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Diversity, botanical origin, and valorization potential of honeys from Lower Guinea, Guinea: A systematic descriptive review

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ABSTRACT

Lower Guinea (Maritime Guinea) comprises mangrove systems, gallery and secondary forests, coastal savannas, and agricultural mosaics that may support a diverse melliferous flora. However, the scientific characterization of honeys produced in this region remains fragmentary, limiting quality certification, traceability, and market valorization. This review critically synthesizes available scientific and technical evidence on honeys produced, or potentially produced, in Lower Guinea, focusing on botanical and geographical origin, melissopalynological signatures, physicochemical quality, sensory attributes, bioactive composition, biological properties, production practices, authentication challenges, and valorization prospects. A systematic descriptive literature review was conducted using PubMed, Scopus, Web of Science, Google Scholar, FAO/Codex resources, and Guinean institutional reports, complemented by evidence from ecologically analogous West and Central African contexts because Guinea-specific literature is scarce. Available evidence suggests that the ecological heterogeneity of Lower Guinea and the foraging ecology of *Apis mellifera adansonii* may support distinct honey categories, including mangrove-associated, forest, savanna, and polyfloral honeys. Comparative studies from Benin, Nigeria, Côte d'Ivoire, Burkina Faso, and Cameroon indicate that botanical origin and production practices strongly influence honey quality. However, melissopalynological reference data, physicochemical profiles, bioactive and antimicrobial characterization, and authentication frameworks specific to Lower Guinea remain largely unavailable. Establishing an integrated analytical pipeline combining melissopalynology, physicochemical analyses, and modern authentication tools is therefore essential for future quality certification, geographical indication strategies, and sustainable valorization of Guinean honey.

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INTRODUCTION

Pollinator-mediated ecosystem services underpin global food security and the maintenance of both wild and cultivated plant diversity. Approximately three-quarters of the leading global food crops benefit to some degree from animal pollination, with bees constituting the most important functional group of pollinators (IPBES, 2016; Potts *et al.*, 2016). Beyond pollination, apiculture generates directly marketable products (honey, beeswax, pollen, propolis, and royal jelly) that provide low-investment income streams particularly relevant to smallholder and rural economies (Bradbear, 2009; Amulen *et al.*, 2017).

Honey is not a simple sugar solution but a biologically transformed food matrix whose composition reflects the interaction between floral resources, bee physiology, and post-harvest handling. Its major constituents, namely fructose, glucose, and minor oligosaccharides, are accompanied by organic acids, proteins and bee-derived enzymes (invertase, diastase, glucose oxidase), free amino acids, minerals, phenolic acids and flavonoids, volatile aromatic compounds, pigments, and pollen grains (da Silva *et al.*, 2016; Escuredo and Seijo, 2019; Seraglio *et al.*, 2019). These minor constituents, although quantitatively small, are disproportionately important: phenolic and flavonoid profiles largely determine antioxidant capacity and colour; volatile compounds shape aroma; mineral content correlates with electrical conductivity and can help distinguish nectar from honeydew honeys; and pollen assemblages provide the principal evidence base for botanical and geographical discrimination. Consequently, the same analytical matrix simultaneously conveys information on sensory quality, biological activity, and authenticity.

Honey composition results from a causal chain that runs from floral resource availability, through nectar and pollen collection and enzymatic transformation by the colony, to a physicochemical and sensory profile whose signature can, in principle, be traced back to its botanical and geographical origin. Monofloral honeys are conventionally defined by the dominance of pollen and chemical markers from a single botanical source, whereas polyfloral honeys derive from multiple, temporally overlapping floral sources; geographical origin, meanwhile, refers to the biogeographic and edaphic context of production, which may be inferred from mineral and isotopic signatures independently of botanical composition (da Silva *et al.*, 2016). Distinguishing between botanical, geographical, and ecological origin is essential to avoid over-interpreting vegetation-based inference as direct proof of monofloral status, a distinction of particular relevance to the present review.

A growing, though still uneven, body of literature documents honey quality across West and Central Africa. In Benin, honeys from different phytogeographic zones show significant differences in moisture, pH, electrical conductivity, and microbiological quality (Azonwade *et al.*, 2018). In Nigeria, honeys sold through different commercial outlets display marked variability in physicochemical and functional grade, exposing gaps in quality control and traceability (Akinwande and Oladapo, 2022). In Côte d'Ivoire, melissopalynological analysis of cooperative-produced honey has demonstrated a strong dependence of pollen spectra and physicochemical properties on botanical origin (Assi *et al.*, 2021). In Burkina Faso, pollen analysis of honey samples identified 46 pollen types across 29 botanical families, confirming the predominantly polyfloral character of honeys produced by *Apis mellifera adansonii* and the prominence of Fabaceae, Asteraceae, and Anacardiaceae in colony diet (Cencetti *et al.*, 2019), while subsequent work documented substantial regional variation in physicochemical, microbiological, and sensory quality across Burkina Faso's main producing zones (Tapsoba *et al.*, 2022). In Cameroon, honeys from different agroecological zones show distinct physicochemical and antioxidant profiles linked to polyphenol and flavonoid content (Tchoumboue *et al.*, 2018; Ndzi *et al.*, 2022). Taken together, these studies establish a consistent regional pattern: ecological zone and botanical origin are primary determinants of honey quality across West and

Central Africa, a pattern that plausibly extends to Guinea but has not yet been empirically tested there.

Lower Guinea (Guinée maritime) is a coastal region characterized by a humid tropical climate with a long rainy season (typically May to November) and a dry season from December to April; annual rainfall commonly ranges from 2,000 to over 4,000 mm, making it one of the wettest regions of West Africa (Direction Nationale de la Météorologie de Guinée, 2023; World Bank, 2021). Its landscape mosaic includes extensive mangrove systems dominated by *Rhizophora* and *Avicennia* along the coast and river estuaries, secondary and gallery forests, coastal and inland savannas, and agricultural land encompassing fruit orchards, market gardens, and oil palm plantations.

The apicultural sector relies almost exclusively on the African honey bee subspecies *Apis mellifera adansonii*, well adapted to tropical seasonal conditions and rainfall-driven flowering patterns. Beekeeping is concentrated in the prefectures of Boffa, Dubréka, Coyah, Forécariah, and Kindia, where mangrove ecosystems are particularly well developed. Despite this ecological and apicultural potential, Lower Guinea lacks an integrated scientific framework for honey authentication and characterization. Existing Guinean literature addresses socioeconomic and production-system dimensions of beekeeping but rarely engages with the botanical origin, melissopalynological signature, physicochemical quality, or biological properties of the honeys themselves. This absence of primary data constrains quality certification, traceability, and the region's capacity to access differentiated or export markets.

The present review aimed to critically synthesize the available scientific and technical evidence concerning honeys produced or potentially produced in Lower Guinea, with particular emphasis on botanical and geographical origin, melissopalynological signatures, physicochemical quality, sensory characteristics, bioactive composition, biological properties, production practices, authentication challenges, and prospects for sustainable valorization. Specifically, this review addresses the following questions: (i) What honey categories can plausibly be distinguished in Lower Guinea on ecological grounds, and with what degree of evidentiary support? (ii) What physicochemical, melissopalynological, and bioactive data exist, whether generated locally or inferred from comparable regional contexts? (iii) What are the principal scientific and methodological gaps that must be addressed before botanical, geographical, or quality-based certification becomes feasible?

MATERIALS AND METHODS

Review design

This work is best described as a systematic descriptive literature review with regional evidence synthesis, rather than a fully systematic review compliant with PRISMA reporting standards. The scarcity of Guinea-specific primary studies, the heterogeneity of available document types (peer-reviewed articles, institutional reports, theses), and the absence of standardized numerical screening records preclude PRISMA-level quantitative reporting. Where comparable evidence from other West African contexts is used to fill gaps in Guinea-specific data, this is explicitly flagged, consistent with the evidence-level framework described in Section 2.5.

Information sources and search strategy

The literature search drew on PubMed, Scopus, Web of Science, and Google Scholar; the documentary resources of the Food and Agriculture Organization of the United Nations (FAO); Codex Alimentarius standards relevant to honey; technical reports of Guinea's Ministry of Agriculture and Livestock; Master's and doctoral theses; and reports from non-governmental organizations active in Guinean apiculture. Searches combined French- and English-language keywords using the Boolean operators "AND" and "OR". Principal search terms included: "Honey" AND "Guinea"; "Apiculture" AND "Guinea"; "West Africa" AND "honey"; "Melissopalynology"; "Honey" AND "physicochemical properties"; "Basse Guinée"; "Mangrove honey"; "Forest honey"; "Polyfloral honey"; "*Apis mellifera adansonii*"; "African honey bee";

"Honey authentication" AND "traceability". Representative search strings included: ("Honey" OR "Miel") AND ("Guinea" OR "Basse Guinée"); ("*Apis mellifera adansonii*") AND ("West Africa") AND ("Honey"); ("Mangrove honey") AND ("Physicochemical properties"); ("Melissopalynology") AND ("Honey") AND ("West Africa"). The retained publication window was 2000–2026, with priority given to studies published between 2015 and 2026, complemented by a limited set of foundational earlier references that remain the primary sources on subspecies taxonomy and ecology.

Eligibility criteria

Study selection and data extraction

Following de-duplication, titles and abstracts were screened for relevance, and eligible documents were read in full. Because the underlying corpus does not provide a documented, stage-by-stage count of records identified, screened, excluded, and included, this review does not report a PRISMA flow diagram with numerical values; the absence of such quantitative screening data is acknowledged explicitly as a methodological limitation (Section 4.14). For each retained reference, the following information was extracted, where reported: geographic area of study; honey type studied; botanical origin; physicochemical characteristics; sensory characteristics; reported biological properties; analytical methods used; production practices; authentication approach; and implications for commercial valorization (Table 1).

Evidence synthesis and evidence-level framework

Given the heterogeneity of study designs, analytical methods, and reporting formats across the included literature, evidence synthesis was conducted qualitatively and descriptively; a quantitative meta-analysis was not appropriate. To avoid overinterpretation, statements throughout this review are implicitly or explicitly classified according to four evidence levels: Level 1, direct evidence from studies conducted in Lower Guinea (currently virtually absent); Level 2, evidence from other regions of Guinea; Level 3, evidence from ecologically comparable West African ecosystems (Benin, Côte d'Ivoire, Burkina Faso, Nigeria, Cameroon, Senegal); and Level 4, general international evidence (e.g., mangrove honeys from Asia, general honey science). Extrapolation from Levels 2–4 to Lower Guinea is presented as plausible but requiring local experimental validation.

Table 1. Eligibility criteria for bibliographic inclusion

Inclusion criteria	Exclusion criteria
Peer-reviewed scientific articles	Documents lacking sufficient methodological information
Studies on honey, beekeeping, or honey bees	Publications not accessible in full text
Work conducted in Guinea or ecologically comparable West African regions	Articles on other hive products with no honey-related data
Studies describing physicochemical, melissopalynological, or sensory honey characteristics	Duplicate or redundant documents
Recognized institutional technical reports (FAO, ministries, NGOs)	Non-scientific or unverifiable sources
Relevant university theses and dissertations	Publications in languages other than French or English
Publications from 2000–2026	Studies with no connection to tropical African ecosystems

RESULTS AND DISCUSSION

Ecological and apicultural context of Lower Guinea

Climate. The long rainy season and high annual rainfall of Lower Guinea (Direction Nationale de la Météorologie de Guinée, 2023; World Bank, 2021) support sustained vegetative growth and a potentially prolonged sequence of flowering events. Because floral phenology, nectar secretion, and pollen availability are tightly coupled to rainfall and temperature regimes in tropical settings (Abou-Shaara, 2014; Requier *et al.*, 2020), seasonal climatic variation is expected to directly shape foraging intensity, colony dynamics, and, downstream, the timing and composition of honey harvests. This relationship has not been quantitatively documented

for Guinean apicultural systems and remains an inference from general tropical apicultural ecology (Level 4 evidence).

Major ecosystems. Coastal and estuarine mangrove stands, dominated by *Rhizophora* and *Avicennia* species, are particularly well developed in the prefectures of Boffa, Dubréka, and Forécariah, and play a major role in coastal ecological functioning along the West African littoral (Alongi, 2014; FAO, 2007); the relative nectar and pollen contribution of mangrove taxa to Guinean honey has not, however, been experimentally quantified. Secondary and gallery forests, associated with genera such as *Syzygium*, *Terminalia*, and *Albizia*, are hypothesized to contribute darker, mineral- and phenolic-rich honeys by analogy with forest honeys documented elsewhere (da Silva *et al.*, 2016; Seraglio *et al.*, 2019). Coastal savannas, dominated by *Vitellaria paradoxa*, *Parkia biglobosa*, *Combretum* spp., and *Acacia* spp., offer a broad nectar base likely to support less-pigmented, moderately floral honeys. Agricultural landscapes, including orchards, market gardens, and oil palm (*Elaeis guineensis*) stands, supplement the natural floral base and are likely to favour polyfloral honey production, consistent with the recognized role of landscape diversity in shaping colony productivity and product quality (Dainese *et al.*, 2019). Each of these ecosystems is expected to influence floral diversity, nectar and pollen availability, and, ultimately, pollen spectra and honey composition, but these relationships remain hypothesized rather than demonstrated for Lower Guinea specifically.

Melliferous flora. Systematic floristic and melliferous inventories for Lower Guinea are lacking. Studies conducted elsewhere in West Africa indicate that African honey bees forage extensively on Fabaceae, Myrtaceae, Euphorbiaceae, Asteraceae, Rubiaceae, and Combretaceae (Orwa *et al.*, 2009; Yédomonhan *et al.*, 2009), with genera such as *Terminalia*, *Eucalyptus*, *Elaeis*, *Lannea*, and *Combretum* frequently visited (Yédomonhan *et al.*, 2009; Amulen *et al.*, 2017). By analogy, *Avicennia germinans* and *Rhizophora racemosa* are plausible nectar and pollen sources in Guinean mangrove zones, but this remains an inference pending melissopalynological confirmation. The distinction between documented melliferous species in comparable West African environments and species experimentally demonstrated as major contributors to Lower Guinea honeys is essential and is maintained throughout this review.

Role of Apis mellifera adansonii. This subspecies underpins West African apiculture and is well adapted to high ambient temperatures, marked seasonality, and heterogeneous floral resources (Hepburn and Radloff, 1998; Ruttner, 1988), being characterized by efficient foraging behaviour, strong colonization capacity, and resilience to environmental stress (Dietemann *et al.*, 2009; Potts *et al.*, 2016). In Guinea, it constitutes the biological basis of traditional, semi-modern, and modern beekeeping systems alike. The ecological compatibility between this subspecies and the floristic mosaic of Lower Guinea plausibly underlies the region's potential honey diversity, although the causal chain from bee ecology to distinct honey types remains to be experimentally established locally.

Honey diversity and potential botanical origins

Building on the ecological heterogeneity described above, the existing (largely regional, non-Guinea-specific) literature is consistent with the potential existence of several honey categories in Lower Guinea. Consistent with the scientific integrity principles guiding this review, these categories are presented as ecologically hypothesized honey types, not as confirmed monofloral or geographically certified products, because melissopalynological confirmation for Guinean samples is currently unavailable.

These categories should be read as a research agenda framed as a typology, not as an established classification. In particular, "mangrove-associated honey" is used deliberately in preference to "mangrove monofloral honey" throughout this review, since monofloral status requires quantitative pollen dominance data that do not yet exist for Guinea (Table 2).

Table 2. Potential honey categories of lower Guinea and their evidence status

Honey/ecological category	Potential botanical sources	Evidence status	Expected sensory traits	Relevant physicochemical markers	Potential bioactive characteristics	Research priority
Mangrove-Associated honey	*Avicennia germinans, A. africana, Rhizophora racemosa, Laguncularia racemosa*	Hypothesized; inferred from ecosystem dominance, not confirmed by local pollen analysis	Dark amber to dark brown; woody, saline, mildly caramelized notes	High mineral content; darker colour; potentially higher phenolic content	Potentially elevated antioxidant activity (by analogy with other mangrove honeys, e.g., Sundarbans)	Very high
Savanna honey	*Vitellaria paradoxa, Parkia biglobosa, Lannea microcarpa, Combretum* spp., *Acacia* spp.	Hypothesized; based on regional floristic analogy	Light to medium amber; mild floral/fruity notes	Moderate sugar content; variable conductivity	Moderate antimicrobial activity (regional analogy)	High
Forest honey	*Syzygium guineense, Terminalia* spp., *Albizia* spp. and other forest taxa	Hypothesized; based on regional floristic analogy	Dark amber to brown; resinous, woody notes	Potentially higher mineral and phenolic content	Potentially higher antibacterial activity (regional analogy)	High
Agricultural/ polyfloral honey	Mixed orchard, market-garden, and oil-palm flora combined with wild taxa	Most plausible dominant category given landscape mosaic; not locally confirmed	Variable colour and aroma reflecting seasonal bloom sequence	Highly variable	Variable bioactive profile reflecting floral diversity	High
Eucalyptus-Associated honey	*Eucalyptus* spp. (planted stands)	Hypothesized where *Eucalyptus* plantations occur locally	Amber; characteristic eucalyptus aroma reported elsewhere	Not documented locally	Not documented locally	Medium
Shea-associated honey (karité)	*Vitellaria paradoxa*	Hypothesized where shea parkland occurs; more characteristic of drier savanna zones further inland	Light amber; mild floral notes	Not documented locally	Not documented locally	Medium

Botanical authentication and melissopalynology

Melissopalynology, the qualitative and quantitative analysis of pollen grains retained in honey sediment, remains the most widely used method for establishing botanical and, indirectly, geographical origin. Standard procedures involve honey dissolution, centrifugation to concentrate the pollen sediment, microscopic slide preparation, and identification against reference pollen collections, followed by quantitative counting to classify pollen types as predominant, secondary, important minor, or minor (da Silva *et al.*, 2016). Because pollen representation in honey does not always match the relative nectar contribution of a given plant, melissopalynological data must be interpreted cautiously and, where possible, combined with chemical and sensory evidence rather than used in isolation (da Silva *et al.*, 2016). No reference pollen collection specific to Lower Guinea's melliferous flora currently exists in the accessible literature; establishing one is a foundational prerequisite for any future melissopalynological programme in the region, since regional pollen atlases from other African contexts cannot be assumed to transfer directly given floristic differences.

Physicochemical characterization

No physicochemical dataset specific to Lower Guinea honeys was identified in the accessible literature. The parameters below are therefore presented as the internationally recognized quality framework (Codex Alimentarius Commission, 2019) against which future Guinean honeys should be assessed, with reference to patterns observed in comparable African and mangrove-honey contexts elsewhere. Moisture content governs fermentation risk, microbial stability, and shelf life; elevated moisture, often associated with traditional harvesting and storage practices, increases susceptibility to yeast-driven fermentation. pH and free acidity reflect the organic acid profile and influence microbial stability; Codex-compliant honeys typically show pH in the acidic range (approximately 3.2–4.5) with free acidity below 50 meq/kg. Electrical conductivity correlates with mineral and ash content and is widely used to help distinguish floral from honeydew honeys and to support botanical discrimination. Sugar profile (fructose, glucose, sucrose, and the fructose/glucose ratio) affects sweetness, crystallization behaviour, and susceptibility to fermentation. Hydroxymethylfurfural (HMF) accumulates with thermal processing, prolonged storage, or elevated ambient temperature and is a key freshness/quality-degradation indicator, of particular relevance in a tropical setting where uncontrolled heat exposure during harvest and storage is plausible. Diastase activity is a complementary freshness indicator that declines with heat damage or ageing. Ash and mineral composition (potassium, calcium, magnesium, sodium, iron, and trace elements) contribute to conductivity and may carry botanical or geographical signal. Colour,

commonly graded on the Pfund scale, tends to correlate with mineral and phenolic content and is often, though not universally, associated with antioxidant potential. None of these parameters can currently be reported for Lower Guinea honeys; their systematic measurement constitutes a priority research phase (Section 3.12).

Chemical and bioactive composition

Beyond the primary physicochemical parameters, honey contains a range of minor but functionally important constituents: phenolic acids and flavonoids (major contributors to antioxidant capacity and colour), volatile organic compounds (key determinants of aroma, increasingly used as chemical markers of botanical origin, e.g., specific compounds proposed as candidate markers for mangrove honey in Kenyan studies), enzymes (diastase, invertase, glucose oxidase), minerals, and Maillard-reaction-derived compounds formed during storage or heating. Modern analytical platforms used to characterize this composition and to support authentication include high-performance liquid chromatography (HPLC) for phenolic and sugar profiling, gas chromatography–mass spectrometry (GC-MS) for volatile compounds, liquid chromatography tandem mass spectrometry (LC-MS/MS) for targeted metabolite fingerprinting, nuclear magnetic resonance (NMR) spectroscopy and Fourier-transform infrared (FTIR) spectroscopy for holistic chemical fingerprinting, and inductively coupled plasma mass spectrometry (ICP-MS) for multi-elemental profiling. None of these platforms has, to date, been applied to Guinean honey samples in the accessible literature; their future application would allow chemical fingerprints to be compared against regional and international reference datasets for authentication purposes.

Biological properties

Antioxidant activity. In vitro assays (DPPH radical scavenging, ABTS, FRAP, and occasionally ORAC) are the standard means of estimating honey antioxidant capacity, and are generally correlated with total phenolic and flavonoid content across the honey literature (Alvarez-Suarez *et al.*, 2020).

It is important to state clearly that *in vitro* antioxidant capacity is not equivalent to demonstrated clinical efficacy; extrapolation from assay results to health claims requires dedicated in vivo and clinical evidence that does not currently exist for any Guinean honey.

Antimicrobial activity. Documented mechanisms in the broader honey-science literature include hydrogen peroxide generation via bee-derived glucose oxidase, high osmotic pressure and low water activity, low pH, phenolic and flavonoid content, methylglyoxal (particularly relevant in *Leptospermum*-derived honeys but potentially present at lower concentrations in other floral sources), and bee-derived peptides such as defensin-1 (Kwakman *et al.*, 2010). These mechanisms act in combination, and their relative contribution varies by botanical origin and processing history. No antimicrobial data exist for Lower Guinea honeys specifically.

Anti-inflammatory potential. Evidence for anti-inflammatory effects of honey exists predominantly at the in vitro and animal level; robust human clinical evidence remains limited even for well-characterized honeys internationally. For Guinean honeys, no evidence at any level (in vitro, animal, or human) currently exists, and any discussion of therapeutic potential must therefore remain strictly hypothesis-generating.

Sensory characterization

Sensory attributes, including colour, aroma, flavour, sweetness, acidity, bitterness, aftertaste, viscosity, and crystallization behaviour, are shaped by botanical origin, climatic conditions during nectar flow, moisture content, volatile compound profile, and post-harvest handling. The source material consulted for this review describes, at the level of qualitative producer and consumer perception rather than trained sensory-panel data, mangrove honey as dark amber to dark brown with woody, saline, and mildly caramelized notes; savanna honey as light-to-medium amber with mild floral and fruity notes; and forest honey as dark amber to brown with resinous, woody notes. These descriptions should be understood as preliminary qualitative impressions rather than validated sensory-panel outputs.

Developing standardized sensory descriptors, training a local panel, and conducting consumer-acceptance studies would allow terroir-specific sensory profiles to be established on a more rigorous basis and linked to the (currently absent) chemical and pollen data.

Production and post-harvest practices

Beekeeping in Guinea, as elsewhere in the sub-region, historically relied on honey hunting and colony destruction by fire, practices associated with swarm loss and vegetation fire risk. The introduction of improved hive technologies, notably the Kenya Top Bar Hive (KTBH), and to a lesser extent Langstroth hives, allows improved colony management, higher yields, and better preservation of *A. m. adansonii* populations (Bradbear, 2009; Dietemann *et al.*, 2009). Traditional practices, such as log hives, bark hives, and locally sourced materials, retain strong cultural value and low-cost accessibility, but are more frequently associated with elevated moisture content, incomplete filtration, uncontrolled smoke exposure, and inconsistent storage conditions, all of which can increase fermentation risk, HMF accumulation, and microbial contamination (Bradbear, 2009; Codex Alimentarius Commission, 2019). Modern hive systems generally support more homogeneous, standards-compliant honey (Akinwande and Oladapo, 2022; Azonwade *et al.*, 2018), but modernization should not be framed as a wholesale replacement of traditional knowledge; an integrated approach combining traditional ecological knowledge with targeted quality-control interventions is more likely to preserve terroir specificity while improving compliance with international standards.

Authentication, traceability, and food fraud

Honey is among the food commodities most frequently subject to adulteration, whether through the addition of sugar syrups, mislabeling of botanical origin, or fraudulent claims of geographical provenance. Modern authentication increasingly relies on multi-platform approaches rather than single-method verification. Melissopalynology remains the historical reference method but has recognized limitations related to pollen under- or over-representation. Stable isotope ratio analysis (particularly $\delta^{13}C$, including recent elemental-analyzer/liquid-chromatography isotope-ratio mass spectrometry approaches applied to individual sugars; e.g., Dua *et al.*, 2025) is increasingly used to detect C4-sugar syrup adulteration and, combined with elemental profiling, to support geographical inference. Pollen DNA metabarcoding, using high-throughput sequencing of plant-specific DNA barcodes recovered from honey sediment, offers a promising complement or alternative to microscopic pollen identification, with demonstrated ability to detect label inaccuracies in commercial honeys, although resolution can be constrained by primer universality and the completeness of regional plant DNA reference libraries. Chemometric and machine-learning approaches, applied to combined chemical, elemental, and spectroscopic datasets, are increasingly used to classify honeys by botanical and geographical origin with improved accuracy relative to single-marker approaches. Combining several of these platforms, rather than relying on any single technique, offers the most robust basis for future Guinean honey authentication, though this would first require the foundational reference datasets (pollen atlas, physicochemical baseline, elemental and isotopic baseline) that are currently absent.

Comparative evidence from West and Central Africa

Direct comparison across the (still limited) African honey-quality literature reveals convergences and open questions rather than a simple uniform pattern. In Benin, Nigeria, Burkina Faso, and Cameroon, ecological zone and botanical origin consistently emerge as major determinants of physicochemical and biochemical quality (Azonwade *et al.*, 2018; Akinwande and Oladapo, 2022; Tapsoba *et al.*, 2022; Tchoumboue *et al.*, 2018; Ndzi *et al.*, 2022). Melissopalynological work in Côte d'Ivoire and Burkina Faso confirms the predominantly polyfloral nature of West African *A. m. adansonii* honeys and the recurrent importance of Fabaceae, Asteraceae, and Anacardiaceae in colony diet (Assi *et al.*, 2021; Cencetti *et al.*, 2019).

However, methodological heterogeneity across these studies (differing analytical standards, sample sizes, and reporting formats) limits direct quantitative comparison, and none of these studies addresses mangrove-associated honey specifically, leaving Guinea's mangrove systems, among the most extensive in the sub-region, essentially uncharacterized relative to comparable mangrove honey research conducted in Asia (e.g., the Sundarbans of India and Bangladesh; Islam *et al.*, 2017; Gaine *et al.*, 2026) and East Africa (e.g., Kenya). This asymmetry, with reasonably well-studied mangrove honeys in South and Southeast Asia versus an almost complete absence of West African mangrove honey data, constitutes one of the clearest geographic knowledge gaps identified by this review.

Synthesis and critical discussion

The available evidence supports three defensible conclusions and leaves several questions genuinely open. First, the ecological heterogeneity of Lower Guinea, comprising mangroves, forests, savannas, and agricultural mosaics, is structurally similar to settings elsewhere in West Africa and beyond (e.g., the Sundarbans) where distinct honey types have been empirically documented; this supports the plausibility, though not the confirmation, of comparable diversity in Guinea. Second, regional comparative evidence consistently identifies botanical origin and production practice as the two dominant determinants of honey quality, a pattern robust enough across independent African studies that it can reasonably be expected to apply to Guinea as well, pending local confirmation.

Third, the near-total absence of melissopalynological, physicochemical, and biological data specific to Lower Guinea means that any claim about the existence, composition, or distinctiveness of "mangrove honey," "forest honey," or "savanna honey" from this region remains a hypothesis generated by ecological analogy rather than an empirically established fact.

Mechanistically, the proposed diversity of Guinean honeys would be expected to arise from the interaction between floristic composition (differential nectar sugar profiles and secondary metabolite content across mangrove, forest, and savanna taxa), seasonal rainfall-driven flowering sequences that determine which floral sources dominate a given harvest, and production practices that modulate moisture and thermal history post-harvest. This mechanistic picture is coherent with general honey science (Da Silva *et al.*, 2016; Escuredo and Seijo, 2019) but has not been tested against Guinean samples.

Methodologically, the evidence base underlying this review is constrained by the scarcity of Guinea-specific studies, reliance on regional analogy (Explicitly flagged throughout as Level 3–4 evidence), heterogeneous methods across the comparator literature, and the absence of a documented systematic screening record. These constraints mean that the honey typology proposed in Section 3.2 should be read as a prioritized research agenda rather than a validated classification. The most urgent research need is the generation of a first melissopalynological and physicochemical baseline dataset for honeys collected across Lower Guinea's main producing prefectures, since this would allow the plausibility arguments developed in this review to be tested directly against local data.

Scientific knowledge gaps and future research agenda

The analysis identifies major gaps concerning: (1) melissopalynology: absence of a regional pollen reference collection and of any published pollen-spectrum data for Guinean honey; (2) physicochemical characterization: no local data on moisture, pH, free acidity, electrical conductivity, or sugar profiles; (3) mineral profiling: no elemental (ICP-MS/AAS) data; (4) phenolic composition: no HPLC- or spectrophotometry-based quantification; (5) volatile compounds: no GC-MS aroma profiling; (6) microbiological safety: no systematic assessment of microbial load or pathogens; (7) adulteration: no isotopic or chromatographic screening; (8) geographical authentication: no isotopic or elemental geographic fingerprinting; (9) botanical authentication: no DNA metabarcoding or chemometric

classification; (10) sensory characterization: no trained panel or standardized descriptor lexicon; (11) seasonal variation: no data on compositional shifts across the rainy/dry season cycle; (12) climate variability: no assessment of inter-annual rainfall effects on nectar flow and yield; (13) post-harvest practices: no quantitative assessment of how hive/harvest methods affect HMF, moisture, or microbial quality locally; and (14) economic valuation: no rigorous value-chain or market-price analysis for differentiated honey types. Each of these gaps directly constrains the region's capacity to support quality certification, geographical indication, or premium-market access, since all such mechanisms require a verifiable, data-based product definition.

Addressing these gaps calls for a coordinated, phased research programme: Phase I– Systematic sampling across Dubréka, Coyah, Forécariah, Boffa, Kindia, and other relevant localities, capturing seasonal and ecosystem-type variation; Phase II– Botanical characterization, including vegetation surveys, flowering-calendar documentation, and construction of a regional pollen reference collection; Phase III– Physicochemical characterization (Moisture, pH, free acidity, electrical conductivity, HMF, diastase activity, sugar profile, ash, minerals) following Codex/International Honey Commission methods; Phase IV – Chemical fingerprinting using HPLC, LC-MS/MS, GC-MS, NMR, and FTIR; Phase V – Biological characterization (antioxidant, antimicrobial, and, where appropriate, anti-inflammatory assays); Phase VI– Authentication, integrating pollen, chemical, elemental/isotopic, and, where feasible, DNA-metabarcoding data within a chemometric classification framework; and Phase VII– Valorization, translating this evidence base into geographical-indication and terroir-based labelling strategies, quality standards, traceability systems, and export-oriented quality control.

Sustainable valorization prospects

Beekeeping is a low-capital activity compatible with natural-resource conservation and is already recognized as a driver of income diversification and women's economic participation in mangrove-adjacent communities of Lower Guinea, where honey harvesting and marketing supplement household income (Amulen *et al.*, 2017; UNDP, 2022). However, commercialization remains largely confined to informal local and cross-border markets, constrained by the absence of certified processing facilities, accredited analytical laboratories, and traceability or organic-certification systems (Codex Alimentarius Commission, 2019; FAO, 2022).

The ecological and geographical specificity of Lower Guinea's honeys represents a plausible basis for future differentiation strategies (quality labels, protected geographical indications, or organic certification), but, consistent with the evidentiary caution maintained throughout this review, any economic projection regarding premium pricing, export volumes, or income gains must await the underlying scientific characterization; no such quantitative economic data currently exist for Guinean honey and none are asserted here.

Strengths and limitations

Strengths. This review offers a regionally focused, interdisciplinary synthesis integrating ecological, apicultural, and food-science perspectives specific to Lower Guinea; it explicitly identifies research gaps rather than overstating existing knowledge; and it frames findings within a valorization-oriented perspective relevant to policy and development actors.

Limitations. The review is constrained by (i) the very limited volume of Guinea-specific honey literature; (ii) consequent reliance on evidence from ecologically comparable but not identical African contexts, requiring explicit evidence-level flagging; (iii) heterogeneous analytical methods across the comparator literature, limiting direct quantitative comparison; (iv) incomplete access to some full-text theses and grey literature; (v) possible publication bias favouring positive or novel findings in the international honey-science literature; (vi) the absence of a quantitative meta-analysis, precluded by this heterogeneity; (vii) the absence of standardized, geographically stratified sampling in the underlying evidence base; and (viii) an essentially absent

melissopalynological dataset for the region. These limitations are not minor caveats but define, in large part, the research agenda proposed in Section 3.12.

CONCLUSION

Lower Guinea possesses substantial ecological and apicultural potential, arising from the coexistence of mangrove, forest, savanna, and agricultural landscapes exploited by *Apis mellifera adansonii*. The existence of ecologically distinct honey types (mangrove-associated, forest, savanna, and polyfloral) is plausible on the basis of regional analogy but remains scientifically unconfirmed for this specific region. Botanical and geographical authentication constitutes the central scientific priority, and melissopalynology alone will not suffice: it must be combined with physicochemical, chemical, and, where feasible, molecular and isotopic approaches to build a robust and defensible honey fingerprint. Establishing this evidence base is a scientific prerequisite, not a parallel or optional track, for any future terroir-based certification, geographical indication, or premium-market strategy. A coordinated, multidisciplinary research programme, as outlined in Section 3.12, could substantially strengthen both the scientific standing and the economic position of Guinean honey, without overstating therapeutic or commercial claims that current evidence cannot support.

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