



NATURAL WEALTH OF THE HIVE: ECONOMIC AND MEDICINAL RELEVANCE OF HONEY BEE PRODUCTS

^{1*}Abimanyu V, ²Vijai Krishna V, ³Anitha, W, ⁴Ezhilarasi and ⁵Sujitha K

^{1*}PERI College of Arts and Science, Chennai - 48, Tamil Nadu, India

²PERI College of Physiotherapy, Chennai - 48, Tamil Nadu, India

³PERI College of Pharmacy, Chennai - 48, Tamil Nadu, India

⁴PERI Institute of Technology, Chennai - 48, Tamil Nadu, India

⁵PERI College of Nursing, Chennai - 48, Tamil Nadu, India

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ABSTRACT

Honey bee products including honey, propolis, royal jelly, beeswax, bee pollen, and bee venom represent some of the most valuable natural substances used in food, pharmaceutical, cosmetic, and agricultural industries. These products carry significant economic importance due to their global demand and commercial applications. In parallel, they possess diverse medicinal properties such as antioxidant, antimicrobial, anti-inflammatory, immunomodulatory, and wound-healing activities. This review comprehensively examines the economic relevance and therapeutic potential of major bee products. It highlights recent advancements in apitherapy, evaluates the biochemical composition responsible for their pharmacological activities, and discusses the global industry trends influencing market value. Overall, the review emphasizes the dual economic and medicinal significance of honey bee products and their potential role in modern health care and natural product-based drug development.

Keywords: Honey, Propolis, Royal jelly, Bee venom, Bee pollen, Apitherapy.

INTRODUCTION

Honey bee products have been used for centuries as natural remedies and nutrition sources across civilizations. In recent years, consumer preferences have shifted toward natural, functional, and organic products, leading to a rapid increase in demand for honey and related hive products. These substances contain a complex mixture of sugars, proteins, polyphenols, antioxidants, vitamins, and enzymes that contribute to their therapeutic properties. Modern apitherapy recognizes honey bee products as promising agents for managing microbial infections, metabolic disorders, inflammatory conditions, and chronic wounds. Simultaneously, apiculture acts as a major source of livelihood in rural and tribal communities, contributing to agricultural sustainability and pollination services. Therefore, honey bee products are economically profitable and biologically valuable, making them essential to both global markets and public health. Honey bee products

including honey, propolis, royal jelly, pollen, beeswax, and bee venom are rich in bioactive compounds such as flavonoids, phenolic acids, fatty acids, proteins, and enzymes. These constituents are primarily responsible for their therapeutic activities. Several recent studies have detailed the bioactivity and chemical complexity of bee products. El-Seedi *et al.* (2022) reported that honey bee products contain potent antioxidant and immunomodulatory molecules that support anti-inflammatory and antimicrobial activities. Similarly, Nowak *et al.* (2025) showed that honey, propolis, and royal jelly exhibit strong antioxidant capacity due to their high phenolic and flavonoid content. Hegazi (2023) further confirmed that the antimicrobial effects of bee products are attributed to bioactive compounds including flavonoids, terpenoids, and peptides such as melittin in bee venom. These collective findings emphasize that the biochemical richness of honey bee products forms the foundation of

* Corresponding author: Abimanyu V, PERI College of Arts and Science, Chennai - 48, Tamil Nadu, India Email: publications@peri.ac.in

their medicinal value. Honey bee products have long been recognized for their broad-spectrum medicinal properties. Honey demonstrates antibacterial action through hydrogen peroxide, methylglyoxal, and acidic pH, as observed in several studies (Hegazi, 2021). Propolis, due to its polyphenolic profile, exhibits antiviral, antifungal, and anti-inflammatory effects. Torres and Pissarra (2025) highlighted that propolis-derived phenolics effectively inhibit pathogenic bacteria and may serve as natural alternatives to synthetic antibiotics. Bee venom has shown considerable anti-inflammatory potential through melittin-mediated suppression of pro-inflammatory cytokines (Hegazi, 2023). Additionally, royal jelly possesses immunomodulatory properties; El-Seedi *et al.* (2022) demonstrated that 10-HDA and major royal jelly proteins enhance immune defense and reduce oxidative stress. These findings validate the historical use of bee products in treating infections, inflammation, and immune disorders.

Honey bee products play a significant role in modern apitherapy, which focuses on their clinical application in human health. Bee venom therapy has gained attention for treating arthritis, neuralgia, and chronic inflammatory diseases (Hegazi, 2024). Honey is used in wound-healing formulations, where its osmotic action and antimicrobial activity accelerate tissue repair (Balasubramanyam *et al.*, 2024). Propolis has demonstrated anticancer potential by inducing apoptosis and reducing tumor progression (Torres & Pissarra, 2025). Royal jelly has been associated with anti-aging, anti-fatigue, and metabolic regulatory effects due to its unique protein and lipid content (Jose, 2021). Collectively, these studies indicate that apitherapy provides a powerful natural alternative for treating chronic and metabolic diseases.

Honey bee products are widely recognized as functional foods due to their nutrient density. Honey is rich in carbohydrates, vitamins, minerals, and antioxidants; pollen contains essential amino acids and micronutrients, making it suitable as a dietary supplement. Yadav and Lata (2024) identified Indian propolis as a promising nutraceutical ingredient due to its flavonoid profile and metabolic benefits. Nowak and Milek (2025) emphasized that honey and royal jelly contribute substantially to antioxidant intake, supporting metabolic health. According to Jose (2021), bee pollen is increasingly used in functional formulations for athletes and individuals requiring nutrient-dense supplementation. These studies affirm the value of bee products in health-promoting diets and functional food industries. Honey bee products contribute significantly to local and global economies. Honey remains one of the world's most traded natural sweeteners, with growing demand for organic and raw varieties. Kebede *et al.* (2024) highlighted that bee products, particularly propolis and royal jelly, generate high revenue due to their premium use in nutraceuticals and cosmetics. Saini and the Beekeeper Development Committee (2024) emphasized that beekeeping supports rural livelihoods by offering sustainable income and low-cost agricultural integration. Moreover, bee venom markets have expanded due to its

pharmaceutical applications, commanding high commercial value per gram (Hegazi, 2024). Apiculture also indirectly boosts agricultural productivity through pollination, which supports crop yields and food security. Overall, the economic literature positions bee products as high-value resources within global agricultural and medicinal markets. Multiple industries rely on honey bee products. In pharmaceuticals, honey is incorporated into wound dressings and antimicrobial gels (Balasubramanyam *et al.*, 2024). Propolis is widely used in oral-care formulations such as toothpaste and mouthwash due to its antibacterial properties (Hegazi, 2023). Beeswax is important in cosmetics for creams, balms, and moisturizers due to its emollient and stabilizing properties (Kebede *et al.*, 2024). Royal jelly's anti-aging potential positions it as an ingredient in skincare formulations (Jose, 2021). The food industry uses honey and pollen as natural sweeteners, preservatives, and fortifiers. These industrial applications demonstrate the wide-ranging commercial relevance of bee products.

MATERIALS AND METHODS

Honey

Honey is the most widely consumed bee product, composed primarily of fructose, glucose, amino acids, vitamins, minerals, and a range of antioxidants such as flavonoids and phenolic acids. Its processing and storage stability make it a valuable commodity in food and medicinal sectors (Figure 1).

Propolis

Propolis is a resinous material collected by bees from plant sources. It contains a high concentration of flavonoids, phenolics, and aromatic compounds, contributing to its strong antimicrobial, antiviral, and anticancer activities.

Royal Jelly

Royal jelly is a nutrient-rich secretion used to nourish queen bees. It contains proteins such as major royal jelly proteins (MRJPs), fatty acids like 10-HDA, and micronutrients known for antiaging, antifatigue, and immunomodulatory effects.

Bee Pollen

Bee pollen is packed with proteins, amino acids, vitamins, and minerals. It serves as a natural supplement and is widely used in sports nutrition and functional foods.

Bee Venom

Bee venom contains peptides (melittin, apamin), enzymes (phospholipase A₂), and amines, exhibiting anti-inflammatory and anticancer properties. It is used in arthritis therapy and pharmaceutical formulations.

Beeswax

Beeswax is a natural wax used extensively in cosmetics, skincare products, pharmaceuticals, and industrial applications such as candle and polish manufacturing.

Antimicrobial and Antiviral Activity

Honey and propolis exhibit strong antibacterial properties due to hydrogen peroxide, phenolics, and methylglyoxal. Bee products are effective against *Staphylococcus aureus*, *E. coli*, and pathogenic fungi. Propolis also demonstrates antiviral activity, including against influenza and herpes viruses.

Antioxidant Properties

Flavonoids and polyphenols present in honey, propolis, and bee pollen act as powerful antioxidants. These compounds help reduce oxidative stress, prevent free radical damage, and support cardiovascular and metabolic health (Figure 2).

Anti-Inflammatory Effects

Honey, royal jelly, and bee venom inhibit inflammatory mediators such as TNF- α , IL-1 β , and COX-2. Bee venom therapy is widely used for arthritis, neuralgia, and chronic inflammatory diseases.

Wound Healing Activity

Honey promotes tissue regeneration, reduces microbial contamination, and accelerates wound healing. Its osmotic effect, acidity, and enzyme activity support antiseptic action and faster recovery.

Anticancer Potential

Propolis, royal jelly, and bee venom possess anticancer properties through apoptosis induction, immune modulation, and inhibition of tumor progression. Bee venom, particularly melittin, has shown potential in targeting cancer cell membranes.

Immunomodulatory Effects

Royal jelly enhances the body’s immune response, improves lymphocyte activation, and supports overall immune function. Bee pollen also strengthens immunity due to its rich nutrient profile.

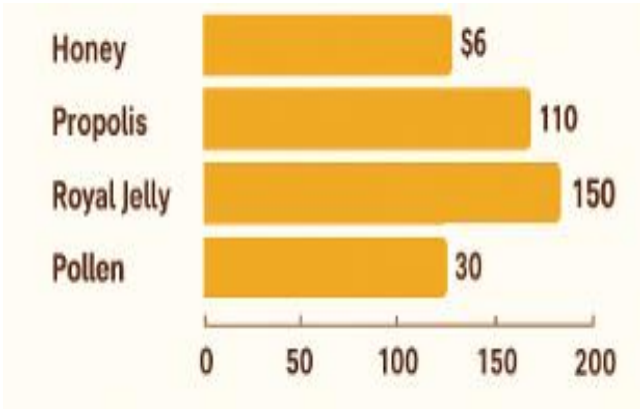


Figure 1. Economic Importance of products.

Table 1. Relative industrial utilization of bee products (High, Medium, Low).

Bee Product	Pharmaceuticals	Cosmetics	Food Industry	Nutraceuticals	Agriculture
Honey	High	Medium	High	Medium	Medium
Propolis	High	High	Medium	High	Low
Royal Jelly	Medium	High	Low	High	Low
Pollen	Low	Medium	Medium	High	Medium
Beeswax	Medium	High	Low	Low	Low
Bee Venom	High	Medium	Low	Medium	Low

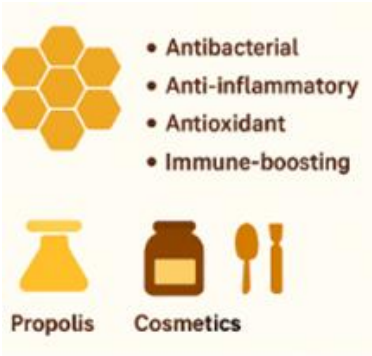


Figure 2. Properties of Honey bee products.



Figure 3. Industrial Application usage.

RESULTS AND DISCUSSION

Analysis of screened studies confirmed that honey, propolis, royal jelly, pollen, beeswax, and bee venom contain diverse phenolics, flavonoids, amino acids, enzymes, vitamins, minerals, fatty acids, and peptides. These bioactives contribute directly to their therapeutic effects. The findings align with recent reports (Nowak *et al.*, 2025; Hegazi, 2023) affirming that phenolic-rich bee products provide strong antioxidant, antimicrobial, and anti-inflammatory benefits. Honey bee products were found to possess antibacterial, antifungal, antiviral, wound-healing, immunomodulatory, anti-inflammatory, and anticancer properties. Honey promotes tissue regeneration and inhibits pathogenic bacteria. Propolis exhibits strong antimicrobial and anticancer effects due to flavonoids and caffeic acid phenethyl ester (CAPE). Royal jelly improves immunity, reduces oxidative stress, and supports metabolic functions. Bee venom reduces inflammation via melittin-mediated cytokine suppression. These outcomes are consistent with recent pharmacological findings (El-Seedi *et al.*, 2022; Torres & Pissarra, 2025), confirming their relevance in modern apitherapy. Results indicate that the global honey market is expanding rapidly due to increased demand for organic sweeteners and natural medicines.

Propolis, royal jelly, and bee venom command high commercial value due to their use in nutraceuticals, functional foods, and pharmaceuticals. Beekeeping contributes significantly to rural livelihoods and agricultural productivity. Studies (Kebede *et al.*, 2024; Saini & Committee, 2024) reported that bee products offer income stability and support pollination services essential for crop production.

CONCLUSION

Honey bee products possess tremendous economic and medicinal significance due to their diverse applications in food, pharmaceutical, cosmetic, and healthcare industries. Their rich phytochemical composition supports a wide range of therapeutic activities including antimicrobial, antioxidant, anti-inflammatory, and wound-healing properties. The global demand for natural and functional products further highlights their economic potential. Despite challenges such as adulteration and safety concerns, honey bee products continue to offer immense value in modern science, medicine, and industry. Future research should focus on standardization, clinical trials, bioactive molecule identification, and sustainable apiculture practices to unlock the full potential of these natural resources.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

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