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Environmentally Friendly Beeswax: Properties, Composition, Adulteration, and its Therapeutic Benefits

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Abstract. Bees produce beeswax, which is used to make honeycombs is biodegradable, sustainable, compostable, eco-friendly. In addition to honey and pollen, honey bees use comb to store nectar and rear their young. More than 300 things are made with beeswax, such as candles, shoe polish and vehicle and floor polishes. Beeswax can also be used in the food processing and packaging, wax crayons, metal casting and modelling, food processing, and cosmetics industries. In addition to these, embalming, papyrus preservation, and artwork conservation are all possible uses for honey beeswax. Beeswax has numerous industrial, pharmacological, and medical uses that demand an understanding of its chemical makeup. Similar to honey, beeswax is considered effective in the treatment of bruising, inflammation and burns. Beeswax's antibacterial properties have recently been the subject of inquiry, despite the fact that there are currently few studies on the subject. For example, beeswax has been proven to significantly reduce affectivity of disease causing bacteria like: *Staphylococcus aureus*, *Candida albicans* and *Salmonella enterica*. This study discusses the characteristics, composition, and adulteration of beeswax, as well as its medicinal effects as an antibiotic and in skin therapy.

Key words: Beeswax, Antimicrobial, Dermatological, Healing, Apis, Honey bees

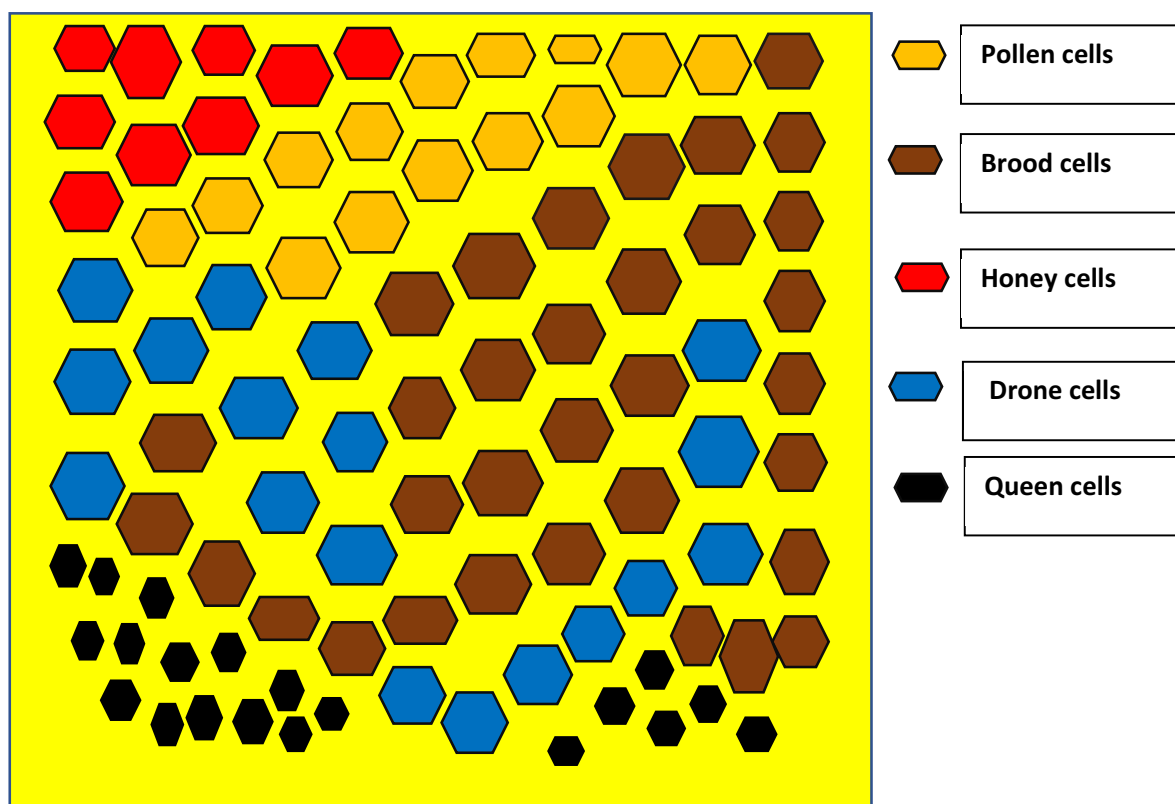
INTRODUCTION

Several insects in nature create wax, but bees and other Apoidea are responsible for the production of wax that is greatly appreciated and utilized by humans. Beeswax is produced by the two most widely cultivated bee species, *Apis mellifera* and *A. cerana*, and is the most widely used wax on the market. Beeswax is produced by younger worker bees (between the ages of 12 and 18 days, when they have completed their nursing duties) and is a complex material that is available in liquid form. Beeswax is made by mixing beeswax, pollen, and enzymes with resin from tree buds. Beeswax can then be used as a substitute for wax. There is a plethora of practical applications for honey beeswax, which include embalming, the preservation of papyrus, the conservation of artworks, the manufacture of candles and cult artefacts, as well as its usage as a medicinal component and adhesive ingredient [1]. Also, it acts as a UV radiation barrier to keep the skin from being corroded or scratched, and it keeps moisture from escaping. Additionally, beeswax serves as a source of nest-mate identification clues for honey bee colonies because of its unique chemical composition. Beeswax is making a comeback in the beekeeping industry, thanks to the fact that it is currently predominantly used to construct comb foundations [2]. Beeswax is commonly used in the food business as a food additive and to extend the shelf life of goods, and it is also widely employed in the pharmaceutical and nutraceutical sectors. Although there has been some improvement, concerns regarding contamination and adulteration of high-quality beeswax have persisted. An adulterant has been introduced into beeswax. For commercial gain, natural or synthetic chemicals are added to beeswax. This is now one of the most important challenges relating to beeswax quality, accounting for around 20% of all problems [3]. Furthermore, the information gathered in this research on the features, content, and adulteration of beeswax, as well as its therapeutical effects as an antibiotic and in skin treatments, is useful and demonstrates beeswax's future usage in related fields.

Structure of Bee Comb:

Many bees work together to build a single cell for different purposes. Cells are hexagonal in structure and are of different sizes [4]. Despite the fact that bees join combs to the surfaces along their upper lateral sides of frame, they make little tunnels around the comb's borders. The fundamental nest structure is as follows: honey storage on top, brood nest on the bottom, and pollen storage in the area between them (Figure 1). There are peculiarities in the comb structure that are associated with this arrangement. Brood nest combs are frequently darker in colour than honey storage combs, and the breadth and cell structure of the combs are more uniform. The drone comb is situated on the outskirts of the brood nest [5].



Fig.1. Structure of Bee Comb

BEESWAX

Honeybee *Apis mellifera* is the only honeybee that produces beeswax commercially available. Because of its long history of usage in the manufacture of other natural products (such as ozocerite), beeswax is considered a highly important resource [6]. According to Faostat, the worldwide production is 64,000 tonnes in 2011, with Asia (mostly India) being the leading producer with 31,000 tonnes [7]. As a by-product of honey harvesting and refinement, wax can be recovered [8]. Accurate knowledge of the beeswax's chemical composition is essential for numerous industrial, pharmaceutical, and medical applications. In order to conduct reliable analyses, the composition of the waxes has been fairly characterized. Beeswax is chemically composed of around 300 distinct compounds. Beeswax contains a variety of free fatty acids, monoesters, diesters, and hydroxyl monoesters, as well as alkanes and alkenes. The majority of them are fatty acid esters (67%), hydrocarbons (14%), and free fatty acids (13 %) [6]. Although their concentrations fluctuate based on the honeybee species and geographical origin, very minor changes in the concentration of particular components and substance groups are identified [9]. In beeswaxes from various bee species, a total content of 27 to 40 percent monoesters, 9 to 23 percent hydroxymonoesters, 7 to 16 percent diesters, 3.9 percent hydroxydiesters, 11 to 28 percent hydrocarbons, 1 to 18 percent saturated, unbranched free fatty acids, 4 to 8 percent other substances, and 0.3 percent free fatty alcohols has been reported [9].

PROPERTIES OF BEESWAX

The newly created beeswax was white at first and subsequently became yellow. Propolis and pollen dyes are used to create this golden tint. Beeswax has an unusual odour and is made from bees, honey, propolis, and pollen. Beeswax smell is sweet, warm, and balsamic, gourmet with a honey aroma, and a highly sought product. Although its perfume is one of its most cherished characteristics, it also has a hay-like undertone, and no research into the volatile ingredients has previously been published [10].

It darkens as it is used in the hive because pollen, silk, and larvae waste are mixed in with the honey. During cold weather conditions, natural beeswax gets harden. Because the composition of beeswax changes a lot depending on where it came from, the melting point is not the same. Its temperature ranges from 61 to 66 °C. It has a relative density of 0.958–0.970 g/cm³ at 15°C and an electrical resistance range of 51012 to 201012 m. It has a thermal conductivity value of 2.5103 J cm/s °C cm². Because beeswax can be used to make soap, its saponification value is between 85 and 100. Beeswax is inert and very strong. While it is insoluble in water and resistant to a wide variety of acids, it is soluble in the majority of organic solvents, as well as alcohol and fatty oils, when heated [2].

The fundamental basic elements for the synthesis of wax are sugars, fructose, glucose, and sucrose. In general, the sugar-to-wax ratio ranges from 3 to 30:1. In Central Europe, the usual ratio is around 20:1. There is a direct correlation between a colony's strength and its ability to produce wax. Only 100 grammes of wax in a Langstroth frame may hold up to 4 kilos of honey [1].

Process of Beeswax production

Wax is required by bees to construct their honeycombs. They create wax glands in 12–18-day workers, which are completely matured. The wax glands of aged bees become less active, yet they may reactivate wax production in an emergency. The development stage of the bee colony will create a lot of wax in the moderate environment of April to June. They get their four pairs of beeswax glands on the ventral side of their abdomen. Wax is made by bees in these glands. These glands convey liquid wax, which is then cooled to make fine white wax flakes. Bees collect beeswax from tree buds. The scales on the hind legs are removed and processed using mouthparts. During this process, scales, which the bees use to make honeycombs with their mandibles and fill them with pollen and propolis, start to form. The color of beeswax changes after it is exposed to honey and pollen. It turns brown after about four years. This is because beeswax is made from the exuviae of pupae, which is what makes the wax look different shades of yellow and brown. Because a gramme of wax weighs around 1 milligram, one kilogram of wax requires approximately one million scales [1].

Wax collection and processing

During the process of extracting honey, wax is often removed from the cap. Wax that is good quality and has a light color comes from this method. By separating white honeycombs from dark ones, different wax grades can be made. There will be more wax in the honey (10–15 percent) than there will be in frame hive beekeeping, where only 1–2 percent of the honey is made from wax. Most of the beeswax in the world comes from the honeybee *A. mellifera*. This bee makes a lot of beeswax. Other honeybee species, such as *A. dorsata* and *A. florea*, have the ability to produce beeswax. During the buildup of honey combs, bees use wax from glands in their abdomen to make them. Bees and their larvae live in the combs, and honey and pollen are stored there, as well as honey and pollen [2].

Wax Extraction Method

There is a big difference in the quality of pure beeswax that can be made by how it is made. Melting and chemical extraction are two of the most common ways to get wax out of things. Boiling water, steam, electricity, or even the sun can be used to melt wax. When producing wax on a small scale, chemical solvent extraction is only practical in the lab. When beeswax is melted and cleaned, it usually turns out to be a bright yellow colour. Once it becomes darker for any reason, such as when it becomes too hot or has a lot of metal in it, it can be illuminated by exposing it to sun or by using chemicals. Complexing agents, which make metals bind together, have also been considered, however these compounds are toxic and detrimental to the environment. After the wax has cured, store it in a cold place. It's possible to keep them in wrapping paper, on a shelf, or in a stainless steel, glass, or plastic container to keep their color and scent the same [1].

QUALITY CONTROL

Quality management of beeswax necessitates a high degree of specialized knowledge and experience. Wax comes in white and yellow, with white beeswax being described as bleached yellow wax. There are two types of wax: white and yellow. The bleached wax lacks beeswax's inherent colourants and scent. Beeswax in solid blocks should always be clean and have the proper colour and odour. While adulteration is straightforward (typically accomplished with cheap paraffin waxes), detection necessitates chemical testing [2]. Paraffins, calf tallow, stearic acid, and carnauba wax were among the adulterants found in commercial beeswax [11].

Different methods can be employed to detect wax adulteration. Pure beeswax was tested for its specific density, saponification, acid-ester ratio number, refractive index, hydrocarbons percentage, melting point, and ash content (Table 1) [12]. Sensory and physicochemical criteria calculated in conformity with the Pharmacopeia do not guarantee that the wax is not adulterated, but they may offer indications of potential adulteration in some cases. Adulteration is frequently detected today by analysing the wax's components using gas chromatography (GC) or liquid chromatography. The components of beeswax are also identified using gas chromatography coupled with spectrophotometry detection (GC–MS) [13, 9]. Some hydrocarbons and monoesters' molecular weights are affected by contaminated beeswax. For a long time, measuring physical-chemical characteristics, such as melting point and saponification number, has been recognized as a method of determining the purity of beeswax based on the standard value [14].

Table.1. Quality parameters for routine beeswax testing

Parameters	Permissible Range of Value
Melting point	61°C to 65°C
Refractive index, 75°C	1.4398 to 1.4451
Ester/Acid ratio	3.3 to 4.3
Saponification number	87 to 102
Hydrocarbons	Max. 14.5%*
Water content	<1%

THERAPEUTIC EFFECTS OF BEESWAX

When used with therapeutic pharmaceuticals or dangerous baits, beeswax aids in the preservation of the active ingredients and their gradual release without causing any harm to people or bigger animals [2]. However, its indirect effects can be rather significant, since it aids in the preservation of active compounds and their gradual release. It may be used to cover a wide range of surfaces, including human skin, with thin, non-corrosive, non-allergenic coating materials. As a result of its anti-inflammatory and antioxidant properties, it protects against rusting and scratches, along with moisture loss. This may be related to the presence of certain propolis inclusions in beeswax. When beeswax is saponified with borax, a very stable and smooth emulsion for cosmetics can be created [15].

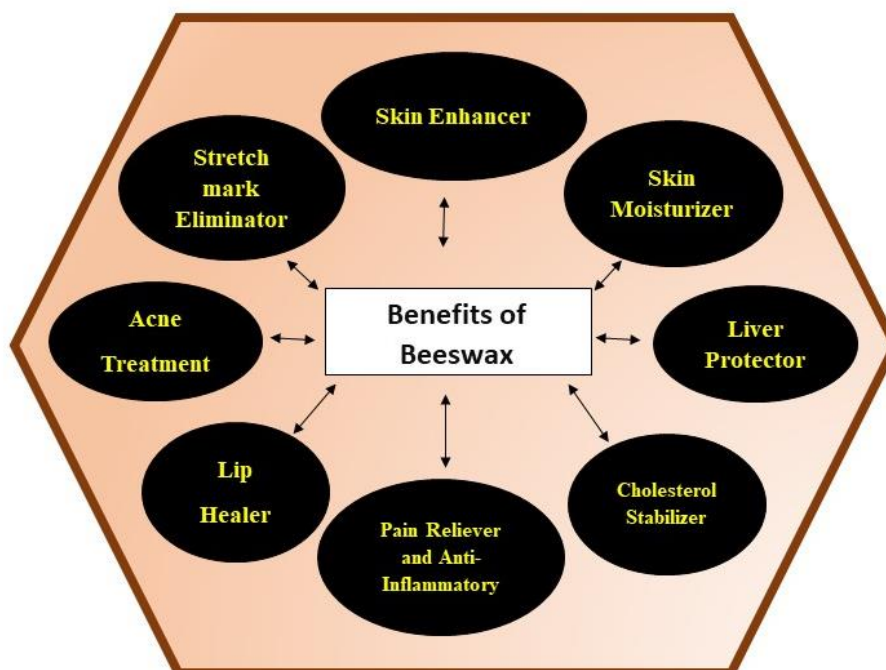


Figure 2. Benefits of Beeswax

Cosmetic and Dermatological Property

Beeswax is used to treat a range of dermatological diseases, including boils, wounds, atopic dermatitis, psoriasis, and paediatric dermatitis. Ointments based on beeswax are mentioned in the Ebers Papyrus, by the Greek-Roman physician Galen, and in historical manuscripts of traditional Chinese medicine, such as the "Shen Nong Book of Herbs" [16]. Numerous studies have demonstrated that a mixture of equal parts honey, olive oil, and beeswax is effective for the treatment of dermatitis, psoriasis, and bacteria and fungi infections of the skin [17]. Because of its minimal irritating and comedogenic properties, beeswax is frequently utilised as a thickening, emollient, and emulsifier in modern cosmetics and makeup. Beeswax protects the skin from UV rays, increases its flexibility, and does not cause allergic reactions [18]. Beeswax has long been used as an Ayurvedic treatment for inflammation, bruising, burns, and cracked heels [19]. Beeswax is used in cosmetics as a stiffener, a material that imparts flexibility and plasticity to the skin, as well as an emulsifier. Beeswax is a foundation ingredient of lipsticks, lip glosses, and lotions. Beeswax lubricates and softens the skin, as well as decreasing trans-epidermal water loss. Squalene, 10-hydroxy-trans-2-decenoic acid, and flavonoids (chrysin) included in beeswax give this product antibacterial characteristics and protect the skin from harmful microbes. Beeswax contains α -carotene, a good source of vitamin A, which slows collagen breakdown, accelerates mitotic division in the epidermis, and protects the skin from a variety of external influences by producing a film on the surface. This results in faster skin regeneration following injury [20].

Antimicrobial activity

Because of its antimicrobial properties, beeswax is being used in Asian and European traditional therapies since ancient times. Its usage in embalming and mummification methods by ancient Egyptians and Persians, perhaps to imitate ancient Romans' death masks, might be attributed to its preservative properties [21]. Antimicrobial action of natural goods, particularly hive products, is receiving attention, and unlike other bee products, beeswax has been investigated just lately [22]. Beeswax in its natural state shown antibacterial action against a variety of bacterial strains including the yeast *C. albicans*. Beeswax has been demonstrated to be specifically effective against *Brevibacterium*

alvei, *Proteus vulgaris*, *S. gallinarum*, and *B. subtilis*. Its efficiency was halved when *S. pullorum*, *S. dublin*, *E. coli*, and *Bacillus* larvae were used [23]. A combination of honey, beeswax, and olive oil when mixed in equal concentrations is effective at inhibiting the growth of *S. aureus* and *C. albicans* isolated from infected people [24]. Honey, beeswax, and olive oil were also evaluated in vivo for antifungal effectiveness against *Pityriasis versicolor*, *Tinea cruris*, *T. corporis*, and *T. faciei* [24]. A crude extract of beeswax inhibited *S. aureus*, *S. enterica*, *C. albicans*, and *Aspergillus niger* [23]. Whereas methanol and ethanol extracts inhibited pathogenic bacteria and microscopic fungus [25]. This type of impact might be due, at least in part, to plant-derived beeswax components [26]. Propolis and beeswax in combinations (1:1, v/v) have also been examined for their antibacterial efficacy against *S. aureus*, *S. epidermidis*, *B. subtilis*, and *Candida albicans* [27].

CONCLUSION

Beeswax is the substance derived from the sugars found in honey. It has a crystalline structure that is good for building hives with. Chemically, it's used in a broad range of industrial items and operations, including food preservation and packaging, candle production, and cosmetics manufacturing. It is employed in pharmaceutical preparations as a thickener, binder, drug carrier, and release retardant. For ages, beeswax has been used in traditional European and Asian therapies because of its antimicrobial characteristics. In conclusion, additional research should be done on the manufacturing, characteristics, composition, quality control, and antibacterial activity of beeswax, as well. Investigations into the antibacterial activity of the many components that distinguish beeswax produced under various climatic and geographical settings would also be interesting to consider.

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