Phytochemical composition and antimicrobial properties of stingless bee products from the East African Region

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ABSTRACT

Stingless bees (Apidae: Meliponini) are widely distributed across tropical and subtropical regions, including East Africa, where they produce honey, propolis, and pollen that have long been valued for their medicinal and nutritional properties. Specifically, the honey is recognized for its antimicrobial, antioxidant, and anti-inflammatory effects due to its rich content of bioactive compounds such as flavonoids, phenolics, and terpenoids. In East African countries, there has been an increasing interest in the antimicrobial properties and phytochemical composition of stingless bee products to validate their traditional uses and explore their therapeutic potential. This narrative review highlights the findings of these studies, which have mainly focused on the honey of Meliponula, Plebeina, Hypotrigona, and Dactylurina species. The honey of these species has particularly been reported to be active against several common bacterial pathogens, including Escherichia coli, Staphylococcus aureus, methicillin-resistant Staphylococcus aureus (MRSA), Haemophilus influenzae, Bacillus subtilis, Enterococcus faecalis, Klebsiella pneumoniae, Listeria monocytogenes, Pseudomonas aeruginosa, and Salmonella typhi. Moreover, reports also indicate that honey and propolis of some East African stingless bees are active against Candida albicans and Aspergillus niger. Reports on phytochemical analyses indicate that depending on the region, stingless bee honey from the East African region contains diverse phytochemical contents, including flavonoids, phenols, tannins, saponins, alkaloids, glycosides, steroids, and triterpenoids. These findings suggest that stingless bee honey possesses significant potential as a natural source of antimicrobial agents and functional food. However, variations in phytochemical composition influenced by species diversity and environmental conditions indicate the need for further research. Future studies should prioritize standardization, detailed phytochemical profiling, and clinical validation, alongside sustainable meliponiculture development. Unlike the honey, however, there are limited studies on the other nest products (pollen, cerumen, and propolis). This calls for more research, particularly on propolis and pollen, which are known to have antimicrobial properties. There is also a need for isolation of pure antimicrobial compounds from the nest's products and subsequent mechanistic studies. Future studies should also expand the antimicrobial studies to include viruses, fungi, and protozoans.

Keywords: Cerumen, East Africa, Ethnomedicinal Uses, Hone, Propolis, Stingless Bees

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I. INTRODUCTION

The rapid rise in resistance even to the most potent antimicrobials pose a great threat to the global public health (Murray *et al*., 2022). This is because antimicrobial resistance is associated with high mortality and morbidity rates, long hospital stays and high cost of care not only in the developed nations, but also in the low and middle income countries (Murray *et al*., 2022; Sartorius *et al*., 2024). In 2019, approximately 5 million deaths associated with antimicrobial resistance including 1.27 million deaths directly attributable to bacterial antimicrobial resistance were reported (Murray *et al*., 2022). According to Naghavi *et al*. (2024), bacterial antimicrobial resistance (AMR) caused 4.71 million associated deaths, including 1.14 million directly attributable deaths in 2021. In the United States alone, antimicrobial resistance (AMR) causes over 2.8 million infections and 35,000 deaths annually (Flynn & Guarner, 2023). This is despite mitigation efforts, including infection control, antimicrobial stewardship and vaccines. More alarming is that AMR is projected to cause up to 10 million deaths per year by 2050 if not addressed (Naghavi *et al*., 2024). This calls for an urgent discovery of novel and effective antimicrobial compounds from various sources, including traditional medicines.

From time immemorial stingless bee products including honey, propolis and pollen have been utilized as traditional medicine to treat various conditions across the globe. The Mayan traditional doctors used stingless bee honey for centuries to cure poisonous stings and treat high fever, pneumonia, wounds, burns, cold and bronchitis (Reyes-González *et al.*, 2014). In the East African region, stingless nest products are utilized by the local communities for food and none-food purposes, particularly traditional medicine (**Table 1)** (Héger *et al.*, 2023; S. Kiprono *et al.*, 2022; S. J. Kiprono *et al.*, 2022). In Kakamega, Kenya, *Meliponula. bocandei* and *M. lendliana* honey are used traditionally to cure skin problems (Héger *et al.*, 2023). In Baringo County also in Kenya, the native communities widely use stingless bee honey as a traditional remedy for various respiratory disorders, gastrointestinal disorders, sore throat, infections and wounds (S. Kiprono *et al.*, 2022; S. J. Kiprono *et al.*, 2022). In Uganda, *M. ferruginea* honey is used in wound treatment (Chemurot *et al.*, 2021) and in alleviating constipation (Byarugaba, 2004).

In Tanzania, honey from *M. beccarii, M. ferruginea, M. togoensis, P. armata, Hypotrigona gribodoi and Dactylurina schmidti* are traditionally used to treat conditions such as asthma, ulcers, fractures, intestinal worms, reproductive issues, burns, and respiratory infections (C. Mduda *et al.*, 2023; Mduda, Hussein, *et al.*, 2025). In Ethiopia *M. beccarii* honey is commonly used as traditional medicine (Gela *et al.*, 2021; Jemberie *et al.*, 2020). The Sheka people of Ethiopia have long been using honey to treat asthma, tuberculosis, and tonsillitis (Kidane *et al.*, 2021). The local community in Amhara, Ethiopia also uses Meliponula stingless bee honey to relief pain and to cure both infectious and non-infectious diseases (Jemberie *et al.*, 2020). To validate this wide spread use of stingless bee products in treatment of infectious diseases, several antimicrobial and phytochemical studies have recently been conducted by researchers in the East African region. This narrative review summarizes the findings of the reports from Kenya, Tanzania, Uganda and Ethiopia.

Table 1

Summary of Traditional Medicinal Uses of Stingless Bee Honey in East Africa

Species	Country origin of origin	Product	Traditional uses	References
M.bocandei and *M.lendliana* *M.ferruginea* *M.togoensis*	Kenya	Honey	Cure skin problems Aphrodisiac effects Alleviate dysentery, treat stomach disorders, dewormer	(Héger *et al.*, 2023)
Meliponula beccarii and *Plebeina hildebrandti*	Kenya	Honey	Respiratory disorders, stomach disorders, infections, throat ailments, allergic reactions, wounds, poisoning, teeth problems, skin disorders, burns (community) Respiratory disorders, stomach disorders, oral thrush, wounds, measles and poisoning(TMPs)	(S. Kiprono *et al.*, 2022; S. J. Kiprono *et al.*, 2022)
Meliponula ferruginea	Uganda	Honey	Wound treatment Alleviating constipation	(Chemurot *et al.*, 2021) (Byarugaba, 2004)
Meliponula beccarii, M.ferruginea, M.togoensis, P.armata, Hypotrigona gribodoi, Dactylurina schimidti	Tanzania	Honey	Asthma, ulcers, fractures, intestinal worms, reproductive issues, burns, respiratory infections	(C. Mduda *et al.*, 2023; Mduda, Hussein, *et al.*, 2025)
Meliponula cockerel	Ethiopia	Honey	Coughs, asthma, tuberculosis, bladder pain, stomach disorders, diarrhea, sore throat, eye infection, dental carries, wounds	(Jemberie *et al.*, 2020b)
Meliponula beccarii		Honey	Coughs, common cold, asthma, tuberculosis, wounds, sore throat Tuberculosis, cough, constipation, asthma, tonsillitis, oral thrush	(Beyene *et al.*, 2024) (Kidane *et al.*, 2021)

II. LITERATURE REVIEW

2.1 Phytochemical Somposition of East African Stingless Bee Nest Products

The major stingless bee nest products include honey, propolis, pollen and cerumen. These products can be harvested from modern meliponiculture farms or the wild occurring colonies by local gatherers. In the East African region, meliponiculture is still underdeveloped (Mduda, Hussein, *et al*., 2025). As such, most of the products are collected from wild occurring colonies often using destructive harvesting methods. A number of phytochemical studies, mainly qualitative, have reported on the composition of honey and propolis from stingless bee species of the East African region.

2.2 Empirical Review

2.2.1 Propolis

Only a few studies have so far investigated the chemical composition of East African stingless bee propolis. Kegode *et al*. (2023) reported that propolis from six Kenyan stingless bee species is exceptionally rich in phytochemicals, particularly flavonoids and phenolics and exhibits notable antioxidant activity. Total flavonoid content (TFC) ranged from 651.90 to 3262.26 mg QE/100 g, while total phenolic content (TPC) ranged from 586.36 to 2010.53 mg GAE/100 g. Of the six species, *Meliponula beccarii* propolis had the highest TFC, *Meliponula togoensis* had the highest TPC and *Meliponula ferruginea* showed the strongest antioxidant activity. These findings underscore that propolis from Kenyan stingless bees can serve as a potential source of natural antioxidants, albeit with variation depending on the species. In Tanzania, preliminary analysis of *Meliponula ferruginea* propolis from Kilimanjaro region revealed the presence of sugars and sugar derivatives, aromatic acids, diterpenes, cardanol, caffeoylquinic acids, triterpenes, quinic acid and resorcinols (Popova *et al*., 2021).

2.2.2 Honey

A study of honey from the stingless bee species *Plebenia spp* and *Meliponula bocandei* in Western Kenya identified 35 organic compounds, including O-glycosyl compounds, tricarboxylic acids and derivatives, isoquinoline derivatives, tannins, peptides and derivatives, flavonoids, terpene glycosides, coumarin derivatives, quinic acid derivatives, phenolic glycosides, anthracycline derivatives, porphyrins, pyridyl piperazine derivatives and indole derivatives (Wavinya *et al*., 2021). The antioxidant activity, measured using DPPH, showed IC50 values between 10.61–14.31 mg/ml and FRAP values ranging from 585.82 µM to 911.36 µM Fe(II)/100 ml (Wavinya *et al*., 2021). Chepkemoi *et al*. (2024) reported the presence of alkaloids, triterpenoids, flavonoids, saponins, tannins, glycosides and steroids, but not terpenoids in *Plebeina hildebrandti* honey samples collected from Baringo, Kenya. Similarly, qualitative analysis of *Meliponula beccarii* honey from Baringo County was also found to contain alkaloids, phenolics, triterpenoids, flavonoids, saponins, tannins, glycosides and steroids, but not terpenoids, perhaps indicating common floral sources by the two species (Chepkemoi *et al*., 2023).

In Tanzania, a study by Mduda *et al*. (2024) evaluated the antioxidant properties of stingless bee honey from the northern highlands of Tanzania in comparison with *Apis mellifera* honey. They reported that stingless bee honey, sourced from *Meliponula (Axestotrigona) ferruginea* and *Meliponula (Axestotrigona) togoensis*, exhibited higher antioxidant activity, with total flavonoid content ranging from 54.12 to 56.40 mg QE/100 g and total phenolic content from 81.92 to 87.56 mg GAE/100 g, compared to 33.17 mg QE/100 g and 61.13 mg GAE/100 g, respectively, in *A. mellifera* honey. DPPH radical scavenging activity and ferric reducing antioxidant power (FRAP) were also significantly higher in stingless bee honey (65.81–68.40% and 109.78–126.64 µmol Fe (II)/100 g) than in *A. mellifera* honey (41.44% and 65.00 µmol Fe (II)/100 g). Noiset *et al*. (2024) investigated the influence of insularity on the physicochemical properties of stingless bee honey in the Zanzibar Archipelago, Tanzania. Their results showed that honey from insular environments had a significantly different composition compared to continental honey, with higher levels of bioactive compounds. These findings indicate that insularity drives unique compositional profiles in stingless bee honey and highlight the potential therapeutic and medicinal applications of these bioactive compounds in Afrotropical honeys. A more recent study from Tanzania also reported that the honey of three stingless bee species in the genus *Hypotrigona*: *H. gribodoi*, *H. ruspolii* and *H. araujoi* contained sucrose (0.28–1.6 g/100 g), hydroxymethylfurfural (1.27–21.38 mg/Kg), flavonoids (39.55–45.96 mg QE/100 g), phenols (70.97–75.03 mg GAE/100 g) and substantial radical scavenging activity (54.13–56.89%) indicating substantive antioxidant potential (Mduda & Makwinja, 2025). Also, *Plebeina armata* honey from western Tanzania was found to be rich in phenols (74.07–177.28 mg GAE/100 g), flavanoids (30.55–93.7 mg QE/100 g) and radical scavenging activity ranging from 42.61 to 82.65% (Mduda & Kalonga, 2025).

In Ethiopia, the honey of *Meliponula beccarii* from four different districts of Oromia region was reported to contain hydroxyl methyl furfural content of 11.2–22.4 mg/Kg and proline concentration ranging from 124 to 307 mg/Kg (Gela *et* *al*., 2021). A comparative study of *Meliponula beccarii* honey from wild nests and modern clay hives in Wolmera and Cheliya districts of Oromia region reported mean total phenolic content, flavonoid content and radical scavenging activity of 28.30 mg GAE/100 g, 27.76 mg QE/100 g and 69.82 mg of ascorbic acid equivalent /100 g, respectively. Importantly there were significant differences in the chemical composition between the honey from the two districts and upon comparisons of wild nests and modern hives (Negera *et al*., 2024). Stingless bee honey from the Amhara region of Ethiopia had an average HMF content of 8.38±4.47 mg/kg, with a mean reducing sugars content of 55.27±4.24% (Ibrahim *et al*., 2024). In Dandi and Meta Robi districts of West Shewa zone, Ethiopia, wild *Meliponula beccarii* honey had a mean HMF of 0.89±1.14 mg/kg. The mean sugar concentrations reported were glucose (9.39 ± 4.26 g/100g), sucrose (0.24 ± 0.01 g/100g), maltose (10.81 ± 4.95 g/100g), fructose (16.57 ± 2.55 g/100g) and turanose (0.20 ± 0.00 g/100g) (Begna *et al*., 2024). A study by Oromokoma *et al*. (2023) in Uganda revealed that *Meliponula bocandei* honey contained HMF of 5.42 ± 4.78 mg/kg.

2.2.3 Pollen

Although pollen is a major nest product, very little data have been reported on its chemical composition in East African region. Our qualitative studies of *Meliponula beccarii* pollen samples from Baringo, Kenya showed the presence of phenols, tannins, saponins, alkaloids, glycosides, steroids, flavonoids and triterpenoids, which mirrored the composition of the honey samples (Chepkemoi *et al*., 2023). Screening of *Plebeina hildebrandti* pollen samples collected from the same region in Kenya revealed the presence of phenols, tannins, saponins, alkaloids, glycosides, steroids, flavonoids and triterpenoids, but terpenoids were not detected. However, the screening was done on only two samples from one specific locality and might not be generalizable (Chepkemoi *et al*., 2024). In a recent Tanzanian study, *Axestotrigona ferruginea* pollen was reported to be rich in lipids, carbohydrates proteins and minerals, including potassium (6167.55 to 7934.62 mg/Kg), calcium (2431.68 to 5293.87 mg/Kg) and magnesium (1538.83 to 1962.70 mg/Kg) (Mduda, Vit, *et al*., 2025). Moreover, the *Axestotrigona ferruginea* pollen exhibited high levels of total phenolic content (1292.16–4043.55 mg GAE/100 g), total flavonoid content (563.99–1261.88 mg QE/100 g) and DPPH radical scavenging activity (65.99 − 93.26%) responsible for its high antioxidant capacity (Mduda, Vit, *et al*., 2025).

2.2.4 Cerumen

Only one study has investigated the chemical composition of *Meliponula ferruginea* cerumen from Kilimanjaro region, Tanzania (Popova *et al*., 2021). In that study, cerumen was found to be rich mainly in terpenoids (di-and triterpenes), fatty acids and monosacharides, moreless similar to the propolis (Popova *et al*., 2021).

In summary, the products of stingless bee species that are found in the East African region have diverse chemical composition. The diversity is likely due to the different floral sources in the different parts of the East Africa. Moreover, methodological differences may also account for the differential chemical composition of the products belonging similar species. Importantly the terpenoids, phenols, steroids and flavonoids, which are present in the honey and propolis of most of the stingless bee species, are known to have antioxidant and antimicrobial properties. Indeed several studies across the East African region have reported broad antimicrobial properties.

2.3 Antimicrobial properties of East African stingless bee nest products

2.3.1 Honey

Evidence indicates that stingless bee honey in the East African region has been mainly tested against bacterial pathogens (**Table 2**). A study in Ethiopia by Kasim and Jilo (2024) evaluated the antibacterial activity of Ethiopian *Meliponula beccarii* honey against *Salmonella typhi*, *Escherichia coli*, *Staphylococcus aureus* and *Enterococcus faecalis* using a disk diffusion assay over 48- and 72-hour exposure. Their results showed that stingless bee honey inhibited both Gram-negative and Gram-positive bacteria, with the 100% concentration being most effective against *S. typhi* and *E. coli*. In another study, Tesfaye *et al*. (2024) investigated the in vitro antimicrobial activities of *Meliponula beccarii* honeys from Kellem and West Wollega Zones, Western Ethiopia, against selected clinical and standard bacterial strains. They reported a mean minimum inhibitory concentration (MIC) and minimum bactericidal concentrations (MBC) of 9.9% and 53.6%, but none of the honey samples inhibited *Candida albicans*. The study concluded that fresh honeys, especially from stingless bees, exhibited stronger antibacterial effects, supporting their potential use as alternative therapies against bacterial infections. Ewnetu *et al*. (2013) reported potent activity of stingless honey from Gojam against *Staphylococcus aureus*, methicillin resistant *Staphylococcus aureus (MRSA)*, *Escherichia coli* and *Klebsiella pneumoniae* with an MIC range of 6.25 to 12.25%.

In Tanzania, C. A. Mduda *et al.* (2023) evaluated the antimicrobial activity of honey from six stingless bee species found in different vegetation zones using agar diffusion and microdilution methods. They reported mean inhibition zones that ranged from 7.0 – 26.3 mm for Gram positive bacteria, 6.9 – 26.9 mm for Gram negative bacteria and 17.0 – 30.9 mm for fungi, with some samples exhibiting stronger antibacterial activity compared to ciprofloxacin (25 µg/mL). Of the six species, *Dactylurina schmidti* honey had the strongest antimicrobial effect. Notably, the antimicrobial activities varied depending on the phytochemical contents. In another study, honey of *Meliponula (Axestotrigona) ferruginea* and *Meliponula (Axestotrigona) togoensis* sourced from northern Tanzania was reportedly effective against *Staphylococcus aureus, Bacillus subtilis and Salmonella typhi,* with MIC of between 0.16 –5% v/v (Mduda *et al.*, 2024). Importantly, *Meliponula (Axestotrigona) ferruginea* honey samples from Tanzania retained their antibacterial potency (89.9 - 98.7%) even after the removal of hydrogen peroxide. Consequently, the antibacterial activity has been suggested to be linked to specific bioactive compounds rather than the overall phytochemical content (Mduda, 2024).

In Kenya, Chepkemoi *et al*. (2023) evaluated eleven honey samples collected from the subterranean nesting stingless bee *Meliponula beccarii* in Baringo County for their antimicrobial activity against *Escherichia coli, Haemophilus influenzae*, MRSA, and *Candida albicans* using a well diffusion assay. The results demonstrated notable antimicrobial activities against *H. influenzae, MRSA* and *E. coli,* which was dependent on honey concentration. However, all samples, including undiluted honey (100% v/v), failed to inhibit *C. albicans*. The mean zones of inhibition at 100% v/v were reported as 9.0 ± 4.7 mm for *E. coli*, 10.8 ± 5.9 mm for *H. influenzae* and approximately 11.1 mm for MRSA. At 75% v/v, the inhibition zones ranged from 6 to 8 mm, while at 50% v/v, the antibacterial effect was minimal. MIC values indicated greater susceptibility of *E. coli* and *H. influenzae* with 9.38% v/v and 18.75% v/v, respectively, compared to MRSA, which had a higher MIC of 60.94% v/v. Similarly, six samples of *P. hildebrandtii* honey from Baringo also significantly inhibited *E. coli, H. influenzae,* and MRSA, with mean zones of inhibition of 12.1 ± 2.1 mm, 10.1 ± 4.8 mm and 14.5 ± 2.4 mm, respectively, but no activity against *C. albicans*. The MICs were 13.75% v/v for both *E. coli and H. influenzae* and 17.71% v/v for MRSA (Chepkemoi *et al*., 2024).

Muli *et al*. (2008) investigated honey of *Dactylurina schmidti* from Tana River, Kenya, comparing antimicrobial activity of pure honey and its dilutions (75%, 50%, and 25% v/v) against several bacterial species using agar diffusion assays. The study found that 70% propolis extract inhibited *Pseudomonas aeruginosa*, *E. coli, S. aureus, S. typhi* and *Bacillus subtilis*, showing larger inhibition zones against Gram-positive bacteria compared to honey. Honey also displayed a concentration-dependent inhibitory effect against the same bacteria. However, neither honey inhibited *Aspergillus niger* nor *C. albicans*. In another study, Wavinya *et al*. (2021) assessed honeys from *Plebeina hildebrandii* and *Meliponula bocandei* from Kakamega, Kenya, using agar well diffusion assays. Both honeys showed activity against *S. aureus*, with *P. hildebrandii* honey exhibiting higher potency. MIC values for *E. coli* and *S. aureus* in *P. hildebrandii* honey were 3.53% v/v and 1.76% v/v, with corresponding MBCs of 4.71% v/v and 2.35% v/v. Conversely, *M. bocandei* honey inhibited only *S. aureus* at an MIC of 16.47% v/v.

2.3.2 Propolis

While studies from other regions have documented antimicrobial activity in pollen, there is limited research on propolis of East African stingless bee species. In one Kenyan study, *Dactylurina schimidti* propolis collected from 4 colonies in Tana River district along the Kenyan Indian Ocean Coast was shown to exhibit strong activity against *Pseudomonas aeruginosa*, *Salmonella typhi*, *Escherichia coli*, *Staphylococcus aureus* and *Bacillus subtilis* and two fungal species namely *Aspergillus niger* and *Candida albicans* (Muli *et al*., 2008). *Meliponula ferruginea* propolis samples from the Kilimanjaro region of Tanzania was shown to have moderate activity against standard strains of *Staphylococcus aureus*, *Enterococcus faecalis*, *Listeria monocytogenes*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Escherichia coli* and *Candida albicans* (Popova *et al*., 2021). Moreover, *Meliponula ferruginea* propolis extracts exhibited anti-biofilm, anti-quorum sensing and anti-swarming/swimming properties (Popova *et al*., 2021). Altogether, these reports indicate that afrotropical stingless bee species propolis is a potential source of compounds that can be used as standalone antimicrobial agents or in combination with conventional antibiotics.

2.3.3 Pollen

Similar to propolis there is very limited research on pollen of East African stingless bee species. Recent studies of pollen from Kenyan *M. beccarii* and *Plebeina hildebrandtii* reported negligible inhibitory effects against *E. coli, H. influenzae, MRSA* and *C. albicans,* despite the pollen having similar phytochemical profiles as honey (Chepkemoi *et al*., 2024; Chepkemoi *et al*., 2023). The authors suggested that the specific antibacterial compounds may be present at very low concentrations in the pollen compared to honey. However, since the pollen was not extracted in that study, further using extracted samples might be needed. This is in contrast to reports from other regions of the world, which have documented potent antimicrobial properties of stingless bee pollen (Carneiro *et al*., 2019).

Table 2

Summary of antimicrobial Activities of Stingless Bee Honey in East Africa

Species	Country of Origin	Product	Assay	Antimicrobial Effect	Unaffected Test organisms	Reference
Meliponula beccarii	Ethiopia	Honey	Disk diffusion	Inhibited *S. typhi*, *E. coli*, *S. aureus*, and *E. faecalis*; 100% concentration most effective	none	(Kasim & Jilo, 2024)
Meliponula beccarii	Ethiopia	Honey	Agar well and disc diffusion	Strong inhibition against *S. aureus* and *E. coli* (16 ± 3 mm); MIC 9.9%, MBC 53.6%	*Candida albicans*	(Tesfaye *et al*., 2024)
Meliponula (Axestotrigona) ferruginea, *Meliponula (Axestotrigona) togoensis*	Tanzania	Honey	Diffusion and microtiter broth dilution method	Inhibited *S. aureus*, *B. subtilis*, and *S. typhi* with MIC 0.16–5% v/v	none	(Mduda *et al*., 2024)
Meliponula beccarii	Kenya	Honey	Well diffusion assay	Inhibited *E. coli*, *H. influenzae*, and *MRSA*; mean inhibition zones 9 –11 mm at 100% v/v; MICs, 9.38 – 60.94% v/v	*Candida albicans*	(Chepkemoi *et al*., 2023)
Meliponula beccarii,	Kenya	Pollen	Well diffusion assay	Negligible activity despite similar phytochemical profiles as honey	*E. coli, H. influenzae, and MRSA*	(Chepkemoi *et al*., 2023)
Plebeina hildebrandtii	Kenya	Honey	Well diffusion assay	Inhibited *E. coli* (12.1 ± 2.1 mm), *H. influenzae* (10.1 ± 4.8 mm), and MRSA (14.5 ± 2.4 mm); MIC 13.75–17.71% v/v	*C. albicans*	(Chepkemoi *et al*., 2024)
Plebeina hildebrandtii	Kenya	Pollen	Well diffusion assay	Negligible activity despite similar phytochemical profiles as honey	*E. coli, H. influenzae, and MRSA*	(Chepkemoi *et al*., 2024)
Dactylurina schmidti	Kenya (Tana River)	Honey and propolis	Agar diffusion assay	70% propolis inhibited *P. aeruginosa*, *E. coli*, *S. aureus*, *S. typhi*, and *B. subtilis*; honey showed concentration-dependent inhibition	*A. niger* and *C. albicans*	(Muli *et al*., 2008)
Plebeina hildebrandtii	Kenya (Kakamega)	Honey	Agar well diffusion	Inhibited *E. coli* (MIC 3.53% v/v, MBC 4.71%) and *S. aureus* (MIC 1.76% v/v, MBC 2.35%)	none	(Wavinya *et al*., 2021)
Meliponula bocandei	Kenya (Kakamega)	Honey	Agar well diffusion	Inhibited only *S. aureus* (MIC 16.47% v/v)	*E. coli*	*(Wavinya et al*., 2021)
Meliponula (Axestotrigona) ferruginea (Lepeletier)	Tanzania	Propolis	Microtiter broth dilution method	*Inhibited S. aureus, E. faecalis, L.monocytogenes, P.aeruginosa, S. typhi, E. coli, C. albicans* Propolis MIC (0.3125 - 2.5 mg/mL)	none	(Popova *et al*., 2021)
		Cerumen	Microtiter broth dilution method	Cerumen MIC (0.1563- 1.25 mg/mL)	none	(Popova *et al*., 2021)

V. CONCLUSION & RECOMMENDATIONS

3.1 Conclusion

In conclusion, stingless bee products from East Africa, including honey and propolis, exhibit substantial antimicrobial potential, which is attributed to their rich and diverse phytochemical composition, specific bioactive compounds, and hydrogen peroxide content. These products demonstrate activity against a wide range of pathogens, including Gram-positive and Gram-negative bacteria and have shown promise in inhibiting biofilm formation, inhibition of quorum sensing and anti-swarming. Collectively, these properties underscore the therapeutic potential of stingless bee products as natural alternatives, adjuncts to conventional antimicrobial agents or potential sources of novel antimicrobial compounds. However, the available evidence reveals substantial variability in antimicrobial efficacy and potency of East African stingless bee products. This variability is likely due to various factors such as botanical sources, environmental conditions, seasonal fluctuations, and colony health, harvesting methods, harvesting locations /ecological zones, wild versus domesticated sources, processing, and storage methods. Consequently, the variability presents challenges in standardizing the quality and antimicrobial effectiveness of the stingless bee products, which is critical for their application in healthcare and pharmaceutical industry. Additionally, current research has predominantly been conducted in vitro, leaving significant gaps in knowledge regarding in vivo efficacy, dosage optimization, and clinical applicability. Moreover, there is lack of mechanistic studies and isolation of pure compounds of potential antimicrobial activity. While substantial studies have focused on the honey, very little studies have been done on pollen, cerumen and propolis, which are also key products that have exhibited rich chemical composition and potent antimicrobial activities in other parts of the world including West Africa.

3.2 Recommendations

Future research should focus on standardizing bioactivity assays to allow consistent comparison across studies and regions. Harmonized methodologies would ensure reproducibility and facilitate meta-analyses of antimicrobial efficacy. Additionally, there is a need for comprehensive chemical profiling using advanced analytical tools such as LC-MS/MS and NMR to isolate identify, quantify and characterize the bioactive compounds responsible for antimicrobial activity. Such efforts will illuminate the mechanistic basis of antimicrobial action and potentially identify novel compounds with therapeutic applications. More research should also focus on propolis, pollen and cerumen, which are likely to be more abundant than the honey. Understanding the chemical profiles and antimicrobial properties of these other products will lead to their targeted production and exploitation, thereby making meliponiculture more economical and attractive.

Moreover, in vivo studies and clinical trials are crucial to translate the reported laboratory findings into practical applications. Research on dosage formulations, shelf-life optimal delivery methods, safety and efficacy in humans and animals will bridge the gap between laboratory potential and real-world therapeutic use. Such studies would also clarify the potential of stingless bee products as alternatives or complements to conventional antimicrobial, especially in regions facing high antimicrobial resistance. Post-harvest processing and storage methods should be optimized to maintain antimicrobial potency. Developing guidelines for temperature control, light exposure and storage duration will preserve sensitive bioactive compounds and ensure consistent product quality.

Conflict of interest
The authors declare none

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