

A review on Apiculture: Trends and opportunities

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Abstract:

Apiculture is the practice of keeping and managing honeybees for producing honey and other related products. Honey is a natural sweetener that has a variety of health benefits. The product is also used for manufacturing other products, such as beeswax, royal jelly, propolis, and pollen. The components of apiculture include bee colonies, beekeepers, beekeeping equipment, and the products produced from the bee colonies. Bees also play a crucial role in pollination, which is essential for growing crops and fruits. In comparison to other forms of agriculture, apiculture requires less land and water and has a lower carbon footprint. It is also a sustainable practice that supports biodiversity and ecological balance. In recent time apiculture is playing a major role in different sectors to strengthening the agriculture as secondary source.

Keywords: Apiculture, bees, royal jelly, pollen, propolis.

Introduction:

India is predominantly an agricultural country, where the economy heavily relies on agriculture for livelihoods⁽¹⁾. However, with the gradual decrease in per capita land holdings and rising unemployment, people need to explore other profitable enterprises within the agricultural sector, such as beekeeping, mushroom production, and dairy farming, to boost their family income. Among these, beekeeping stands out as it requires relatively small capital investment. It is a vital activity for strengthening the livelihoods of rural communities, offering a promising non-farm venture that can significantly enhance the income of smallholders and contribute to the national economy. Beekeeping plays a crucial role in diversifying and increasing the income of Indian smallholder farmers and landless youth. Given the challenges posed by depleting natural resources and the reduced profitability of traditional agriculture, beekeeping holds great potential to uplift the economy of Indian farmers⁽²⁾. In addition of providing honey and other bee products, honey bees also play an important role in increasing the yield of agricultural/horticultural crops by means of pollination, and improve the quality of produce^(3,4). It have been reported that the honey bees increased agricultural productivity to the tune of 30–80 per cent annually through cross-pollination. There is growing recognition that honey bees represent a cost-effective input for promoting sustainable, ecofriendly agriculture and enhancing crop productivity.

Beekeeping means a scientific insects breeding process capable of producing honey and wax. Wax and other foreign materials are removed from honey for sweets production⁽⁵⁾.

Trends in Apiculture

1. Sustainability and Eco-friendly Practices

i) Beekeeping and Climate Change:

The European honey bee, *Apis mellifera*, is the most economically valuable pollinator of agricultural crops worldwide. Bees are also crucial in maintaining biodiversity by pollinating numerous plant species whose fertilisation requires an obligatory pollinator. *Apis mellifera* is a species that has shown great adaptive potential, as it is found almost everywhere in the world and in highly diverse climates. In a context of climate change, the variability of the honey bee's life-history traits as regards temperature and the environment shows that the species possesses such plasticity and genetic variability that this could give rise to the selection of development cycles suited to new environmental conditions. Although we do not know the precise impact of potential environmental changes on honey bees as a result of climate change, there is a large body of data at our disposal indicating that environmental changes have a direct influence on honey bee development. In this article, the authors examine the potential impact of climate change on honey bee behaviour, physiology and distribution, as well as on the evolution of the honey bee's interaction with diseases. Conservation measures will be needed to prevent the loss of this rich genetic diversity of honey bees and to preserve ecotypes that are so valuable for world biodiversity⁽⁶⁾.

ii) Organic Beekeeping:

Beekeeping with *Apis cerana* has been practicing in Asia by using traditional methods from time immemorial. Beekeeping as a non-land based income generating tiny industrial sector is fast emerging an important component of

present day strategies for integrated rural development and off-farm employment for sustainable livelihoods. Though the beekeeping in South Asian countries has a long history with traditional management practices, the scientific methods of management is poorly understood by the beekeepers. The present paper provides information on present status of beekeeping, honeybee species, potentialities for honey production for sustainable livelihoods in South Asian countries viz., India, Bhutan, Bangladesh, Nepal, Sri Lanka, Pakistan and Maldives. The paper suggests that the South Asian has tremendous scope for commercial beekeeping and use of bee for pollination of diversity agri-horticultural crops and wild flora. Also, the paper emphasizes on the constraints for beekeeping development and strategies for organic honey production in South Asia ⁽⁷⁾.

iii) Bee Conservation Initiatives:

Pollination stands as a crucial process vital for ecosystem maintenance, with pollinators serving as pivotal vectors. Approximately 80% of pollination relies on insects, with bees emerging as primary contributors. Their significant role in ecosystem services and economic value cannot be overstated, given that approximately 30% of food sources directly or indirectly rely on honeybee pollination. Additionally, honeybees provide essential products such as honey, propolis, beeswax, and venom. However, the alarming decline in honeybee populations due to various threats, including habitat loss from land use intensification, pesticides, climate change, pathogens, parasites, diseases, invasive species, and nutritional deficiencies, poses a grave concern. To ensure the conservation of honeybees and sustain pollination for future generations, a multifaceted approach is imperative. Key strategies include promoting beekeeping in urban areas to provide alternative habitats, implementing pesticide bans to mitigate harmful effects, fostering genetic resistance to combat diseases, establishing wildflower strips to enhance foraging resources, employing biocontrol agents for pest management, ensuring proper nutrition through diverse floral resources, and implementing effective sterilization techniques. Evaluating the impact of these conservation efforts on pollination ecosystems is paramount for assessing their efficacy and guiding future conservation initiatives ⁽⁸⁾.

2. Technological Innovations in Hive Management

I Smart Beekeeping Technologies:

The use of information and communication technologies (ICT) in agriculture is far from their potential. In this article, we consider how to facilitate and systematize the process of transforming traditional agriculture into digital agriculture; Agriculture 4.0. Among the different technologies, we focus on the IoT aspects. In the article, we propose a new approach

for the design of intelligent agricultural management and supervision systems. The proposed approach is illustrated as an example of application in the beekeeping sector. Indeed, this sector is affected by a crisis due to the disappearance of bees and the different actors need support to make their decisions. As an example of decisions that can be made, we can cite: treatment planning or policy planning. An architecture based on sensors and open data is proposed to help them make decisions. An implementation of it is shown; it is based on a device with sensors, as well as an interface to collect the data on beehives and show notifications and alerts to beekeepers. The proposed architecture is flexible, and it can be used in the context of different levels of technology maturity ⁽⁹⁾.

ii) Automated Hive Systems:

The present innovation helps to increase the quality attributes of the honey by automating the process of monitoring the honey broods in order to obtain the first quality honey. The proposed invention continuously monitors the honey brood using the webcam and image processing technique is used to identify the capping level with absolute accuracy. We also monitor the humidity level inside the brood box using the humidity sensor ensuring the quality of honey produced and quality of the environment for the sustaining of bees. Image processing and machine learning is used to identify the level of capping occurred in the beehive and first quality of honey could be extracted if at least 75% of cells of the hive are capped ⁽¹⁰⁾.

3) Drone Beekeeping:

In our perspective, ground robots, despite the challenges posed by unstructured farm environments and the limitations of current sensor technologies like GNSS, demonstrates a great potential for precision pollination in various crops. Their ability to navigate around complex agricultural environments substantiates the promise. Further advancement in vision and path planning to manage the varied orientations of crop flowers would be crucial for enhancing pollination effectiveness. Moreover, while spray-based and other pollen transferring methods show potential, the technology needs to be refined to cater a broader range of crops. Comparatively, UAVs, especially larger drones, offer a more immediately deployable solution due to their ability to carry heavier payloads and cover larger areas, though they too are hindered by factors like lack of desired precision, limited battery life, and weather susceptibility. In addition, micro aerial vehicles are studied widely with a potential for robotic pollination, but the road to practical application appears longer, hindered by lack of desired precision and power source. Ultimately, considering the current state of technology and the outlined challenges, ground robots stand

out as a more applicable and economically viable option in the medium to long term for achieving artificial pollination in broad commercial agriculture.

3. Bee Products Beyond Honey

Propolis, Royal Jelly, and Beeswax:

This study is evidence that the cosmetics and skincare market is poised for a substantial growth in demand for products containing bee based ingredients. This heightened interest is driven not only by the pursuit of natural and sustainable alternatives but also by the increasing awareness of the numerous benefits offered by bee products. Therefore, industry stakeholders, researchers, and consumers alike can anticipate a flourishing market for bee derived cosmetics and skincare products in the years to come. This trend not only reflects a return to nature but also a recognition of the timeless wisdom encapsulated in the world of bees. In essence, bee products have emerged as more than mere ingredients; they symbolize a harmonious blend of nature's wisdom and scientific innovation, offering a promising pathway toward healthier and more radiant skin⁽¹¹⁾.

4. Commercial Pollination Services

Pollination in Agriculture:

There is a rising demand for food security in the face of threats posed by a growing human population. Bees as an insect play a crucial role in crop pollination alongside other animal pollinators such as bats, birds, beetles, moths, hoverflies, wasps, thrips, and butterflies and other vectors such as wind and water. Bees contribute to the global food supply via pollinating a wide range of crops, including fruits, vegetables, oilseeds, legumes, etc. The economic benefit of bees to food production per year was reported including the cash crops, i.e., coffee, cocoa, almond and soybean, compared to self-pollination. Bee pollination improves the quality and quantity of fruits, nuts, and oils. Bee colonies are faced with many challenges that influence their growth, reproduction, and sustainability, particularly climate change, pesticides, land use, and management strength, so it is important to highlight these factors for the sake of gainful pollination⁽¹²⁾.

Opportunities in Apiculture

1) Expansion of the Bee Product Market

i) Honey Diversification:

The demand for honey in India is augmenting on account of COVID-19 as well as due to the growing consumer preference for natural and healthy alternatives of artificial sweeteners, rising awareness regarding the benefits of honey and increasing popularity of various honey flavours. In addition, owing to its proven anti-inflammatory, anti-bacterial and anti-microbial properties, honey is projected

to gain a momentum in both the food and non-food applications across the country⁽¹³⁾.

ii) Health and Wellness:

The present review focused on the potential health benefits of bee products such as honey, propolis, and royal jelly. These products are highly rich in active components such as flavonoids, phenolic acid, phenolic compounds, terpenes, and enzymes, which have biological functions in preventing some diseases and promoting good health. Honey, propolis, and royal jelly have distinct efficacies with significant nutritional properties and functional values. Thus, these bee products can be developed into potent apitherapeutic agents. However, some precautions need to be taken in case of allergens associated with bee products and in finding the right intake dosage. Hence, it is necessary to conduct further studies to determine the critical mechanisms related to the pharmacological activities of these bee products and the appropriate amounts that can be taken in order to obtain promising health benefits⁽¹⁴⁾.

1) Educational Opportunities and Beekeeping as a Profession

I Apiculture as a Business:

The findings would help to improve the potential of entrepreneurs by analyzing their strength and weakness and improve upon their weakness, development of appropriate training programs for beekeepers by the beekeeping agencies, provide an in-depth understanding about entrepreneurial potential of beekeepers and can be utilized to design developmental strategies in beekeeping venture, extension policy makers to formulate appropriate beekeeping schemes for marginal and small holders, stream line strategies to overcome the problems experienced by the beekeepers in the beekeeping venture by beekeeping institutions. It also helps the government and their agencies to take various new initiatives in the field of agriculture and allied enterprise. While the current product of honey is low it can be improved by encouraging farmers to take up beekeeping on a large scale and providing necessary inputs and support the beekeeping venture⁽¹⁵⁾.

I Public Interest and Education:

The dynamically developing market of food products makes the good quality of products, especially natural ones, a priority demand factor. Getting to know some of the positive features of bee products arouses even greater interest in scientists who go deeper in their research—examining the chemical and microbiological composition. The need for education and awareness raising should cover the entire area of the developing economy, but also its society as potential buyers. In order to distinguish themselves from ecological

technologies, food producers should invest in education and development because, without innovation in the field of food technology and biotechnology, it will be difficult to maintain competitiveness and, consequently, consumer interest in bee products⁽¹⁶⁾.

Conclusion

Apiculture has emerged as a dynamic and multifaceted sector within modern agriculture, offering both ecological and economic benefits. This review highlights the key trends shaping the industry, including the adoption of precision beekeeping technologies, increasing global awareness of pollinator health, and the diversification of bee-based products. The rise of urban and sustainable beekeeping practices, alongside growing consumer demand for organic and natural goods, further reinforces the sector's relevance in today's bio-economy.

Despite challenges such as climate change, pesticide exposure, and disease prevalence, significant opportunities exist to enhance productivity, resilience, and profitability in apiculture. Strategic investments in research, education, and policy development are essential to harness these opportunities and ensure the long-term sustainability of beekeeping. Strengthening value chains, improving access to markets, and encouraging innovation will be key to unlocking the full potential of apiculture as a tool for rural development, biodiversity conservation, and food security.

In conclusion, apiculture stands at the crossroads of tradition and innovation. With the right support and vision, it can serve as a catalyst for sustainable agricultural transformation and environmental stewardship in the years to come.

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Conflict of Interest: Nil

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References

- Lal, R., Sharma, S. D., Sharma, J. K., Sharma, V. & Singh, D. (2012). Impact of bee-keeping training on socioeconomic status of farmers and rural youth in Kullu and Mandi districts of Himachal Pradesh. *Journal of Human Ecology*, 39(3), 205-08.
- Singh, G. M., Chhuneja, P. K. and Gill, M. S. (2010). Beekeeping: The future growth engine for Indian farmers. *Bee world*, 87(3), 47-49.
- Singh, D. (2000). A focus on honey bees in the tropics. *Current Science*, 79, 115-57.
- Monga, K. and Manocha, A. (2011). Adoption and constraints of bee-keeping in Districts Panchkula (Haryana), India. *Livestock Research and Rural Development*, 23, 05.
- Kumar Y and Sharma SK. (2014) Scientific beekeeping for apiculture development. Workshop Promotion Honeybee Keeping Haryana, 113-122.
- Y. Le Conte & M. Navajas (2008). Climate change: Impact on honey bee population and disease. *Rev. sci. tech. Off. int. Epiz.*, 27 (2), 499-510.
- Sivaram V. (2021). Status, prospects and strategies for development of organic beekeeping in the South Asian Countries, Pg. 1-32.
- Deepika S., Durge D, Khushboo S and Priya G (2024) *Journal of Advances in Biology & Biotechnology* Volume 27, Issue 2, Page 57-66.
- Jean-C.H., Lamine B., Yassine K., Katarzyna W.W and Corinne A. 2022. Digital Transformation of Beekeeping through the Use of a Decision Making Architecture. 12(21), 11179.
- Albert Raj, Kavin, T. Jeeva, Kiran L.K 2022. Effective and Efficient Honey Harvest Alert System for Bee Farms *Journal of physics: Conference series* Page 1-7 2325.
- Garima G, Divyanshi R. and Rahul A 2024. The Role of Bee Products in Cosmetic and Skincare Industry: Current Trends and Future Prospects *Uttar Pradesh Journal of Zoology*. Volume 45, Issue 16, Page 360-371.
- Shaden A.M., Esraa H.E., Aya D.S. and Aida A.A. *Insects* 2021, 12(8), 688; <https://doi.org/10.3390/insects12080688>.
- Ramashrit Singh 2021. Current honey market in India - Volume and Value. *International Journal of Ayurveda and Pharma Research* Pg 82-88, Vol 9/ Issue 8.
- Visweswara R P., Lakshmi Sammugam and Nagesvari R. 2017. Honey, Propolis, and Royal Jelly: A Comprehensive Review of Their Biological Actions and Health Benefits. *Oxid Med Cell Longev*. 2017:1259510.
- Esakkimuthu M. and Kameswari V. 2017. Entrepreneurial Potential of Small scale Beekeeping in Rural India: A Case in Kanniyakumari district, Tamil Nadu. *Tropical Agricultural Research* Vol. 28 (4): 411 – 424.
- Marek K., Kamil P., Anna M., Marta W., Marek R., Marcin B. and Anka T.P. 2023. Recent advances and opportunities related to the use of bee products in food processing. *Food Sci Nutr*. 11:4372–4397.