

# Exploitation of bee honey health-related properties in human nutrition

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Review article

## Abstract

The application of bee honey in human nutrition is among the earliest branches of medicine. Bee honey constitutes a natural source of ingredients that exhibit beneficial effects on the human body. Owing to its high content of components supporting human health, honey is considered a 'cure-all'. Pure honey exerts a particularly strong therapeutic influence. Honey is produced by bees from flower nectar or honeydew. Floral or nectar honeys are named after the particular plants; examples include rapeseed honey. A particular type is honeydew honey, obtained from the so-called honeydew, i.e. plant secretions produced in sites damaged by aphids. The main ingredients of honey are carbohydrates, i.e. glucose (30%–39%) and fructose (33%–43%), and active substances, which include enzymes, predominantly coming from the secretions of bee throat and salivary glands. Honeys popular in Poland: rapeseed honey, linden honey, buckwheat honey, acacia honey, heather honey, multifloral honey. The health-related properties of honey are significant in medicine: honey consumption helps counteract pathogenic microorganisms that attack the human body. The aim of this article is to present the most significant health-related properties of bee honey exploited in human nutrition.

## Keywords

- honey
- well-being
- diet
- nutrition

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## Introduction

The beneficial properties of honey have been known for centuries. Honey is a food product of natural origin that has demonstrated its dietary applications for thousands of years. It has already been found in pharaohs' tombs. Honey gained popularity in ancient civilizations, more specifically in Egypt, where it was put in the tombs of pharaohs and sacrificed to gods, in Babylonia, as well as in Israel and Greece.<sup>1,2</sup> Hippocrates (born ca. 460 BC) recommended the use of honey and incorporated it into his recipes. The Roman physician Claudius Galenus (131–201), who introduced bee honey, alongside other medicines, into medicinal practice, is considered to be the founder of apitherapy. During the Middle Ages, the properties of honey became increasingly valuable, as the Slavic peoples exploited it to prepare a variety of recipes intended to help people with ailments.<sup>3</sup> Jan Kochanowski, a Polish poet of the Renaissance, in his poem entitled *The Linden Tree*, being a praise of the beauty of nature, wrote: 'here the hard-working bees extract from my sweet-smelling flower / honey that graces the finest of tables at family hour' (as translated by William Auld).<sup>4</sup>

Natural honeys produced by bees are still utilized in human nutrition. For long millennia, honey was the only source of sweet taste, but it also had other applications, constituting, among others, a valuable remedy for medical conditions. Its nutritional qualities were appreciated by athletes, who believed that 'honey relieves anger and repels bad moods'.<sup>3</sup> In vitro and in silico studies have demonstrated the efficacy of honey and its bioactive components in inactivating the SARS-CoV-2 virus.<sup>5</sup>

The aim of this article is to present the most significant health-related properties of bee honey exploited in human nutrition.

## The composition of natural honey

Honey is produced by bees from flower nectar or honeydew. The insects transform the collected flower nectar or other plant saps by enzymatic processes and deposit the product in honeycombs, in which the honey matures.<sup>6</sup> Floral or nectar honeys are named after the particular plants; examples include rapeseed honey, linden honey, buckwheat honey, acacia honey, heather honey, and multifloral honey. Depending on their origin, honeys can vary in colour, aroma, taste, or consistency. A particular type is honeydew honey, obtained

from the so-called honeydew, i.e. plant secretions produced in sites damaged by aphids.

The origin of honey may be indicated, in addition to pollen analysis, by the quantitative content of sugars.<sup>7</sup> The main ingredients of honey are carbohydrates, i.e. glucose (30%–39%) and fructose (33%–43%), and active substances, which include enzymes, predominantly coming from the secretions of bee throat and salivary glands. Among the enzymes, there are invertase,  $\alpha$ - and  $\beta$ -amylase, glucose oxidase, catalase, and phosphatases. The most crucial enzyme in honey is  $\beta$ -fructofuranosidase, formerly known as invertase or saccharase, which accelerates the breakdown of sucrose into the simple sugars of glucose and fructose.<sup>8</sup> Amylases hydrolyse starch into simpler substances:  $\alpha$ -amylase breaks down starch into polysaccharides, while  $\beta$ -amylase breaks down polysaccharides into disaccharides, mainly maltose. Maltose, in turn, is hydrolysed to glucose under the influence of the enzyme maltase.<sup>9</sup> Glucose oxidase contributes to the antibacterial properties of honey. It induces the oxidation of glucose to gluconolactone, which, when combined with water, forms gluconic acid. This results in the formation of a small amount of hydrogen peroxide ( $H_2O_2$ ),<sup>9</sup> exhibiting a strong antibacterial effect.<sup>8</sup> Catalase, a nectar-derived enzyme, is called a haemoproteid because it catalyses the breakdown of hydrogen peroxide that is produced in living cells.<sup>8</sup> Phosphatases, in turn, accelerate the intermediate transformations of phosphoric acid esters with glycerol, sugars, and proteins. Phosphatase activity is especially strong in dark honeys, such as heather honey or buckwheat honey.<sup>8</sup>

Among the important components of honey are substances with bacteriostatic properties, as well as minor amounts of minerals and B vitamins.<sup>6</sup> The mineral compounds present in honey are determined with the help of ash produced by combustion of honey samples. These compounds are mainly derived from the primary components, namely nectar and honeydew. According to the *Encyclopaedia of Beekeeping*, 1 kg of light honey contains 245–1034 mg (an average of 470 mg) of mineral compounds, while 1 kg of dark honey provides 287–6054 mg (an average of 2160 mg) of these compounds.<sup>10</sup> Potassium oxide (ca. 50%) and phosphorus oxide (ca. 20%) are the predominant oxides included in honey ashes. The remaining ones are calcium and sodium oxides. Particularly in dark honeys, certain amounts of iron and manganese compounds are present.<sup>10</sup> The spectral analysis method allowed 0000-0001-5420-4779 to identify small amounts of trace elements, such as aluminium, barium, boron, cadmium, chromium, cobalt, iodine, lead, lithium, molybdenum, nickel, silicon, silver, titanium, or vanadium.<sup>9</sup>

Honey also contains minor quantities of vitamins. Their proportion depends on the content of pollen and royal jelly. Worth mentioning are especially B vitamins, including B1 (thiamine), B2 (riboflavin), B5 (pantothenic acid), B6 (pyridoxine), B9 (folate; 0.03–0.63 µg per 1 g of honey on average), and B12, vitamin PP, as well as vitamin H (biotin). Also, vitamin C (ca. 22 µg/g) is present in honey; buckwheat honey is particularly rich in it. There are also trace amounts of fat-soluble vitamins, i.e. provitamin A (carotene) and vitamin D, E, and K.<sup>9</sup>

In addition to carbohydrates, the taste of honey is influenced by organic acids. Depending on the type of honey, these acids differentiate its qualities. The following acids have been identified as honey components: acetic acid, butyric acid, citric acid, formic acid, gluconic acid, lactic acid, malic acid, pyroglutamic acid, and succinic acid. Citric acid and gluconic acid are recognized as the main acids of honey.<sup>11</sup>

The amount of proteins in honey is negligible (ca. 0.35%). These are mainly simple proteins: albumins and globulins.<sup>10</sup> Honey also contains amino acids. Nectar honeys provide 100–250 mg of amino acids per 100 g, while honeydew honeys include 54–269 mg of amino acids per 100 g.<sup>7</sup> The amino acids most commonly found in honey are the following: α-alanine, arginine, asparagine, aspartic acid, glutamic acid, glutamine, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, proline, serine, tyrosine, and valine. The predominant amino acid is proline, which accounts for ca. 49% of the total amino acid content in nectar honeys and for 59% in honeydew honeys. Another amino acid occurring in large amounts in honey is phenylalanine. Its content equals 32% in nectar honeys and 6% in honeydew honeys.<sup>7</sup>

One should bear in mind the proper conditions for storing honey. Honey is characterized by a very long shelf life (2 years). It should be stored in a dark place (out of direct sunlight), at a temperature of 8–12°C; at temperatures exceeding 20°C, adverse changes occur in honey, e.g. the colour becomes dark, the saccharide composition alters, and the enzymatic activity decreases.<sup>12</sup>

## Honeys popular in Poland

### Rapeseed honey

Rapeseed honey is among the most common honeys in Poland. It is straw-coloured when liquid and pale yellow when crystallized. It is a spring honey, obtained in the period of rapeseed flowering, which occurs at the turn of April and May. Rapeseed honey is recommended for

cardiovascular diseases (owing to its antiatherosclerotic effect and lowering of blood pressure), liver diseases, and inflammation of the upper respiratory tract.

### Linden honey

It is now considered the most valuable of nectar honeys. Linden honey is golden yellow or greenish yellow in its liquid form and turns creamy or yellowish orange when crystallized. Linden honey is available in July. It exerts a strong antibiotic, diaphoretic, antitussive, expectorant, and antispasmodic effect.

### Buckwheat honey

Buckwheat honey is distinguished by its dark brown colour and specific flavour. It has a beneficial influence on the cardiovascular system because of rutin, which helps prevent atherosclerosis. Buckwheat honey contains rutin in the highest amount of all honeys. This honey also provides large quantities of magnesium, which supports the nervous system.

### Acacia honey

It is a light-coloured honey. It contains a high proportion of fructose and hence crystallizes very slowly. Acacia honey is characterized by a very delicate, barely perceptible sweet taste and aroma. It is particularly recommended against urinary tract diseases, digestive disorders, and cardiovascular system conditions.

### Heather honey

This is the most expensive Polish honey. Heather honeys are very dense, ruby and brown in colour. They crystallize quickly, taking on a slightly orange shade. The inhubin contained in heather honey exhibits antiseptic properties. This honey contains more than 40 elements, including calcium, potassium, chlorine, phosphorus or magnesium. It is recommended for men as a preventive measure for urogenital problems.

### Multifloral honey

This honey comes from nectar collected by bees from various plants. It is light cream in colour; it crystallizes quickly, turning light grey or light brown. Owing

to its mineral and bioelement content, it counteracts tooth decay. It exerts positive effects in cardiovascular diseases, especially atherosclerosis. Multifloral honey serves as a valuable source of energy, as well as participates in liver detoxification and supports gallbladder function.

## Health-related properties of honey

The health-related properties of honey are significant in medicine: honey consumption helps counteract pathogenic microorganisms that attack the human body, especially Gram-positive bacteria, such as *Staphylococci* (mainly *Staphylococcus aureus*) or *Streptococci* (e.g. *Streptococcus pneumoniae*), as well as Gram-negative bacilli, i.e. *Enterobacteriaceae* (e.g. *Escherichia coli*) or the so-called non-fermenting bacilli (e.g. *Pseudomonas aeruginosa*).<sup>9</sup> The main antimicrobial agent in domestic honeys is hydrogen peroxide, which is formed through the activity of glucose oxidase.<sup>13</sup> In an in vitro study conducted in 1977, hydrogen peroxide was shown to strongly inactivate human coronavirus 229E, as well as influenza virus A and B.<sup>14</sup> The compound damages the viral envelope. In macaques, SARS-CoV-2 virus has been shown to persist for 2 days on mucous membranes and only afterwards enter the lower respiratory tract; this may be an important factor in favour of applying hydrogen peroxide to block viral infection.<sup>15</sup> The various honey types differ in their antibacterial activity, which is highest for buckwheat honey, linden honey, honeydew honey, heather honey, and multifloral honey. In contrast, nectar honeys, such as rapeseed honey or acacia honey, demonstrate limited antibacterial activity.<sup>7</sup>

Honey is often used to treat the initial stages of a cold; it contributes to higher immunity of the body and protects the respiratory tract from further disease development.<sup>16</sup> Thyme honey, salvia honey, or honeydew honeys are particularly recommended for treating the upper respiratory tract, whereas linden honey, clover honey, lavender honey, or honeydew honey from coniferous honeydew – for lower respiratory tract management.<sup>2</sup> Moreover, honey exhibits anti-allergic properties, which makes it suitable in the treatment of bronchial asthma and pollinosis, including hay fever.<sup>17</sup> The anti-inflammatory effects of honey also help in the therapy of oral mucositis, sinusitis, or periodontitis. In these cases, it is recommended to suck crystallized honey or chew a honeycomb several times a day. In periodontitis, rubbing crystallized

buckwheat honey or honeydew honey into the gums turns out effective.<sup>9</sup>

Honey is also applied to treat diseases of the digestive system, such as gastritis, gastric ulcers, or duodenal ulcers. During the therapy, pain is reduced, heartburn and nausea disappear, gastric acid secretion increases, the patients' mood improves, and appetite returns.<sup>2</sup> In the case of gastric or duodenal ulcers, honey accelerates the regenerative processes within the tissues affected by ulcers and, by increasing the production of mucus, protects the mucous membrane from the harmful influence of gastric acid. Honey is also employed in treating inflammation of the small intestine or large intestine prone to diarrhoea.<sup>9</sup> Oligosaccharides stimulate the growth of lactic bacilli (mainly of the *Lactobacillus* and *Bifidobacterium genera*), which are present in the large intestine. An increase in their population and fermentation activity protects the digestive system from infection by pathogenic bacteria.<sup>18</sup> The use of honey solutions for gastrointestinal diseases can considerably reduce the harmful effects of bacterial toxins on intestinal epithelial cells.<sup>19</sup> Honey improves intestinal peristalsis, exerting a laxative effect, which is exploited in chronic constipation management. In these cases, acacia honey, sweet clover honey, taraxacum honey, or thyme honey are especially recommended.<sup>2</sup>

Honey largely consists of simple sugars and is easily absorbed by the liver. In addition, honey contains choline, which regulates cholesterol concentrations and lowers lipid levels in the liver.<sup>9</sup> In the case of jaundice, honey consumption leads to an increase in bile flow, faster emptying of the gallbladder, and a reduction in bilirubin levels.<sup>2</sup> For liver and biliary tract disorders, best effects are brought about with mint honey, sunflower honey, taraxacum honey, rapeseed honey, raspberry honey, or multifloral honey.<sup>2</sup> Honey also stimulates the synthesis of many compounds and enzymes, vitamin A, prothrombin, and fibrinogen.<sup>9</sup>

Regular consumption of honey favourably affects the heart and circulatory system by inhibiting atherosclerotic lesions, dilating coronary vessels, and regulating blood pressure. The acetylcholine and potassium present in honey positively influence the regulation of heart function by enhancing the contraction strength and heart muscle performance.<sup>17</sup> Linden honey and sweet clover honey contribute to blood pressure reduction, and buckwheat honey is particularly recommended in atherosclerosis.<sup>9</sup>

Bee honey is also used to treat urinary tract disorders.<sup>2</sup> Owing to the small amount of protein, as well as sodium and chlorine ions, honey has a positive effect on the kidneys and urinary tract.<sup>20</sup> Honey is also recommended to prevent kidney stone formation.

The most significant role is played here by nectar honeys with small amounts of amino acids and bioelements, e.g. acacia honey, linden honey, taraxacum honey, or multifloral honey.<sup>9</sup>

Thanks to its calming properties, honey facilitates falling asleep, affects the quality of sleep, and helps with insomnia. Neurosis treatment is supported by the consumption of sweet clover honey, lavender honey, lemon balm honey, or linden honey.<sup>2</sup> Honey increases the production of endorphins and thus alleviates depression symptoms.<sup>9</sup>

## Conclusions

Bee honey is exploited in human nutrition for its health-related properties. It turns out helpful in preventing a variety of illnesses and in treating chronic diseases. Honeys are recommended in digestive, respiratory, urinary, or nervous system conditions. The consumption of bee honey is safe.

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