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EDITED BY

Tatiana Colombo Pimentel,
Federal Institute of Education, Science and
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REVIEWED BY

Ujjwal Layek,
Rampurhat College, India
Tahis Regina Bau,
Instituto Federal de Santa Catarina (IFSC), Brazil

*CORRESPONDENCE

Etsemeskel Tadele
✉ etsemeskeltadele5@gmail.com

RECEIVED 05 March 2025

ACCEPTED 15 October 2025

PUBLISHED 30 October 2025

CITATION

Tadele E, Worku D, Muluneh T, Ayana Y and
Melese A (2025) Comprehensive review on
improved honey production: techniques,
challenges, opportunities, and future
prospects in Africa.
Front. Bee Sci. 3:1588416.
doi: 10.3389/frbee.2025.1588416

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Comprehensive review on improved honey production: techniques, challenges, opportunities, and future prospects in Africa

Etsemeskel Tadele*, Destaw Worku, Teshager Muluneh,
Yitayih Ayana and Abebe Melese

Department of Animal Sciences, College of Agriculture, Food and Climate Sciences, Injibara
University, Injibara, Ethiopia

Beekeeping production in Africa is important for economic development, food security, environmental conservation, and social well-being. It is important for employment, income generation, plant pollination, ecological awareness, medication, and nutrition. The objective of this review is to explore the improvement of honey production, navigating the causes that reduce honey production as well as techniques to optimize honey production, opportunities, and future prospects in Africa. The improvement of honey production in Africa faces various economic, social, and environmental limits that reduce its production. The causes of low honey production include traditional beekeeping system, inadequate management, technical gaps, and environmental factors as well as lack of technological knowledge, inadequate training, and market constraints, which collectively impede the producers' ability to improve their honey production. Techniques to improve honey production include improving the beekeeping management system, enhancing forage resources, post-harvest, and value addition, and capacity building and extension services. Improved honey production opportunities include the expansion of beekeeping as an agribusiness, the availability of rich floral diversity to high-quality honey, the adoption of modern beekeeping technologies, resilience to climate change with pollination services, access to both local and export markets, and the incorporation of digital and mobile innovations in beekeeping practices. By strengthening honey production through investment in modern beekeeping practices, enhancing cooperative structures, improving market access, and supporting policy frameworks, stakeholders possess the capacity to collectively transform the honey sector into a sustainable and resilient industry.

KEYWORDS

challenge, honey, improved, opportunity, production

1 Introduction

Beekeeping production in Africa is important for economic development, food security, environmental conservation, and social well-being. It is the management of honey bee colonies for crop pollination, honey, and other products (Terefe, 2018). It is the source of income and employment for many rural households in Africa. Honey production has increased by 236.2% from 1961 to 2017, indicating a rising demand for honey and pollination services. One-third of global agricultural production relies on pollination, highlighting the economic importance of honey bees (Fikadu, 2019). In Tanzania, plots pollinated by honey bees produced 3.5 times more seeds than those without pollinators, highlighting the importance of apiculture for food security (Nene et al., 2022).

The economic impact of beekeeping production in Africa and other parts of the world is important for honey and beeswax production, pollination support, and income generation (Yusuf et al., 2018). Honey bees are important sources for their valued products like honey, wax, pollen, royal jelly, venom, broods, and propolis, and they help with pollination (Basa et al., 2016). In Ethiopia, for instance, beekeeping contributes to household income and poverty alleviation while also playing a role in the national economy through exports (Yadeta, 2015). Similarly, in Kenya, honey production is a key economic activity, particularly in regions where other agricultural activities are challenging due to climatic conditions (Abuje et al., 2017; Sagwa, 2021). It is a low-input activity that does not compete with other agricultural

practices for resources. This makes it an environmentally friendly option for rural communities (Moinde, 2016). The general importance of beekeeping production in Africa is summarized in Figure 1.

Despite its importance, the improved honey production sector in Africa faces several challenges that hinder its growth and efficiency. The widespread use of traditional methods in African countries results in low production and quality, limiting the sector's potential (Fikru, 2015; Enbiyale, 2018). Insufficient infrastructure, inadequate access to modern equipment, and limited extension services are barriers to improving production and quality standards (Gina, 2014; Belete, 2019; Mizero et al., 2024). Pests, predators, and pesticide use threaten honey bee health, while climate change impacts forage availability, further challenging the sector (Enbiyale, 2018; Fikadu, 2019). The purpose of this review on the improved honey production in Africa is to identify the cause of constraints, find solutions, improve farmers' income, ensure food security, and promote sustainability. This review focuses on the improved honey production as well as the causes and potential opportunities associated with sustainable honey production in Africa.

2 Data extraction management

This review was conducted following a structured approach, and relevant literature was identified using platforms including Scopus,

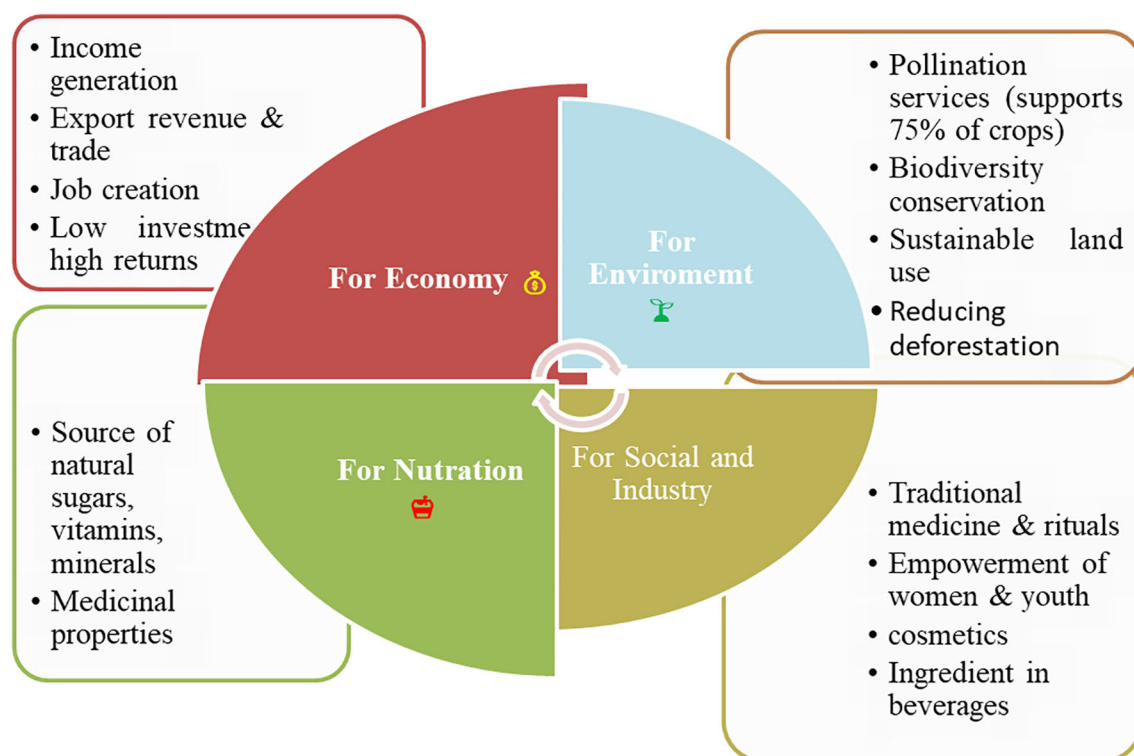


FIGURE 1
Importance of beekeeping production in Africa.

Web of Science, PubMed, and Google Scholar. The search covered studies published between 2010 and 2024 using combinations of the following keywords: “honey production,” “beekeeping practices,” “apiculture,” “Africa,” “challenges,” and “opportunities of honey.” The inclusion criteria focused on peer-reviewed journal articles, official reports, and conference proceedings that provided data or analysis on honey production practices, challenges, and opportunities. Studies not written in English, duplicate records, or those lacking sufficient methodological clarity were excluded. The findings were organized into five major sections: (i) honey production in Africa: countries and current scenario, (ii) causes of low honey productivity in Africa, (iii) techniques for improved honey production in Africa, (iv) opportunities for improved honey production in Africa, and (v) Future prospects for improved honey production in Africa.

3 Honey production in Africa: Countries and current scenario

Africa is gifted with abundant apicultural resources that play a vital role in pollination, enhancing agricultural productivity and sustaining ecosystem health across the continent. According to different studies, Ethiopia leads Africa in honey production, contributing to national exports and household incomes (Fikru, 2015; Nega and Eshete, 2018). Other notable countries include Kenya, Tanzania, Nigeria, Uganda, Cameroon, and Morocco. Kenya is recognized for its diverse beekeeping practices, including both traditional and modern methods. The country has a growing number of managed colonies, contributing to its status as a honey producer in East Africa (Brodschneider, 2020). Despite its potential, Tanzania faces challenges such as poor infrastructure and marketing issues that hinder honey production growth. Morocco has substantial apiarian potential but struggles with stagnation in honey production due to challenges in colony repopulation and

modernization efforts (Moujanni et al., 2017). The major honey-producing countries in Africa are summarized in Figure 2.

Africa has large areas of unexploited natural vegetation, which can support organic honey production (Moinde, 2016). There is a high demand for honey and hive products in both domestic and export markets, providing opportunities for economic growth (Moinde, 2016). Modernizing beekeeping practices and improving existing indigenous knowledge can lead to developments in the sector (Moinde, 2016). In Morocco, efforts to modernize the sector and improve honey quality are ongoing, though challenges remain in repopulating colonies and enhancing productivity (Moujanni et al., 2017). Beekeeping contributes 1.3% to Ethiopia’s agricultural GDP, highlighting its importance in rural income generation (Tekle, 2018).

Africa, being the original home of the honey bee, has a rich diversity of honey bee subspecies and a growing number of managed and feral colonies. However, the continent’s honey production is currently underutilized, with production levels significantly below potential due to various constraints. Transitioning to a more organized and modernized beekeeping industry could significantly enhance honey production across the continent. Honey production in Africa is estimated to be less than 10% of its potential, with beeswax production at approximately 25% of its potential (Moinde, 2016). Development strategies should focus on improving existing technologies and gradually adopting advanced methods to increase output and maintain low-input costs. Public–private partnerships could help create a viable beekeeping industry by addressing technical, financial, and administrative constraints (Moinde, 2016). Enhancing institutional support and infrastructure is crucial to promote beekeeping as a commercial enterprise.

Honey production and marketing in Africa can benefit from practices employed in other regions, particularly by adopting modern technologies and enhancing value chains. Transitioning from traditional to modern beehives can increase honey yield and quality. Ethiopia has seen a gradual shift toward modern hives,

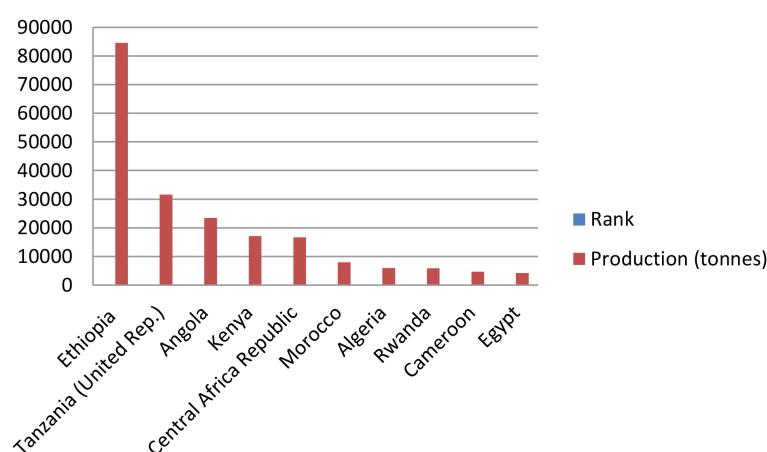


FIGURE 2
Highest honey-producing countries in Africa.

which enhances productivity (Shanku and Ijara, 2024). Providing beekeepers with training on modern techniques and management practices is crucial. Establishing structured marketing systems can help beekeepers access broader markets. In most African countries, the lack of organized channels has been a barrier, and encouraging beekeepers to form cooperatives can enhance bargaining power and improve access to resources and markets. Beekeeping contributes to rural income, with Ethiopia generating substantial revenue from honey sales. This model can be replicated in other African nations to alleviate poverty (Gebrehiwot, 2015).

4 Causes of low honey productivity in Africa

Low honey productivity in Africa is caused by a variety of interrelated factors, including environmental condition, traditional management practice, socio-economic problem, pest, and weak institutional support (Nganso et al., 2024; Nyunza, 2018; Tadesse et al., 2021). Environmental and climate factors were highlighted as major challenges. Drought, deforestation, and habitat degradation were cited as leading causes of reduced forage availability, negatively impacting bee health, production, and colony survival (Mustafa et al., 2015). However, a few studies noted promising results with the introduction of climate-resilient bee species and improved forage management. Market-related findings indicated that although Africa contributes to global honey production, commercialization remains limited due to weak quality standards,

poor infrastructure, and low access to international markets (Bayissa et al., 2025) (Figure 3).

4.1 Environmental and ecological causes

Habitat loss due to agricultural expansion and urbanization reduces forage availability for bees (Sagwa, 2021). Deforestation and land use changes have led to a decline in bee habitats, impacting bee populations and honey production (Sagwa, 2021). Variability in weather patterns affects forage availability, leading to reduced honey yields (Terefe, 2018; Sagwa, 2021). Changes in weather patterns affect flowering times and nectar availability, impacting bee health and productivity (Huho et al., 2024). Studies indicate a direct correlation between honey production and rainfall; insufficient rainfall leads to lower honey yields (Nyunza, 2018). Beekeeping practices require access to water sources, favorable climatic conditions, and the availability of flowering plants influencing honey production.

4.2 Beekeeping practices and technology

Traditional beekeeping methods often result in low honey yields, with average production per hive remaining below optimal levels (Nganso et al., 2024). Beekeepers in Africa rely on traditional methods, which yield lower honey production compared to modern techniques (Anza and YEMAN, 2024). Many beekeepers lack

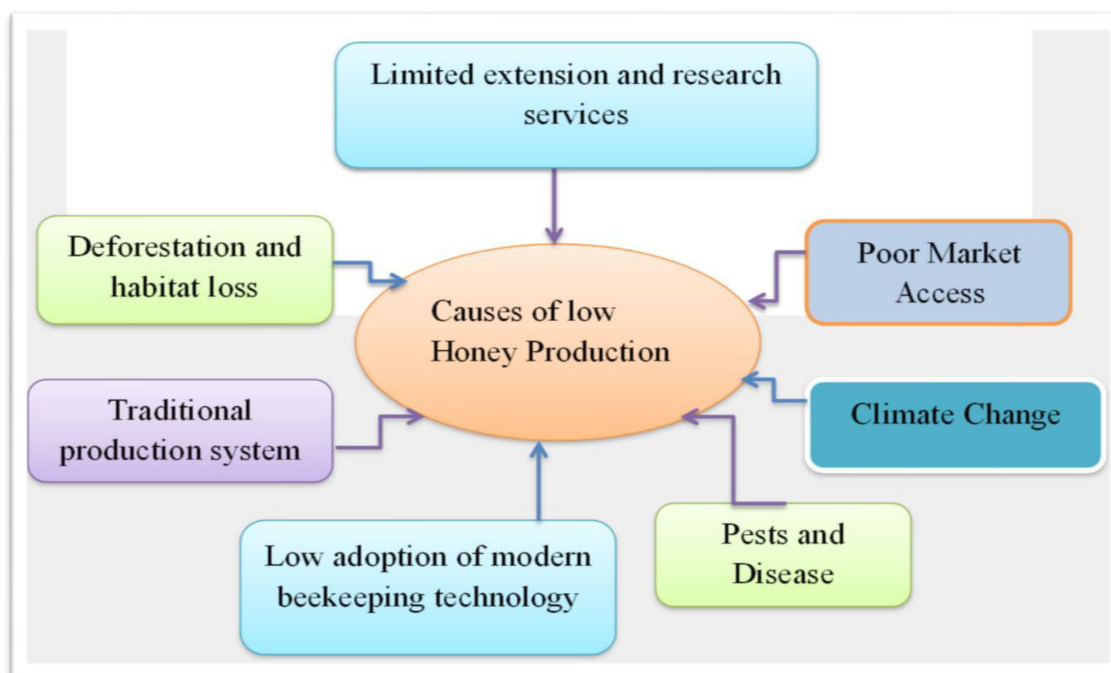


FIGURE 3
Causes of low honey production in Africa.

knowledge of modern practices, which limits their ability to adopt improved technologies (Shanku and Ijara, 2024). Poor management practices lead to low productivity and health issues within bee colonies (Nganso et al., 2024). In Africa, the productivity per hive is notably low due to reliance on outdated techniques, despite the country being a leading honey producer in Africa (Tarekegn and Ayele, 2020; Shanku and Ijara, 2024). Major barriers include a lack of modern beekeeping equipment, insufficient training, and limited access to extension services (Sagwa, 2021; Shanku and Ijara, 2024). The absence of structured marketing and apiculture policies further complicates the situation, leading to underutilization of available resources (Sagwa, 2021).

Lack of training and knowledge has an impact on honey production, as evidenced by various studies highlighting the importance of effective training programs and knowledge-sharing initiatives. These can be addressed through targeted training that enhances beekeepers' skills and knowledge, ultimately leading to improved honey yields. There is a lack of knowledge and skills in modern beekeeping practices, which limits productivity (Moujanni et al., 2017; Moinde, 2016).

Training programs, such as the Beekeeping Development Program in Nepal, have shown significant improvements in participants' knowledge and skills, leading to increased honey productivity (Kafle and Aryal, 2024). A cross-country survey revealed that beekeepers are keen to update their knowledge on apiary health and pest control, indicating a demand for continuous professional development (Guiné et al., 2023). The establishment of Beekeeping Knowledge and Innovation Systems (B-KIS) can facilitate better knowledge dissemination and innovation in the sector (Kristiansen et al., 2024). Research on feeding modifications in honey bees demonstrated that specific dietary changes can enhance honey production, showcasing the potential for integrating scientific findings into practical beekeeping strategies (Akinwande and Badejo, 2010).

Effective colony management practices are often neglected, which is crucial to enhance honey bee health and productivity (Nganso et al., 2024). There is a significant lack of modern equipment, such as hives and extractors, which are essential for efficient production (Shanku and Ijara, 2024). Factors like temperature and humidity control are often neglected, leading to colony losses and reduced honey yield. Studies show that beekeepers using modern hives exhibit higher technical efficiency, yet many still operate below optimal production levels (Tesema et al., 2023).

4.3 Socio-economic constraints

Despite the continent's rich biodiversity and potential for honey production, various causes hinder the growth of the honey production sector. Insufficient extension services and technical knowledge hinder the beekeepers' ability to adopt improved practices (Terefe, 2018). Poor marketing channels and high costs of modern beekeeping equipment limit profitability for many producers. The absence of structured marketing channels and

policies hampers the ability of beekeepers to sell their products effectively (Sagwa, 2021). Poor infrastructure and unstructured marketing channels restrict honey producers from accessing broader markets (Moinde, 2016). The absence of an apiculture policy and organized marketing systems further complicates market access (Sagwa, 2021).

4.4 Forage and floral resources

Forage and floral resource constraints have impact on honey production in Africa, affecting the availability of both nectar and pollen for honey bee colonies. In South Africa's fynbos biome, 54 plant species serve as primary nectar and pollen sources, indicating a diverse but regionally specific floral resource base (Addi et al., 2006). In Ethiopia, honey bee forage is critically limited from December to August, with a flowering calendar identifying 98 plant species as potential resources (Seboka and Workiye, 2022). Research on Africanized honey bees shows that colonies with low pollen storage exhibit increased foraging activity, but overall efficiency is reduced compared to those with adequate pollen levels (Tadesse et al., 2021). This suggests that forage availability directly influences colony strength and honey production. Cultivating specific plants like *Annona senegalensis* and *Croton macrostachyus* can enhance honey production by providing reliable nectar and pollen sources. Promoting these plants could mitigate forage shortages and improve honey yields.

5 Techniques for improved honey production in Africa

The review identified several recurring themes across the literature. First, improved hive technologies (such as Kenyan Top-Bar and Langstroth hives) were consistently associated with higher productivity compared to traditional log hives (Wambua, 2015)—for instance, multiple studies reported that modern hives increased yields by 30%–50% while also improving honey quality. Improving honey production in Africa involves a combination of adopting modern beekeeping technologies, enhancing technical efficiency, and integrating apiculture with environmental conservation (Moinde, 2016). These strategies not only increase honey yields but also contribute to economic development and ecological sustainability. Table 1 presents a summary of the main strategies to enhance honey production in Africa.

5.1 Improving beekeeping practices

The use of modern hives, such as frame and transitional hives, has been shown to significantly increase honey yields—for instance, in Sidama, Ethiopia, the adoption of these technologies resulted in an increase from 10.5 to 25.5 kg of honey per hive annually (Negash et al., 2022; Milanović, 2022). Improved beehive technologies have been associated with a 19.5% increase in technical efficiency among

TABLE 1 Summary of the main strategies for improved honey production in Africa.

Strategies	Key interventions/actions	Expected impact	References
Beekeeping practices and technology	Promote the use of modern hives (Kenya top-bar, Langstroth) Train farmers in colony management, queen rearing, and pest control Introduce protective gear and harvesting tools	Higher yields, better quality honey, reduced colony losses	(Anuar et al., 2023; Haillesselasi, 2016)
Forage and environment management	Establish bee forage plantations (indigenous nectar-rich plants) Promote agroforestry and diversified cropping Protect natural forests and habitats	Increased nectar flow, sustainable ecosystems, climate resilience	(Alhamza and Osman, 2024; Saikanth et al., 2023)
Capacity building and training	Farmer field schools and extension services Training on hygienic honey handling, processing, and storage Gender/youth inclusion in beekeeping programs	Skilled workforce, reduced post-harvest losses, empowerment	(Gupta et al., 2019)
Quality standards and value addition	Enforce national honey standards Establish honey collection centers and processing facilities Develop value-added products (beeswax, propolis, royal jelly)	Higher market value, export competitiveness, consumer trust	(Anand and Sisay, 2011; Tahir et al., 2019)
Market access and marketing	Strengthen cooperatives and producer groups Branding and certification (organic, fair trade, geographical indication) Promote domestic consumption and export channels	Improved incomes, market diversification, regional/global competitiveness	(Mgalama, 2015; Tadesse et al., 2021)
Policy and institutional support	Government support through subsidies, credit schemes, insurance Regional collaboration in apiculture policies Incentives for private sector investment in honey value chains	Enabling environment, investment growth, sustainable sector development	(Yusof et al., 2019; Oladimeji et al., 2016)

adopters compared to non-adopters in Southern Ethiopia (Tareegn and Ayele, 2020). Technical efficiency in honey production can be improved by increasing the number of hives, utilizing credit services, and providing extension services and training to beekeepers (Tesema et al., 2023).

Proper care and maintenance of bee colonies are essential. These include monitoring hive health and ensuring adequate nutrition for bees (Kilani, 2024). Utilizing modern technologies can improve honey quality and production efficiency (Kilani, 2024). A specific method involves creating comb frames with steel wires and a comb honey mold, allowing for unique comb shapes that enhance marketability. In regions like Ethiopia, enhancing technical efficiency through better input management has shown to increase honey production (Bati, 2020).

The implementation of smart hives equipped with sensors allows for real-time monitoring of environmental conditions, which can significantly enhance bee health and productivity (Yusof et al., 2019; Saranchin et al., 2024). Utilizing Internet of Things technology helps beekeepers track parameters such as temperature, humidity, and hive weight, thereby reducing colony loss and optimizing honey production (Yusof et al., 2019). Effective management of bee diseases is crucial. Regular health monitoring and preventive measures can lead to healthier colonies and increased honey yield (Kilani, 2024; Saranchin et al., 2024). Employing best practices in harvesting and processing can

improve honey quality, making it more valuable as a medicinal product (Kilani, 2024). A structured approach to breeding male bees, including optimal timing and environmental conditions, can enhance honey production by up to 167%.

5.2 Enhancing forage resources

Enhancing forage resources is pursued to improve honey production in Africa, particularly in regions where beekeeping is integrated with agricultural practices. The availability of diverse floral resources directly influences honey yield, making the enhancement of forage systems a strategic priority. Beekeepers benefit from maintaining a variety of flowering plants, which are essential to maximize honey production. Studies indicate that improved beekeeping practices lead to better management of these resources, resulting in increased honey yields (Gemed, 2014). The integration of beekeeping with watershed management not only enhances honey production but also provides economic incentives for local communities to conserve natural habitats (Kinati, 2022).

East Africa faces forage deficits, with nearly 40% of annual feed demand unmet. This scarcity affects both livestock and honey production, as bees rely on healthy forage systems for nectar and pollen (Burkart and Mwendia, 2024; Paul, 2019). Many farmers depend on outdated seed varieties, limiting the potential for

improved forage cultivation. Promoting access to high-quality forage seeds is essential to enhance both livestock and honey production (Burkart and Mwendia, 2024). Effective policies are needed to support the development of forage seed systems and improve beekeeping practices. These include providing technical assistance and resources to marginalized communities (Burkart and Mwendia, 2024). Engaging local beekeepers in watershed conservation efforts can lead to sustainable honey production while promoting environmental stewardship (Gemed, 2014). Enhancing forage resources presents opportunities to improve honey production; it is essential to address the underlying challenges of forage availability and quality. A balanced approach that integrates community needs with environmental conservation can yield sustainable benefits for both honey production and local ecosystems.

5.3 Post-harvest and value addition

Improving honey production in Africa through post-harvest and value addition strategies is essential to enhance livelihoods and address poverty. The integration of effective post-harvest handling and agro-processing technologies can improve honey quality and marketability. Educating beekeepers on best practices for honey extraction and storage can reduce losses and enhance quality. Establishing appropriate facilities for honey processing and storage can minimize spoilage and maintain product integrity.

Introducing value-added products such as beeswax, propolis, and royal jelly can increase income streams for beekeepers (Berem et al., 2010). Implementing good apiculture practices, including proper hive management and disease control, can improve honey quality, making it more appealing to consumers (Kilani, 2024). Developing structured marketing strategies can help beekeepers reach broader markets and improve sales (Moujanni et al., 2017). Promoting the health benefits of honey can stimulate demand and justify higher prices for quality products (Kilani, 2024).

5.4 Capacity building and extension services

Capacity building and extension services are enhancing honey production in Africa, as they provide the necessary support and resources to improve productivity and quality. These services include training, technology inputs, and organizational support, which help beekeepers transition from traditional to modern practices, thereby increasing their output and income. The integration of smallholder farmers into value chains and the development of enabling policy environments are also essential components of this process. Initiatives have provided beekeepers with training and technology inputs, enabling them to produce certified organic honey for export, increasing their incomes (Anand and Sisay, 2011). The introduction of transitional hives in Ethiopia's

Jimma Zone has increased hive productivity from 6 to 17.4 kg per hive, demonstrating the impact of modern beekeeping techniques (Biyena, 2021).

The creation of alliances between smallholder farmers and private-sector companies has facilitated the development of honey value chains, allowing farmers to access international markets (Anand and Sisay, 2011). Extension services have played a role in organizing production and creating policy environments that support beekeeping as a viable economic activity (Anand and Sisay, 2011). Innovative extension models, such as farmer learning platforms and community-based seed multiplication, have been effective in delivering technologies and innovations to farmers, emphasizing the importance of context-specific approaches (Oluoch and Kitanaka, 2024). Community engagement and training have empowered rural youth in Ethiopia, providing employment opportunities and encouraging sustainable practices (Biyena, 2021). The techniques of improved honey production in Africa are shown in Figure 4.

6 Opportunities for improved honey production in Africa

Improving honey production in Africa presents different opportunities, particularly through the adoption of modern beekeeping practices, enhanced colony management, and better resource utilization.

6.1 Expanding beekeeping as an agribusiness

Improved honey production presents opportunities for expanding beekeeping as an agribusiness in Africa. The continent has vast untapped potential, with the current production levels being only a fraction of what is achievable. By leveraging modern technologies and enhancing existing practices, African countries can increase honey output, improve quality, and tap into lucrative markets.

The global demand for honey is rising, creating opportunities for African producers to enter both domestic and international markets (Moinde, 2016; Bayissa et al., 2024). Niche markets for organic and value-added honey products are particularly promising, given the continent's rich biodiversity (Moinde, 2016). The introduction of modern beekeeping equipment and techniques can enhance productivity and quality. Transitioning from traditional to improved beekeeping systems can yield higher honey outputs while maintaining low-input costs (Moinde, 2016). Beekeeping contributes to job creation and income generation, particularly in rural areas, thus addressing unemployment issues (Labe, 2017; Mwakatobe et al., 2016). The practice supports environmental conservation through the maintenance of diverse floral resources, which is important for sustainable agriculture.

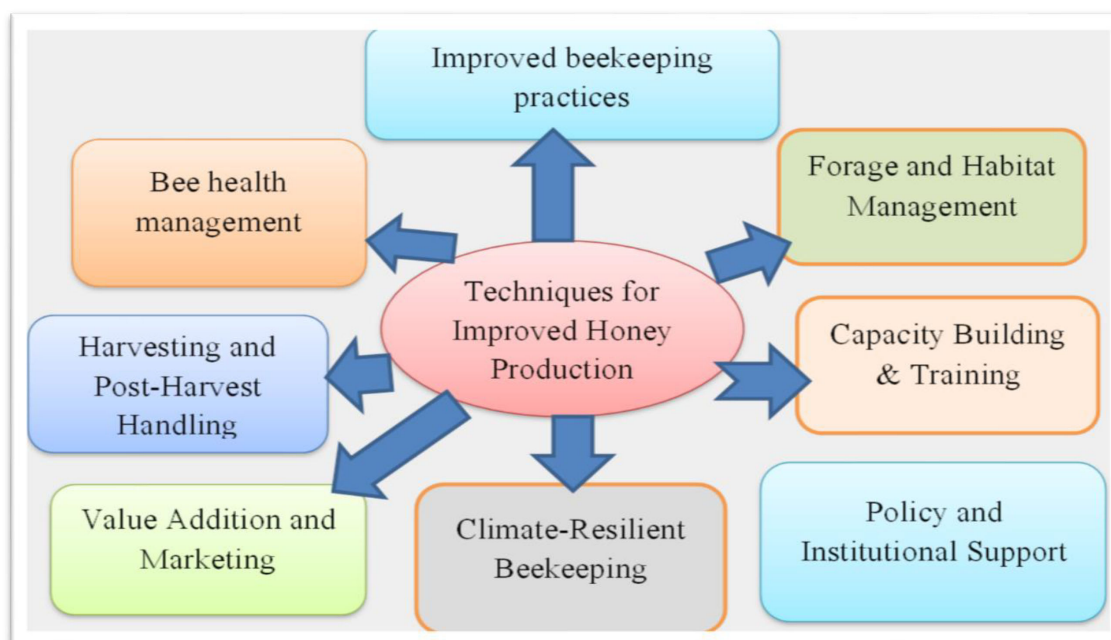


FIGURE 4
Techniques to improve honey production in Africa.

6.2 Floral diversity for high-quality honey

Improved honey production in Africa, particularly in regions with rich floral diversity, presents opportunities to enhance both quality and economic viability. The interplay between diverse melliferous plants and beekeeping practices can lead to the production of high-quality honey, which is increasingly sought after in both local and international markets.

Studies indicate that regions like the Sahara and Ethiopia exhibit a rich diversity of bee forage plants, with 89 species identified in Algeria and 122 in Ethiopia (Bareke et al., 2024). The presence of specific plant families, such as Asteraceae and Fabaceae, influences pollen diversity and honey quality, with manual extraction methods yielding richer pollen profiles. The beekeeping sector in Africa is underutilized, with the current production levels at less than 10% of its potential (Moinde, 2016).

The conservation of melliferous plants is sustaining honey production. Many identified honey plants are threatened, necessitating urgent conservation strategies. Promoting the cultivation of multipurpose plant species can support bee populations and honey production, ensuring ecological balance and biodiversity (Bareke et al., 2024). Africa has unique honey types, such as white honey from Ethiopia and organic forest honey from Tanzania. Branding and certification (e.g., organic, fair trade) should be promoted to access premium markets. The challenges and potential improvements for honey production in Africa are summarized in Table 1.

6.3 Adoption of modern beekeeping techniques

Traditional log hives have low productivity. Training farmers in modern hive technologies (e.g., Langstroth hives, Kenya Top Bar hives) can increase honey yields. Adoption of improved beehive technologies has shown importance in honey output, with farmers experiencing a positive return on investment. Smart hives equipped with sensors and monitoring systems can enhance management practices, leading to better colony health and productivity (Saranchin et al., 2024). Access to training and extension services is crucial for beekeepers to effectively utilize modern technologies (Angasu et al., 2024). Increased awareness and education about modern beekeeping practices can facilitate higher adoption rates and better management of bee colonies (Shanku and Ijara, 2024). Implementing supportive policies that promote the distribution of modern beehives and accessories can enhance adoption (Angasu et al., 2024). Developing local substitutes for beehives from readily available materials can lower costs and increase accessibility for beekeepers.

6.4 Climate change resilience and pollination services

Improved honey production in Africa presents opportunities for climate change resilience and enhanced pollination services. By

leveraging the ecological and economic benefits of honey bees, communities can support food security and adapt to changing environmental conditions. Honey bees contribute approximately \$0.815 billion to Ethiopia's agricultural economy through pollination services, vital for 62.2% of the country's crops (Fikadu, 2019). Increased honey production can provide alternative income sources for farmers, promoting sustainable livelihoods and watershed conservation. Beekeeping practices can enhance resilience against climate change by maintaining diverse floral resources, which are vital for honey production and pollination. Effective management strategies, such as overwintering colonies, can mitigate risks associated with warmer autumns and winters, ensuring the survival of honey bee populations. Honey bees are essential for food security, as they facilitate the pollination of crops that constitute a significant portion of human diets (Fikadu, 2019). The decline in pollinator populations due to climate change poses risks to agricultural productivity and underscores the need for improved beekeeping practices (Decourtye et al., 2019).

6.5 Access to local and export markets

Improved honey production in Africa presents important opportunities to access both local and export markets. By leveraging geographical indications, enhancing smallholder capabilities, and developing cooperative structures, the honey sector can thrive economically. Geographical indications can enhance product value and market access by certifying unique honey varieties, as seen with the Oku white honey in Cameroon, which improved the prices and sales for beekeepers (Ingram et al., 2020). However, challenges such as deforestation and competition threaten long-term benefits, indicating the need for effective governance (Ingram et al., 2020). Initiatives in Ethiopia have successfully linked smallholder farmers with export markets, quadrupling honey output and enabling organic certification, which significantly boosts incomes (Anand and Sisay, 2011). Access to technology and training is improving production quality and quantity, as evidenced by the cooperative models that facilitate market access (Alemu, 2015). Establishing cooperatives enhances resource sharing and skill development among beekeepers, leading to increased honey yields, as demonstrated in Dawro Zone, Ethiopia (Tufo et al., 2017). Cooperatives also help mitigate transaction costs and improve market linkages, essential for smallholder success (Alemu, 2015).

6.6 Digital and mobile innovations in beekeeping

Improved honey production in Africa can benefit from digital and mobile innovations in beekeeping. These technologies enhance productivity, streamline operations, and promote sustainability, addressing challenges faced by beekeepers. Modern beekeeping system is also a monitoring system that tracks hive health and production metrics, allowing beekeepers to manage their operations

remotely. Integrating remote sensing and AI provides insights on beekeeping flora and hive management, enhancing decision-making and productivity (Grammalidis et al., 2023). An open data sharing platform consolidates diverse datasets, facilitating better analysis and understanding of bee health and environmental conditions (Guruprasad & Leiding, 2024). Digital innovations not only improve honey production but also contribute to environmental sustainability by monitoring bee health and promoting biodiversity (Burma, 2023).

7 Future prospects for improved honey production in Africa

The future prospects for improved honey production in Africa are given the continents of beekeeping traditions and the increasing adoption of modern technologies. Ethiopia, as the leading honey producer in Africa, exemplifies the potential for growth through the adoption of modern beekeeping technologies despite challenges such as lack of equipment and training (Shanku and Ijara, 2024). Similarly, in Kenya, beekeeping is seen as a solution to ecological and economic challenges, with efforts to modernize practices showing positive impacts on honey production (Huho et al., 2024). The integration of modern beekeeping practices and improved hive technologies can enhance productivity, as evidenced by studies showing increased honey yields with the adoption of improved beehives (Tarekegn and Ayele, 2020). Additionally, the role of pollinators, particularly honey bees, in improving crop yields, such as sunflowers, underscores the importance of maintaining healthy bee populations for agricultural productivity (Nene et al., 2022). Effective agricultural policies that recognize the unique needs of the beekeeping sector are essential for growth (Moinde, 2016). Establishing structured marketing systems and conservation programs can enhance the sustainability of honey production (Sagwa, 2021).

7.1 Adoption of beekeeping technologies

Adoption of improved hives, protective gear, and honey extraction equipment can enhance productivity and product quality. Traditionally, the majority of African beekeepers depend on traditional hives (such as bark and log hives), which are low-cost but inefficient in terms of honey harvesting and colony management (Wambua, 2015). In recent decades, efforts have been made to introduce improved and modern technologies that enhance both productivity and sustainability. Technologies and their adoption levels improved hives (e.g., Kenya Top-Bar Hive and Langstroth Hive), allowing for better colony management, easier harvesting, and higher yields, but adoption remains limited due to higher initial costs. Protective equipment and tools—including bee suits, smokers, and gloves—reduce risks and encourage a more effective hive management. Honey harvesting and processing equipment such as centrifugal extractors, sieves, and stainless steel storage containers improve honey quality and meet

export standards (Orina, 2014). However, access is often constrained by cost and lack of awareness. Digital and precision technologies—including hive monitoring sensors, mobile applications for colony tracking, and GIS-based forage mapping—are emerging but remain limited to pilot projects and high-investment settings (Bharadwaj et al., 2024). The gradual introduction of digital hive monitoring systems and precision beekeeping tools may further revolutionize production.

7.2 Value addition and product diversification

The future prospects for improved honey production in Africa hinge on value addition and product diversification, which enhance economic viability and sustainability. By leveraging existing resources and addressing current challenges, the beekeeping sector can transform into a robust economic activity. Expanding beyond honey to include products like beeswax, propolis, and royal jelly can tap into lucrative markets, as these products have high demand for their health benefits (Nega and Eshete, 2018). Implementing better production practices and adhering to international standards can enhance product quality, making African honey more competitive globally (Nega and Eshete, 2018). Providing beekeepers with training and modern technologies can increase productivity and quality, as demonstrated in Ethiopia where farmers quadrupled their output (Anand and Sisay, 2011). Encouraging group membership among beekeepers can facilitate access to resources and markets, as collective bargaining can improve market positioning (Berem et al., 2010). Value addition in honey production has been linked to improved household incomes, particularly in regions facing climatic challenges (Berem et al., 2010). Sustainable beekeeping practices contribute to biodiversity and environmental conservation, aligning economic activities with ecological health (Moinde, 2016).

7.3 Improved pest and disease management

Improved pest and disease management is important to enhance honey production in Africa, where the current output is below its potential. Integrated pest management strategies, which combine biological control and non-chemical methods, have shown promise in increasing agricultural productivity and sustainability. These approaches not only reduce reliance on harmful pesticides but also improve the health of honey bee populations, which are vital for pollination and honey production. IPM practices have demonstrated a net present value of \$500 million in East Africa, with a benefit–cost ratio of 8:1, enhancing food security for over 641,000 people (Mulungu et al., 2024). Effective IPM can mitigate threats from pests like *Varroa destructor* and *Nosema* spp., which significantly impact honey bee colonies (Dwarka et al., 2025).

7.4 Strengthening market access and trade opportunities

Strengthening market access and trade opportunities for honey production in Africa involves addressing several critical factors that influence smallholder farmers' participation in the market. By enhancing technology access, improving cooperative structures, and leveraging trade preferences, the potential for increased honey production and market engagement can be realized. Smallholder honey producers in Ethiopia benefit from technology acquisition and cooperative engagement, which reduce transaction costs and enhance productivity (Alemu, 2015). Participation in contracts and cooperatives is driven by market access, credit availability, and household wealth, indicating the need for targeted interventions to support these structures (Alemu, 2015). Market access conditions vary across regions and time, demonstrating the complexity of improving access for honey producers. Disorganized markets and lack of information hinder smallholder farmers, necessitating better marketing strategies and infrastructure to facilitate trade (Chiuri et al., 2013). Strengthening legal frameworks around trade preferences is essential to maximize the benefits for honey producers.

7.5 Research, training, and capacity building

The future prospects for improved honey production in Africa hinge on effective research, training, and capacity building initiatives. Despite the continent's vast potential, the current production levels are below capacity due to fragmented practices and inadequate support systems. Addressing these challenges through targeted strategies can enhance honey production efficiency and economic benefits for rural communities. The beekeeping sector is highly fragmented, complicating accurate production assessments (Moinde, 2016). Participatory evaluations of improved technologies have demonstrated increased honey yields, suggesting that hands-on training can enhance productivity (Milanović, 2022). Initiatives like Reform aim to strengthen agricultural research and training, fostering a new generation of agricultural scientists to support beekeeping and other agricultural sectors (Chindime et al., 2016). Collaborations between governments and private entities can facilitate the dissemination of knowledge and resources necessary for sustainable beekeeping practices (Moinde, 2016).

8 Conclusion

Improving honey production in Africa is both an agricultural imperative and a development opportunity. Additionally, it supports rural livelihoods, enhances biodiversity through pollination, and provides valuable health and industrial products.

This review shows that improvements will come from pairing context-appropriate modern techniques with Africa's beekeeping traditions. Priority interventions include expanding the use of improved or modern hives and colony management, strengthening apiary hygiene and pest-disease control, diversifying forage through agroforestry and climate-smart landscape planning, and professionalizing post-harvest handling to meet food safety and quality standards. The causes of low honey production in Africa such as fragmented extension services, limited access to finance and inputs, quality losses from poor processing, environmental degradation, and climate variability are solvable with coordinated policy and investment. By addressing these causes, leveraging the opportunities and using different improvement techniques with increased investment, technology adoption, and strong policy support, the honey industry can drive economic growth, environmental conservation, and sustainable livelihoods. To realize these benefits at scale, future work should focus on (i) strong monitoring to modern bee keeping practices and data systems for honey productivity, disease, and market trends, (ii) breeding and distribution of resilient bee stocks suited to local ecologies, (iii) forage restoration and pesticide-safe integrated pest management, and (iv) business development services that link producer groups to finance and formal buyers. Africa's honey production can improve from traditional to a competitive, climate-smart honey economy by aligning on quality and modern technology, investing in skills and infrastructure, restoring forage landscapes, and building inclusive market linkages.

Author contributions

ET: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. DW: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. TM: Formal Analysis, Project administration, Resources,

Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. YA: Data curation, Methodology, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. AM: Conceptualization, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, and/or publication of this article.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

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