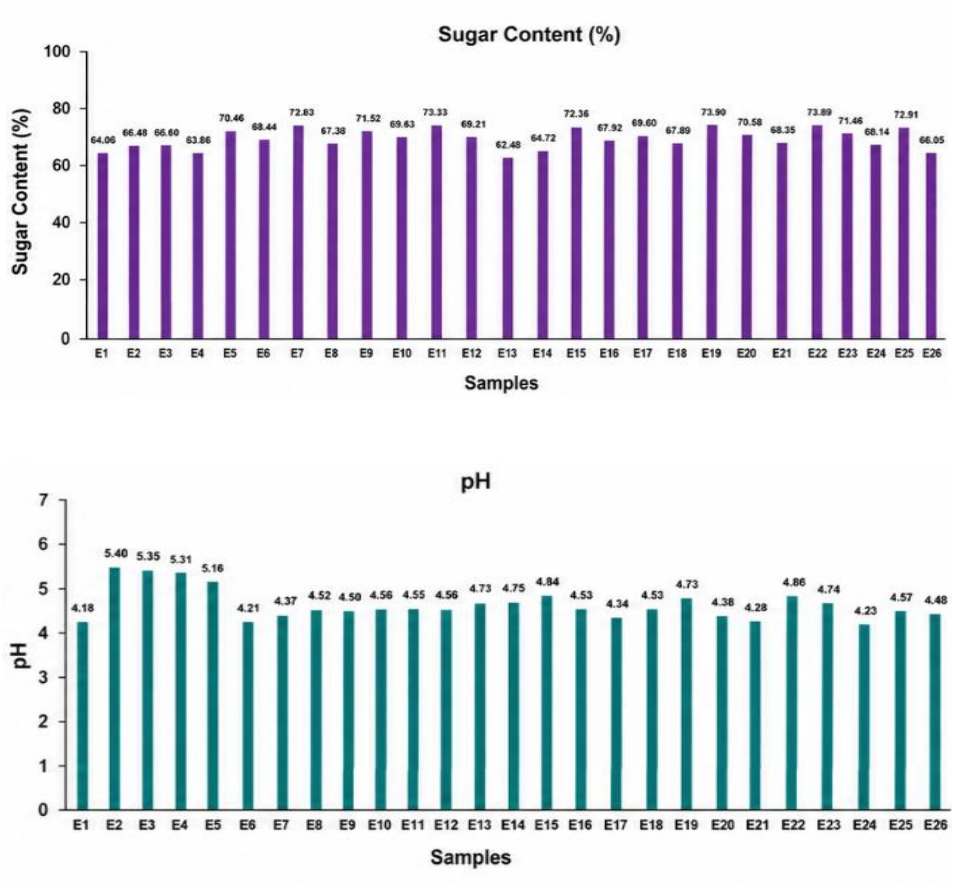
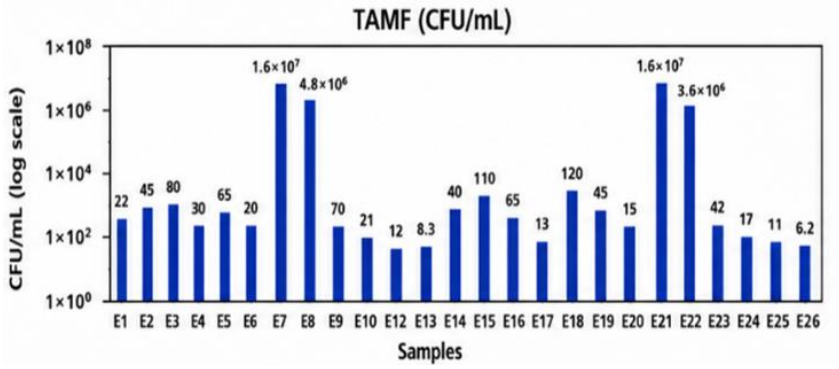
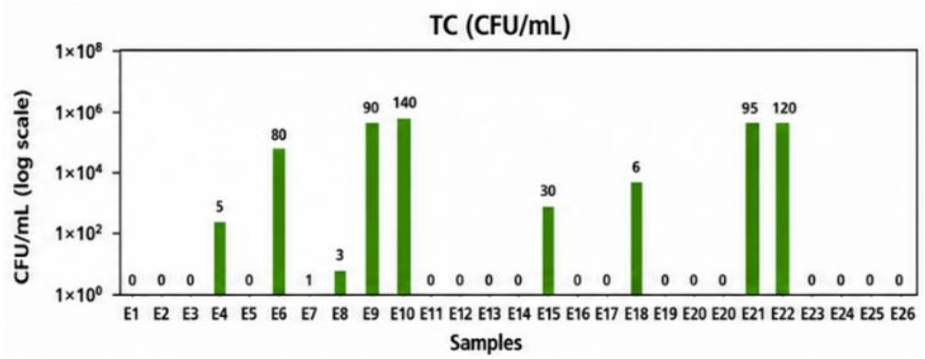


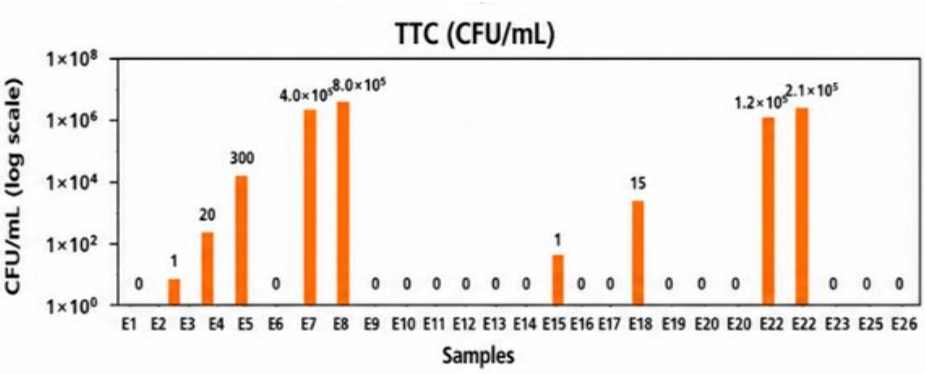
Figure 4. *Results of the physicochemical analysis of honey.*

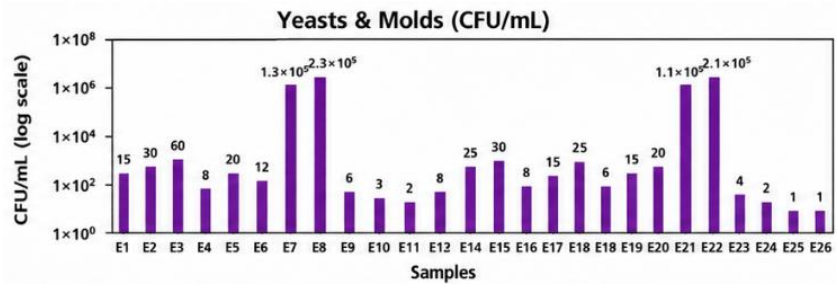
3.2. Microbiological Parameters

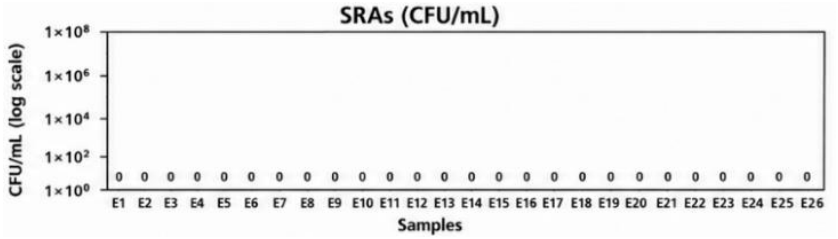
Figure 5 presents the microbiological results of twenty-six (26) honey samples. The majority of samples (E1 to E7, E10 to E20, and E23 to E26) exhibited a low microbial load, with total aerobic mesophilic flora (TAMF) values around 1.3×10^2 CFU/mL. These samples were also characterized by the absence or very low levels of total and thermotolerant coliforms, sulfite-reducing anaerobes, and Salmonella spp. Yeasts and molds were generally low, indicating satisfactory microbiological quality. In contrast, four samples (E8, E9, E21, and E22) showed high TAMF counts ($\geq 10^4$ CFU/mL), accompanied by total coliforms ($\approx 10^2$ CFU/mL) and thermotolerant coliforms ($\approx 10^1$ CFU/mL), as well as high levels of yeasts and molds ($\geq 2 \times 10^4$ CFU/mL). These results suggest environmental contamination, most likely related to inadequate hygiene conditions during production, handling, or storage. Furthermore, the absence of sulfite-reducing anaerobes and Salmonella spp. in all samples represents a favorable indicator of sanitary safety with respect to major pathogenic microorganisms. Overall, the findings indicate a generally satisfactory but heterogeneous microbiological quality, highlighting the need to strengthen good hygiene practices and improve honey storage conditions.











***Salmonella* spp. (CFU/25 mL)**

Sample	Result
E1 – E26	Absence in all samples

Figure 5. *Results of the microbiological analysis of honey samples.*

4. Discussion

4.1. Physicochemical Parameters

Moisture content ranged from 14.09 to 17.95%, falling within the 14-24.7% range reported by Nabeneza S et al., [15] for Indian Ocean honeys analyzed using near-infrared spectroscopy. The maximum value obtained (17.95%) is close to the mean value of 17.44 g/100 g reported by Ucuncu O et al., [16] for Turkish multifloral honeys. However, the values obtained in this study are slightly lower than those reported by Polatidou K et al., [17] (14.60-18.10%) for monofloral honeys, as well as those reported by Oroian M et al., [18] (17.12-18.52%) regarding the chemical composition and textural properties of honey. Nevertheless, these differences were not statistically significant ($p > 0.05$), suggesting relative homogeneity in moisture content across studies. The observed variations may be attributed to climatic conditions, botanical origin of nectar, and analytical methods used.

Protein contents (0.62-1.25%) were generally higher than those reported in the literature by White JW et al., [19], who observed an average value of 169 mg/100 g (i.e., 0.169%) across 740 honey samples, while Cucu A-A et al., [20] and Khan SU et al., [21] reported mean values close to 0.5%. A lower value (~0.3%) was reported by Zammit Young G-W et al., [22]. Statistical analysis revealed that the differences between the present results and those reported in the literature were significant ($p < 0.05$). The relatively higher levels observed may be attributed to increased pollen content, which represents the main protein source in honey, as well as to botanical origin and environmental conditions. Variations related to analytical methods cannot be excluded. These findings suggest a specific composition of the studied honeys, likely influenced by floral origin and filtration degree.

Ash contents (0.24-1.21%) were slightly higher than those reported by Guerzou M et al., [6] for Algerian honeys (0.06-0.48%) and generally higher than those reported by Lewoyehu M et al., [23] for Ethiopian honeys (0.08 ± 0.00 to 0.45 ± 0.03%). However, they were close to values reported by Rababah T et al., [24] for crystallized honeys (1.14-1.17%). Statistical analysis showed that differences with Guerzou M et al., [6] and Bonte F et al., [25] were significant ($p < 0.05$), whereas no significant difference was observed with Waworuntu J [26]. This mineral richness may be attributed to the botanical origin of the honeys and environmental conditions in which they were produced.

Sugar content (62.50-76.25%) was lower than values reported by Bonte F et al., [25] for honeys (~80%), by Waworuntu J [26] for Apis mellifera L. honeys (73.40-83.9%), and by Gajek M et al., [8] (81.5-82.5 °Brix). Similarly, Zammit Young G-W et al., [22] reported a carbohydrate content of approximately 80%, slightly higher than the values observed in this study. Statistical analysis indicated that these differences were significant ($p < 0.05$), confirming that the honeys in this study exhibited lower sugar levels compared to those reported in the literature. These variations may be linked to botanical origin, degree of maturity, water content, or environmental conditions.

pH values (3.63-5.04) were generally close to those reported by Bonte F et al., [25] (3.5-6.0) and Raweh HAS et al., [27] (4.5-5.0). They were higher than the value of 4 reported by Werner A et al., [28], and slightly higher than those observed by Khan SU et al., [21] (2.4-4.7). Statistical analysis showed that some differences, particularly with Luca L et al., [30] and Lewoyehu M et al., [23], were significant ($p < 0.05$), while those with Raweh HAS et al., [27] and Damto T et al., [31] were not significant. These pH variations may be related to botanical origin and water content, both of which are known to influence acidity and microbiological stability.

4.2. Microbiological Parameters

Total aerobic mesophilic flora counts obtained in the present study (1.5×10^1 to 1.08×10^4 CFU/mL) are generally higher than those reported by Iurlina MO et al., [29], who observed counts below 10^3 CFU/g across 70 honey samples analyzed. Lower values were also reported by Luca L et al., [30] in honeys from the Bukovina region (Romania), with counts ranging from 10 to 5×10^2 CFU/g. In contrast, the contamination levels observed in this study remain lower than those reported by Damto T et al., [31], who recorded values between 1.9×10^3 and 2.55×10^4 CFU/mL in honey produced by Meliponula beccarii in Ethiopia. These variations may be explained by differences in harvesting, handling, processing, and storage conditions, as well as by botanical origin and beekeeping practices.

Total coliform counts (0 to 1.08×10^2 CFU/mL) and thermotolerant coliforms (0 to 2.8×10^1 CFU/mL) observed in the present study are higher than those reported by Bakary C et al., [12], who detected no coliform contamination in honey samples from the Worodougou region (Côte d'Ivoire). Similarly, a recent study by Bruxel F et al., [10] on commercial honeys reported the absence of total coliforms in all analyzed samples. Furthermore, Fernández LA et al., [32], in a study on the microbiological quality of honey from the Pampas region (Argentina), did not observe any fecal coliforms in the examined samples. These differences suggest that the presence of coliforms in the present study may result from post-harvest contamination associated with less stringent hygiene practices during honey handling, processing, or packaging.

Yeast and mold counts (2.0 to 2.25×10^4 CFU/mL) obtained in this study are markedly higher than those reported by Luca L et al., [30], who recorded values ranging from 1.68×10^4 to 9×10^2 CFU/mL for yeasts and from 1.8×10^3 to 2×10^2 CFU/mL for molds in honeys from the Bukovina region (Romania). These levels also exceed those reported by Kędzierska-Matysek M et al., [33] in artisanal Polish honeys of different varieties, where counts were below 10 CFU/g, as

well as those reported by Bakary C et al., [12] in Côte d'Ivoire (Worodougou region), with a value of 2 CFU/g. These discrepancies may be attributed to variations in environmental conditions (floral origin, climate), hygiene practices during harvesting and handling, and storage conditions.

No anaerobic bacteria were detected in the analyzed samples, which is consistent with the findings of Kędzierska-Matysek M. et al. [33], who detected these microorganisms in only 0.1 g of a single buckwheat honey sample among all Polish artisanal honeys studied. The absence of sulfite-reducing anaerobes observed in the present study also agrees with the results of Iurlina MO et al. [29], who reported the absence of sulfite-reducing Clostridium spp. in 70 honey samples from Argentina of different botanical origins. Furthermore, these results are consistent with those of Snowdon JA et al. [11], who did not detect any vegetative forms of pathogenic bacteria in honey. This absence of anaerobic bacteria may be explained by the intrinsic properties of honey, including low water activity, acidic pH, and the presence of antimicrobial compounds. However, it should be noted that bacterial spores, particularly those of Clostridium spp., may persist in honey without being detected by conventional enumeration methods, highlighting the limitations of detection thresholds and analytical approaches.

No *Salmonella spp* were detected in the analyzed samples, which is in agreement with the findings of Vázquez-Quiñones CR et al. [3], who also reported its absence in honey samples studied in Mexico. These observations are consistent with those of Bruxel F et al. [10], who did not detect *Salmonella spp*. in commercial honeys during food safety and quality control assessments. Similarly, Bakary C et al. [12] reported the absence of *Salmonella spp*. in all analyzed honey samples, while Iurlina MO et al., [29] confirmed that this microorganism was not detecte in Argentine honeys of different botanical origins. The absence of *Salmonella spp*. in the studied samples may be explained by the intrinsic properties of honey, particularly low water activity, acidic pH, and antimicrobial compounds that limit the survival of pathogenic bacteria. Nevertheless, this absence should be interpreted with caution, considering the detection limits of analytical methods (generally expressed in CFU/25 g) and the potential risk of post-harvest contamination during handling and storage operations.

5. Conclusion

This study aimed to evaluate the physicochemical and microbiological quality of honey marketed in the urban municipality of Macenta (Guinea). The results showed that, from a physicochemical standpoint, most samples exhibited characteristics generally compliant with honey quality standards, particularly in terms of moisture content, pH, and sugar composition, indicating good preservation potential. However, the observed variations in ash and sugar contents suggest a certain heterogeneity, likely related to differences in botanical origin and production conditions. From a microbiological perspective, most samples showed low counts of total aerobic mesophilic flora and an absence of major pathogenic microorganisms such as Salmonella spp. and sulfite-reducing anaerobes, indicating overall satisfactory quality. Nevertheless, the presence of coliforms and elevated levels of yeasts and molds in some samples reveals deficiencies in hygiene practices during production, handling, and marketing. Overall, although the honey marketed in Macenta is generally compliant in terms of physicochemical quality, its microbiological quality remains heterogeneous. These findings highlight the need to strengthen good hygiene practices, improve storage conditions, and enhance the training of stakeholders in the apiculture sector. Future research should focus on a more detailed characterization of honey, including the identification of botanical origin through melissopalynological analysis, the assessment of chemical contaminants such as pesticide residues and heavy metals, and the evaluation of storage stability over time. In addition, studies investigating the impact of improved processing and handling practices on honey quality, as well as consumer perception and market acceptance, would provide valuable insights for the sustainable development of the honey sector in Guinea.

Abbreviations

TAMF (CFU/mL)	Total Aerobic Mesophilic Flora, Expressed in Colony-forming Units Per Millilitre
TC (CFU/mL)	Total Coliforms, Expressed in Colony-forming Units Per Millilitre
TTC (CFU/mL)	Thermotolerant Coliforms, Expressed in Colony-forming Units Per Millilitre
YM (CFU/mL)	Yeasts and Molds, Expressed in Colony-forming Units Per Millilitre
SRA (CFU/mL)	Sulfite-reducing Anaerobes, Expressed in Colony-forming Units Per Millilitre
SAL (CFU/25 mL)	Salmonella Spp., Expressed in Colony-forming Units Per 25 Ml of Sample

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Author Contributions

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

Ndeye Adiara Ndiaye: Validation, Writing – review & editing

Lahat Niang: Validation, Writing – review & editing

Modou Dieng: Validation, Writing – review & editing

Aly Traore: 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.



Mme 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



Lahat Niang, originally from Ndeme (Diourbel region, Senegal), is an assistant in the Department of Chemical Engineering and Applied Biology at the École Supérieure Polytechnique (ESP) of Cheikh Anta Diop University (UCAD) in Dakar. He holds a bachelor's degree in Physics and Chemistry from the Faculty of Science and Technology at UCAD. He was admitted through a competitive examination to ESP, where he trained as a food industry engineer. He subsequently worked in the industrial sector as a process engineer and later as a manager of industrial laboratories. He obtained his Ph.D. in Process and Environmental Engineering with highest honors. He is a specialist in industrial and environmental processes. His research focuses mainly on agri-food issues, particularly food safety and processing technologies, and he has authored several

scientific publications in this field.



Modou Dieng was born in Pékesse, Thiès region (Senegal). He completed his secondary education at the Military Prytanée of Saint-Louis, obtaining a bac-calaureate in natural and physical sciences with hon-ors. He pursued higher education at ENSUT (now ESP), earning a DUT in Biological Analyses and a Tech-nologist 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 Biotech-nology 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.



Aly Traore graduated from the Department of Food Technology and Quality Control. He has a solid background in food microbiology, quality control, and food safety. His research interests focus on assessing the microbiological quality of food products, preventing foodborne health risks, and improving agro-food processing methods. He is particularly interested in the safety of locally marketed food products and in developing strategies to reduce contamination. Through his work, he 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.

Lahat Niang: Enhancement and valorization of local agro-food products, Valorization of underutilized plant resources, Agro-food processing and product development, Food science and technology.

Aly Traore: Microbiological analysis of foods, techniques for counting microorganisms.