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All the Properties of Beeswax

A scientific review - recently published in the journal Food Macromolecules – reports all the properties of the beeswax and its biochemical and analytical characteristics, focused on its nutritional, cosmetic, industrial, and pharmaceutical uses.

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Beeswax is one of the oldest natural materials used by humans, yet it is finding a new role in modern industry and sustainable technologies. Produced by honeybees, it is a complex substance made up of hundreds of organic compounds, mainly esters, hydrocarbons, fatty acids and alcohols. What makes beeswax particularly valuable is the combination of its physical properties, biological activity and environmental compatibility.

From a material point of view, beeswax is remarkably versatile. It softens at relatively low temperatures and melts at around 61–65°C, which makes it easy to shape and process. At the same time, it is stable and resistant, maintaining its structure over time. One of its most important characteristics is its strong water-repellent nature. Beeswax is highly hydrophobic and can form surfaces that strongly repel water, a property that makes it ideal for coatings and protective layers. It also acts as an effective barrier against air and moisture, helping preserve materials and products. These features explain why beeswax is used in everything from food coatings to industrial materials.

Beyond its physical properties, beeswax also has biological functions that increase its value. It shows antimicrobial, antioxidant and anti-inflammatory activity, and it can support tissue regeneration. These effects are linked to the natural compounds it contains, such as fatty alcohols and plant-derived molecules. Because of this, beeswax is not only a passive material but also an active one, capable of inhibiting bacteria and fungi and supporting healing processes. This makes it particularly useful in medical and cosmetic applications.

In terms of safety, beeswax is generally considered a low-risk material. It is approved in the European Union as a food additive, known as E901, and is widely used in products that come

into direct contact with the human body. Its long history of use in food, cosmetics and pharmaceuticals supports its safety profile. However, the article highlights that safety is closely linked to quality. Beeswax can be adulterated with cheaper substances such as paraffin or other waxes, which reduces its purity. In addition, because it is a lipophilic material, it can accumulate environmental contaminants like pesticides and other chemicals. These substances can remain in the wax over time, raising concerns about long-term exposure. For this reason, proper sourcing, purification and quality control are essential.

Beeswax is used across a wide range of industries. In the food sector, it serves as a coating and glazing agent, helping to extend the shelf life of fruits, vegetables and confectionery products. Its barrier properties reduce moisture loss and protect against spoilage. More recently, it has been used in advanced food systems such as oleogels and emulsions, as well as in edible products like biodegradable cutlery. In packaging, beeswax is becoming increasingly important as a component of edible films and coatings. These materials can act not only as barriers but also as active or intelligent packaging, interacting with food to improve preservation and even providing sensing functions.

In cosmetics, beeswax is valued for its protective and moisturizing effects. It is widely used in creams, lotions and lip products, where it helps maintain skin hydration and supports healing. Its anti-inflammatory and antimicrobial properties further enhance its role in skincare. In the pharmaceutical field, beeswax is used as a carrier for drugs and as a material for controlled release systems. It can improve the stability and delivery of active compounds, including those used in advanced treatments. The wax also contains bioactive substances that may have health benefits, such as helping to regulate cholesterol levels.

The material is also used in textiles and other industrial applications. When applied to fabrics, beeswax can improve water resistance, durability and thermal stability. These characteristics make it useful in technical textiles and protective materials. At the same time, its natural origin gives it an advantage over synthetic alternatives. One of the most important developments described in the article is the growing role of beeswax in green technology. As industries look for alternatives to petroleum-based materials, beeswax offers a renewable and biodegradable option. It is being used to produce sustainable packaging materials that can replace plastics, reducing environmental impact. In marine environments, beeswax-based materials show good biodegradability, which is particularly important in addressing pollution.

Beeswax is also being explored in new types of eco-friendly materials, including biofoams and biodegradable consumer products such as plates and straws. In construction, it can be used in natural building materials like bio-based plasters, contributing to more sustainable building practices. Another promising area is energy technology. Beeswax can function as a phase change material, meaning it can store and release heat. This makes it useful in thermal energy storage systems, including solar heating and low-cost heating devices.

At the same time, beeswax is enabling the development of advanced materials with special functions. These include self-healing coatings, highly water-repellent surfaces and smart packaging systems that can respond to environmental changes. Such applications show how a traditional natural material can play a role in high-tech innovation. Despite its advantages, beeswax also faces some challenges. Its quality can be affected by contamination and adulteration, which remain significant issues. Its relatively low melting point can limit its use in high-temperature applications, and certain physical defects can affect its appearance. In addition, its availability depends on bee populations, which are under pressure from environmental changes and human activity.

Looking to the future, the article suggests that beeswax will become increasingly important in several key areas. These include advanced food packaging, where it can help replace plastics and improve food preservation, and biomedical applications, where it can be used in wound healing and drug delivery systems. There is also growing interest in its use in sustainable construction and in the development of new functional materials with enhanced properties. At the same time, further research is needed to fully understand its environmental impact and to support large-scale use. Studies on life cycle assessment and biodegradability will be important, as will improvements in quality control and standardization.

In conclusion, beeswax is moving beyond its traditional uses and becoming a material of strategic importance in modern industry. Its combination of functionality, safety and sustainability makes it a strong candidate for future applications, especially in the transition toward greener technologies.

Reference: (Naveen and Loganathan 2026) - Beeswax: Food and beyond - Food Macromolecules