

A COMPREHENSIVE REVIEW ON APICULTURE AND HONEY RESEARCH, HONEY FRAUD, HONEY PHARMACOPEIA AND FDA-APPROVED HONEY PRODUCTS, CLINICAL EFFICACY OF HONEY PHARMACEUTICAL PRODUCTS, HONEY CONTAMINATION WITH CONSUMER HEALTH RISKS WITH ONE HEALTH PERSPECTIVE

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ABSTRACT

Background: Honey is a divine gift from Allah, described in the Quran as a source of healing for mankind, and Allah urges people to think (do research) about honey. Scientists have found that honey is an insect-derived natural sweetener rich in antioxidants, antimicrobials, and essential nutrients that support immune function, offer therapeutic benefits and promote healing, and have cosmetic and industrial value. But adulteration and fake honey production by dishonest people (a clear sin/haram) have severely damaged the global honey industry by undercutting honest beekeepers, misleading consumers, threatening pollinator populations, and depriving people of Allah's divine gift.

Objectives: This review describes apiculture and honey research from ancient to modern times; honey fraud, pharmacopeia and FDA-approved honey products, clinical efficacy of honey pharmaceuticals, and honey contamination with consumer health risks with a 'One Health' perspective

Materials and Methods: A narrative review of Google Scholar, PubMed, and other databases identified 580 relevant research reports on different aspects of honey to meet the objectives of this review. In addition, seven sources of honey, four from different Facebook vendors and three from supermarkets, were examined to detect adulteration and contamination in Bangladesh.

Results: Honey is Allah's gift to mankind, but this review shows that finding authentic honey in supermarkets globally is increasingly difficult because of complex global supply-chain blending and widespread economic adulteration with cheap sugar syrups. Reports show that 46% of imported honey and 96% of supermarket honeys in the UK, up to 70% in the US, 75 to 86.5% in the Philippines, up to 75% of Chinese honey, 93% in Turkey, and 77% of Indian honeys are adulterated. Global honey exports have increased by 67%, while honey production has increased by only 15%, indicating that the world is selling more honey than bees can produce. Reviews also show that all nine popular imported honey brands and seven locally produced honeys available in the Bangladeshi market are adulterated. Fake and adulterated honey poses significant metabolic syndrome, organ damage, systemic health risks, potential carcinogenic effects, and allergic reactions, often worsening conditions like Type II diabetes and obesity. Medical-grade honey (MGH) has shown strong antibacterial activity against both MDR (multidrug-resistant) and non-MDR bacteria, is effective against biofilm formation, and is also effective in diabetic patients with infected foot ulcers. This review compares the clinical efficacy of pharmaceutical honey products, including their indications, uses, and efficacy. This review examines research on apiculture and honey research, including honeybee diseases and human health risks. Reported risks include infant botulism (*Cl. botulinum* spores), gastroenteritis (*Bacillus cereus*, *Cl. perfringens*, *Salmonella* spp., *Shigella* spp., *Staphylococcus aureus*), yeast and mold infections, and antibiotic-resistant bacterial problems. The interaction between honey contaminants, wound healing, and the 'One Health' framework centers on managing chronic or infected wounds by recognizing the deep links between human medicine, veterinary care, and environmental factors. This collaborative approach is vital to stop the spread of dangerous pathogens and combat drug resistance.

Conclusion: This review suggests that there is no guarantee of getting authentic honey from local or imported sources on the global market, including Bangladesh. The only way to guarantee authentic honey from a local producer is to see it coming out of the hive (but not bee sugar syrup feeding honey), or to produce our own honey ourselves. These indicate that Allah's gift of pure honey has healing properties, and original Islam is viewed as the complete and final guidance sent by Allah for humanity, but both have lost their originality or been modified to an unacceptable status. However, MGH's especially authentic manuka honey-based formulations are FDA-approved, and their clinical efficacy supports the Quranic verses in which Allah says honey has healing properties. Modern laboratory tests needed to detect sophisticated honey adulterants are not currently available for routine testing. A 'One Health' approach to honey fraud control integrates human health, animal (bee) health, and environmental stewardship with systemic governance to protect product integrity.

Keywords: Apiculture and honey research, Honey fraud, Pharmacopeia, Pharmaceuticals, FDA-approved products, Clinical efficacy, Honey contamination, Consumer health risks, 'One Health'

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INTRODUCTION

The United States Food and Drug Administration (FDA) recognizes that the term ‘honey’ commonly refers to the thick, sweet, syrupy substance that bees make from plant nectar or secretions and store in honeycomb.¹ Honey flavor and color are determined by the flowers from which the nectar is gathered. More than 20,000 species of bees on Earth produce honey, with domesticated honeybees (*Apis mellifera*) as the primary commercial source.² An 8,000-year-old cave painting³ in Spain depicts honey harvesting, and we know cultures worldwide have used it for food, medicine, and more since then. Honeybees visit millions of blossoms in their lifetimes, pollinating plants and collecting nectar to bring back to the hive. Bees make more honey than their colony needs, and beekeepers remove the excess and bottle it, as they have since time immemorial.⁴ Honey is a complex food made up of two simple sugars, glucose and fructose, but it also contains hundreds of organic compounds that make it not only delicious but also beneficial for health. People worldwide have praised honey's health benefits for thousands of years. Medical-grade honey (MGH) has been used in herbal medicine for many diseases, including blindness, throat infections, asthma, tuberculosis, hiccups, thirst, dizziness, fatigue, constipation, hepatitis, worm infestation, eczema, piles, and the healing of ulcers and sores.⁵ The Qur'an also mentions the benefits of pure honey, but some greedy people manufacture fake honey and adulterate pure honey for sale in the market for human consumption to gain economic benefit. Pure (raw) honey is a natural, unaltered, unheated, and unfiltered sweet substance produced exclusively by honeybees from floral nectar, which retains natural pollens, enzymes, amino acids, and antioxidants. Fake honey is an imitation made from flavored sugar syrups (such as beet or cane sugar), artificial food colorings, and synthetic flavors to mimic the look and taste of natural honey. Adulterated honey is genuine honey diluted with cheap bulk additives such as high-fructose corn syrup (HFCS), molasses, rice syrup, beet sugar, or water to increase volume and profit. Honey can be contaminated at various stages, from environmental exposure and agricultural practices to beekeeping and processing. Common contaminants include environmental pollutants, veterinary drugs, microbes and spores, and artificial adulterants. Studies suggest that economically motivated honey adulteration has been reported at 13% in Canada⁶ and 14% in the European Union.⁷ More recently, European authorities estimate that up to 46% of commercially sold honey is adulterated or fake.⁸ More than 70% of the honey consumed in the US is imported,⁹ and of the 144 imported samples collected from 32 countries and tested, the FDA found 14 (10%) to be violative and made an import alert.¹⁰ A 2020 Center for Science and Environment (CSE) investigation found that 77% of Indian honey has been reported as fake.¹¹ Honey adulteration, in both local Bangladeshi production and imported foreign brands, remains a major food safety challenge in Bangladesh. However, studies estimate that 70 to 90% of processed foods in Bangladesh, including market honeys, contain artificial sweeteners.¹² Recent studies on Bangladeshi commercial honey show widespread ‘micro-adulteration’ with cheap sweeteners.^{13,14} Sundarbans honey is being registered as a geographical indication product of Bangladesh, but its high market value and limited supply make it a prime target for fraud, with scammers mislabeling mass-produced or sugar-syrup-adulterated honey to capitalize on the region's premium reputation.¹⁵ However, adulterated and fake honeys are recognized sources of microbial contamination, but their health risk assessment, especially from a ‘One Health’ perspective, is very limited in the literature.¹⁶⁻¹⁹ Medical-grade honey (MGH) as a pharmaceutical product has been used widely in clinical practice, but efficacy results vary in the literature.^{20,21} No reports assess the Qur'anic indication of honey's healing properties through scientific research, and adulteration and fake honey are associated with health risks for consumers. Considering these facts, this review paper describes the current status of pure, adulterated, and fake honey, and their effects on health; research from ancient times to the latest on advancements in apiculture and honey, microbial contamination of honey from a ‘One Health’ perspective, and Hadith and Qur'anic assessment of honey frauds with comparison of different division sects in Muslims.

MATERIALS AND METHODS

The findings presented in this article were obtained through literature analysis, mainly Google Scholar, PubMed, and others) using the different keywords mentioned in the different titles of this article. A total of 580 related articles, including research reports, review papers, organizational reports, and expert papers online, have been reviewed to prepare this article. In Bangladesh, Facebook has become a major platform for both selling honey and exposing honey-related fraud. Adulteration, often called ‘Honey Laundering,’ involves diluting pure honey with inexpensive syrups made from corn, rice, or beet sugar, and marketing the products as pure and raw honey. Given these facts, we purchased and evaluated the following eight commercially marketed honeys available in the local market and on Facebook.

- Nectar Drops (Sundarbans Honey)
- Saffola Active Plus (Marico BD Ltd.)
- Kalo-Jera Honey (Nahal Multi-products)
- Pure Honey of Sundarbans (Takwa Shop)
- Aussie Bee Organic Honey (Australia)
- Dabur (Dabur Pvt Ltd., India)
- Kalo-Jera Honey (Amanot Foods)
- ACI Pure Honey (Multifloral)

Vendors in Bangladesh often use various methods to adulterate or create fake honey.

- Syrup dilution:** Mixing honey with low-cost commercial syrups such as corn syrup, glucose syrup, or cane sugar syrup.
- Artificial colorants:** Using caramel color to mimic the appearance of specific botanical honey types like wild or blackseed honey.
- Overfeeding bees:** Unethically providing sugar syrup directly to bees so they produce honey from sugar rather than nectar.
- Inert fillers:** In some cases, adding water or molasses to increase weight and volume.

Detection of fake, adulterated, or contaminated honey relies on physical, chemical, and biological methods. The most reliable approaches today include advanced spectroscopy, chromatography, and immunoassays, which are increasingly applied in Bangladesh and globally to ensure consumer safety.

① Physical methods

- Visual inspection: Crystallization patterns, color, and viscosity.
- Refractometer test: Measures refractive index to detect dilution.
- Particle count analysis: Identifies pollen absence (suggesting adulteration).

② Chemical methods

- High-performance liquid chromatography (HPLC): Detects sugar profiles and foreign syrups.
- Gas chromatography- Mass spectrometry (GC-MS): Identifies volatile compounds and contaminants.
- Atomic emission spectroscopy (AES): Measures trace elements and heavy metals.

③ Biological methods

- Microbiological analysis: Detect bacterial or fungal contamination by using culture methods.
- Enzyme-linked immunosorbent assay (ELISA): Identifies specific adulterants or pathogens.
- DNA barcoding: Confirms floral origin and authenticity.

④ Advanced techniques

- Spectroscopy (FTIR, NMR, Raman): Rapid fingerprinting of adulterated honey.
- Chemometrics and AI models: Pattern recognition for subtle adulteration.
- Stable isotope ratio analysis (IRMS): Differentiates C₃ vs. C₄ plant sugars (e.g., rice syrup vs. cane sugar).

Detection of adulteration of honey at home

Home and laboratory tests detect honey adulteration. A few simple testing methods can easily detect common honey adulteration, such as added sugar, molasses, or water, at home. Home tests are simple, and individual tests may not be accurate, but together they provide a good indication.²² The most effective and common home tests that can be performed in Bangladesh include

① **Smell (The Aroma Test):** Raw, pure honey contains complex volatile compounds from flower nectar. Pure honey will have a distinct floral, herbal, or earthy aroma, depending on the flowers the bees visited. Adulterated honey- or corn syrup-based flakes will either have no scent at all or smell strongly of industry, sourness, or raw sugar. No aroma or an overly pungent smell = Adulterated honey.

② **Taste:** Pure honey has a complex, floral taste and a lingering taste that does not coat the throat; it can cause a distinct mild tingling or burning sensation in the back of the throat when swollen, natural sweetness that disappears quickly, whereas adulterated honey has an intensely sweet taste that resembles standard sugar or corn syrup, lacks any rich depth or throat-catching sensation, and leaves a sugary aftertaste for a long time.

③ Water dissolution test

- Fill a clear glass with room-temperature water.
- Gently add a spoonful of honey to the water.
- Observe without stirring.
- Pure honey will clump together and slowly sink to the bottom (Photo 1A)
- Adulterated honey will start dissolving immediately, creating cloudy streaks or dispersing quickly (Photo 1B).

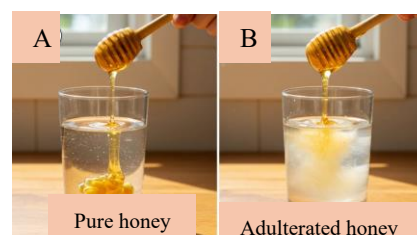


Photo 1. Water dissolution test of honey

④ Thumb/Drop test

- Place a drop of honey on a clean and dry thumb, holding the hand horizontally.
- Pure honey is viscous and sticky, so it shouldn't spread quickly (Photo 2A), whereas adulterated honey (with added water/sugars) is runnier and will flow (Photo 2B).
- Nahal is using this method in online advertisements, just placing a drop of honey on the palate of the hand or two separate drops of two different Kalo Jira honey on a white plate that can't be differentiated by its stickiness.

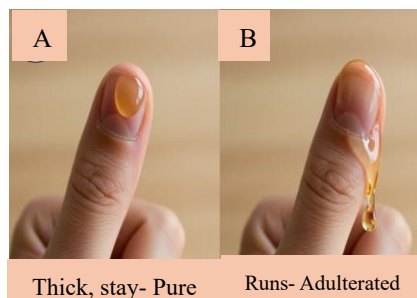


Photo 2. Thumb/drop test of honey

⑤ Flame test

Dip a dry matchstick or cotton bud into honey, then try to light it. Pure honey has a very low moisture content; it is flammable, which means the match can ignite and burn steadily, whereas if the match won't light, it indicates honey contains added water or liquid adulterants (Photo 3)



Photo 3. Flame test of honey



Photo 4. Heat test of honey

⑥ Heat test of honey

- Put a teaspoonful of honey into a metal spoon or a small pan and heat over low heat.
- Pure honey will caramelize and release a pleasant, natural caramel-like aroma, but it will not foam or bubble excessively, whereas adulterated honey produces vigorous bubbles or froth, or burns quickly due to added moisture or artificial sweeteners (Photo 4).
- When the Nectar Drop (Sundarbans Honey) purchased online was found watery and heated in a small pan, it produced excessive bubbles, like boiling milk.

⑦ Method for the quicklime and honey test

- Place a small, equal amount of honey sample into a clean, dry bowl, and mix in a small amount of powdered quicklime (calcium oxide)
- The primary reaction occurs between the quicklime (CaO) and the water (H₂O) naturally present in the honey in an exothermic combination reaction to form calcium hydroxide (Ca (OH)₂), also known as slaked lime: $\text{CaO(s)} + \text{H}_2\text{O(l)} \rightarrow \text{Ca (OH)}_2 + \text{Heat energy}$
- **Pure honey:** The mixture should stay relatively inactive or form a solid mass, as pure honey has very low moisture and is naturally acidic.
- **Adulterated honey:** If the mixture fizzes, bubbles, or shows a significant chemical reaction, it indicates added water, sugar syrup, or alkaline impurities.
- **Interpretation:** If the mixture produces a significant reaction, the honey is likely not pure.

⑧ Vinegar (Acid) test

- The vinegar (or acid) test is a popular kitchen method for checking whether honey has been adulterated with chalk powder or other alkaline substances.



Photo 5. Vinegar (acid) test of honey

- Mix 2 tablespoons of honey with ¼ cup of water; add 2-3 drops of white vinegar. If the mixture foams or fizzes, it could indicate adulteration.
- Pure honey is naturally slightly acidic (pH 3.9- 6.5), so it usually won't react vigorously with another acid like vinegar. If chalk (calcium carbonate) or other alkaline contaminants have been added to the honey to increase its weight or volume, they will react with the vinegar to create a fizzy foam reaction (Photo 5).

⑨ Pure honey crystallized faster



Photo 6. Crystallization of pure honey

- Crystallization is a natural, spontaneous process where honey turns from a liquid into a thick, grainy solid.
 - It happens because honey is a supersaturated sugar solution. It contains more sugar than water can hold.
 - This does not mean the honey has gone bad, spoiled, or is fake; rather, it is a key indicator of pure, raw, and high-quality honey.
 - Honey is made up of two primary sugars: glucose and fructose. Glucose is less soluble in water and tends to separate and solidify, while fructose stays liquid. Honey with higher glucose levels crystallizes much faster (Photo 6).
- Pure, unfiltered honey contains microscopic particles like pollen, beeswax, and propolis. These tiny

particles act as seeds (nuclear sites) to which sugar crystals cling, causing them to multiply.

- Honey crystallizes faster in cool environments, typically between 10 °C and 15 °C (50 °F to 59 °F).
- Minimal processing keeps real honey’s natural components intact, while fake honey is often heavily processed to prevent crystallization.

Modern methods

Modern methods are required to detect honey adulteration, as traditional techniques are no longer effective against increasingly sophisticated, engineered, and ‘tailor-made’ sugar syrups designed to mimic the profile of genuine honey. These advanced techniques, such as spectroscopy and DNA-based testing, are necessary to identify low-level adulteration and distinguish between C₃ and C₄ plant sugars.²³

- Fraudsters now use sophisticated syrups, tailor-made from rice, wheat, or sugar beet, designed to bypass traditional analytical methods, such as stable carbon isotope ratio analysis (SCIRA).
- Advanced spectroscopy, chromatography, and isotope analysis are increasingly used to detect fraud.²⁴
- Complex adulteration: Modern adulteration often involves ‘indirect’ methods, such as feeding bees sugar syrup, which produces honey that closely matches the chemical profile of pure honey.

RESULTS AND DISCUSSION

There are four main types of honey, which include (a) blossom honey (source: nectar of flowers), (b) honeydew honey (source: ‘honeydew’ *Rhynchoa* genus insects pierce plant cells, ingest plant sap, and then secrete it again) collected by bees, (c) moonflower (source: single botanical flower), and (d) multifloral (poly-floral) honey (source: several botanical flowers).

Immature and mature honeys

Mature honey is fully processed by bees, capped with beeswax, and has low moisture (<20%). Immature (unripe) honey is harvested before bee’s complete natural dehydration, sealing it in the comb and leaving it with high moisture content (>20%), making it prone to fermentation. Unlike immature honey, mature honey is thicker, richer in beneficial enzymes and antioxidants, and naturally crystallizes (Table 1)

① Water content and spoilage

- Mature honey: Moisture content is usually below 18%, and this dense, low-moisture environment prevents the growth of yeasts and bacteria, giving it an indefinite shelf life.
- Immature honey: Moisture can range anywhere from 21% to over 30%. Because it is essentially diluted, it is highly prone to natural fermentation and spoilage unless it is artificially dehydrated.

Table 1. Differences between immature and mature honeys		
SN Feature	Immature honey	Mature honey
① Moisture content	Higher (often >20% up to 30%)	Lower (standard is <18 to 20%)
② Beeswax capping	Open/uncapped cells	Sealed/capped cells
③ Stability and storage	Prone to rapid fermentation	Highly stable; long shelf life
④ Sugar composition	Higher sucrose, lower antioxidant	Higher fructose, lower sucrose
⑤ Bioactive quality	Fewer amino acids, lower antioxidant count	Rich in polyphenols and vital enzymes

② Sugar composition

- Mature honey: Bees break down the complex sugars from nectar (like sucrose) through continuous regurgitation and enzymatic addition, resulting in higher and more stable levels of simple sugars like fructose and glucose.
- Immature honey: Processing time is cut short, meaning the conversion of nectar is incomplete. It contains higher levels of complex sugars (sucrose) and lower overall sugar concentration.

③ Biological and medicinal values

- Mature honey:** The extended time in the hive allows for a rich accumulation of polyphenols, enzymes (like diastase and invertase), and proteins, giving it highly effective antibacterial and antioxidant properties.
- Immature honey:** Because it lacks the same level of enzymatic breakdown and nutrient density, its antioxidant and antibacterial effects are significantly weaker.

④ Taste, texture, and crystallization

- Mature honey:** Richer in floral aromas, denser in texture, and will naturally crystallize over time in cooler temperatures.
- Immature honey:** Tends to taste much like raw nectar, has a thinner/watery consistency, and may not crystallize.

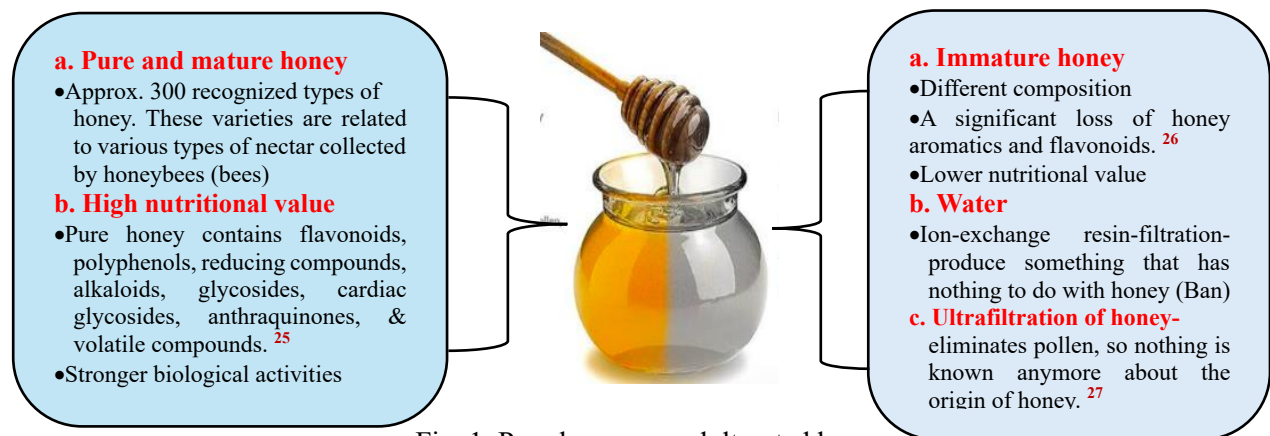


Fig. 1. Pure honey vs. adulterated honey

Nutritional value of honey

Pure honey contains water, carbohydrates, flavoring, vitamins, minerals, enzymes, and antioxidants (Table 2,3).¹⁸

Table 2. Nutritional composition of pure honey (g/100 g honey)			Table 3. Chemical constituents in pure honey			
SN Constituents	Blossom honey	Honeydew honey	SN Minerals	Amount (mg/100g)	SN Vitamins	Amount (mg/ 100g)
01. Water	15-20	-	01. Sodium (Na)	1.6-17	01. Thiamine (B ₁)	0.00-0.01
02. Fructose	30-45	28-40	02. Calcium (Ca)	3.0-31	02. Riboflavin (B ₂)	0.010-0.02
03. Glucose	24-40	19-32	03. Potassium (K)	40-3500	03. Niacin (B ₃)	0.10-0.20
04. Sucrose	0.1-4.8	01-4.7	04. Magnesium (Mg)	0.7-13	04. Pantothenic acid (B ₅)	0.02-0.11
05. Others	2.0-8.0	1.0-6.0	05. Phosphorus (P)	2.0-15	05. Pyridoxine (B ₆)	0.01-0.32
06. Erlose	0.5-6.0	0.1-6.0	06. Selenium (Se)	0.002-0.01	06. Folic acid (B ₉)	0.002-0.01
07. Melezitose	NA	0.3-22	07. Copper (Cu)	0.02-2.0	07. Ascorbic acid (C)	2.2-2.5
08. Others	0.5-1.0	0.1-6.0	08. Iron (Fe)	0.03-4.0	08. Phyllochinon (K)	0.025
09. Minerals	0.1-0.5	0.6-2.0	09. Manganese (Mn)	0.02-2.0		
10. Amino acids	0.2-0.4	0.4-0.7	10. Chromium (Cr)	0.01-0.3		
11. Acids	0.2-0.8	0.8-1.5	11. Zinc (Zn)	0.05-2.0		
12. pH value	3.2-4.5	4.5-6.5				

Honey adulterants

Honey adulteration is a widespread form of food fraud in which fraudsters alter pure honey by adding cheaper industrial sugar syrups to increase volume and maximize profits. Because pure honey commands a premium price due to its labor-intensive production and medicinal properties, fraudsters frequently target it.

These low-cost, engineered additives closely mimic the natural fructose-to-glucose ratio of authentic honey, making detection increasingly difficult for standard food safety tests. Adulteration of honey with sugars alters its chemical and biochemical properties, such as enzymatic activity, electrical conductivity, and specific compound content.²⁸ Honey adulterants are selected based on three factors: (a) the specific region of origin, (b) economic benefits, and (c) the accessibility of sugars or sweeteners. Rice and wheat are used as adulterants in Turkey and France,²⁸ whereas European countries adulterate honey with High-Fructose Corn Syrup (HFCS), cane sugar syrup, and industrial glucose.²⁹

① Cane sugar syrup

- Cane sugar is one of the most common and cost-effective adulterants used in the honey industry. Cane sugar is sucrose, consisting of glucose and fructose, obtained by extracting juice from sugar cane, which originates from plants with a C₄ metabolic pathway, while nectar originates from the C₃ pathway.
- Cane sugar syrup is used in both direct (10, 20, and 40% of syrup) and indirect (the bees are fed with syrup) adulteration of honey. Processors mix refined cane invert sugar or syrup directly into bulk honey (Photo 7). Indirectly, beekeepers feed sugar syrup to bees during the honey-making process (Photo 8). The bees process it into honey, heavily diluting the natural floral enzymes and pollen.



Photos 7: Homemade and commercial cane sugar syrup used for adulteration of honey

Photo 8: Beekeepers feed sugar syrup to bees during the honey-making process

Detection methods

- Stable carbon Isotope Analysis (¹³C/¹²C ratio):** This is the gold standard for identifying C₄ sugars (like cane and corn) in honey.³⁰
- Nuclear Magnetic Resonance (NMR) Profiling:** Advanced analytical techniques like NMR are used to detect cane sugar and other syrup adulterants in honey. It generates a comprehensive molecular fingerprint of the sample (honey) in minutes, which is then compared against a massive, global database of authentic honeys to verify purity, botanical origin, and geographic source.³¹
- Microscopic analysis:** Polarization microscopy can detect cellular fragments and plant tissue characteristics of sugarcane stems or molasses.³²
- Sugar profile Testing:** High-Performance Liquid Chromatography (HPLC) is a leading laboratory method for detecting honey adulteration. It identifies foreign sugars (such as corn syrup or beet sugar), measures sugar ratios (e.g., fructose/glucose), and detects markers of overheating or artificial flavors.³³

② Corn syrup

- Corn syrup (specifically High-Fructose Corn Syrup = HFCS) is one of the most common adulterants used

in the honey industry because its sugar profile and consistency closely mimic natural nectar.

- Corn syrup (HFCS) is a viscous, odorless, and colorless liquid that is much denser than water, and this liquid sweetener is derived from cornstarch hydrolysis, which is used as a sweetener in honey (Photo 9,10).
- HFCS has a remarkably similar carbohydrate composition (glucose and fructose) to natural honey, making it virtually impossible to detect with basic at-home sensory tests.
- Corn syrup is divided into three categories according to its fructose content: HFCS-42 (42% fructose), HFCS-55 (55% fructose), and HFCS-90 (90% fructose).³⁴
- The fructose from high-fructose corn syrup cannot be utilized directly for energy and must be stored in the liver as fat or glycogen, which may cause diarrhea in humans. The excessive amount of fructose in HFCS cannot be processed beneficially by the body.³⁵



Photo 9: Commercial high fructose corn syrup used for adulteration of honey



Photo 10. Homemade high fructose corn syrup is used for adulteration of honey

Adulteration detection methods

- **Stable Isotope Analysis ($^{13}\text{C} \div ^{12}\text{C}$ ratio):** Corn and sugarcane (C_4 plants) have different carbon isotope ratios than flowers used by bees (C_3 plants). This is the gold-standard method for detecting corn syrup adulteration.³⁶
- **Molecular testing:** Modern techniques like quantitative real-time PCR (qPCR) detect residual maize DNA or plant pollen in the honey to specifically identify corn-based adulteration.³⁷
- **Liquid Chromatography (HPLC):** Used to map the exact sugar composition as a ‘fingerprint’ to catch unusual ratios and adulterants.³⁸

③ Palm sugar syrup

- Palm sugar is extracted from the flower buds of the palm, and the major carbohydrates are sucrose, followed by glucose and fructose. Palm sugar (or jaggery syrup) is a common and affordable adulterant mixed directly into honey (Photos 11 & 12)
- Sellers boil and dilute it into a thick syrup to mimic the color, texture, and sweetness of pure honey.
- Palm sugar contains similar primary carbohydrates (sucrose, glucose, and fructose); fraudulent batches can easily bypass basic quality checks, allowing them to be sold at a higher profit margin.
- The significant advantages of palm sugar include the absence of a blood sugar-spiking effect, owing to its low glycemic index (~35). The most common honey adulterant in India is jaggery syrup, which is prepared by evaporating palm tree sap.³⁹

Detection in lab tests

Detecting palm sugar in honey requires specific tests, as its sugar profile closely mimics natural flower nectar.



Photo 11. Homemade palm sugar syrup is used for adulteration of honey



Photo 12. Commercial palm sugar syrup is used for adulteration of honey

- NMR Spectroscopy:** Nuclear magnetic resonance spectroscopy provides a comprehensive chemical fingerprint of the honey, detecting trace compounds and identifying the true botanical origin.
- Stable Carbon Isotope Ratio Analysis (SCIRA):** This method differentiates the origins of sugar (such as the C_3 versus C_4 pathway) to distinguish cane and palm sugars from natural floral nectar.
- Diastase and HMF levels:** Pure honey naturally contains active enzymes (like diastase) and has strict limits on hydroxy-methyl-furfural (HMF). Adulterated honeys often fail these enzymatic tests due to artificial heating or altered sugar profiles.

④ Invert sugar syrup (ISS)

- ISS is a viscous liquid sweetener made by splitting sucrose (table sugar) into equal parts glucose and fructose. This process, called hydrolysis or inversion, makes the syrup sweeter than regular sugar, helps retain moisture, is highly soluble, resists crystallization, and offers preservation benefits.⁴⁰
- The sugar content of invert sugar originates from beet and cane plants, mimicking the pure honey sugar profile.⁴¹
- Invert sugar has been widely used in the beverage and food industries for making non-crystallized cream, jams, artificial honey, and liquid sugar.⁴²
- Adulterating honey with invert sugar, a liquid mixture of glucose and fructose, is a widespread form of food fraud that undercuts apiculture and misleads consumers (Photos 13 & 14).



Photo 13: Homemade liquid invert sugar used for adulteration of honey



Photo 14: Commercial liquid invert sugar used for adulteration



Photo 15: Fiehe's test- cherry-red positive (lower petri dish)

- Unscrupulous producers use it because inverted sugar mimics the natural sugar profile of honey, as beet is a C_3 plant, making it cheap and difficult to detect without a specialized laboratory.⁴³

- It is a generally accepted, safe substance and does not cause toxic effects, but no honey benefits are obtained. However, precautions are required in patients with diabetes mellitus, hereditary problems of fructose intolerance, glucose-galactose malabsorption, or sucrose-iso-maltase insufficiency.⁴⁴

Detection in lab tests

Because modern invert sugar is manufactured to chemically match the glucose-to-fructose ratio of pure honey, home tests (like the water dispersion test) are largely ineffective. Authentic detection requires professional laboratory analysis.

- a. **Stable Carbon Isotope Ratio Analysis (SCIRA):** Differentiates between sugars derived from different plant pathways (e.g., C₃ vs. C₄ plants).⁴⁵
- b. **Fiehe's Test:** A classic chemical qualitative method used to detect the presence of hydroxy-methylfurfural (HMF) in honey. HMF is an organic compound that forms when honey is excessively heated or stored for long periods, and it is a key marker for detecting honey adulteration with commercial invert sugar. When HMF reacts with resorcinol in an acidic medium (e.g., hydrochloric acid), it forms a distinct red complex. An instant cherry-red color indicates a positive result, meaning the honey is likely overheated or adulterated (**Photo 15**).⁴⁶

- c. **Proline content**

- Proline is the predominant free amino acid in honey, naturally secreted by honeybees during the conversion of nectar into honey. Because commercial sugar syrups and invert sugars contain very little proline, measuring proline content is an essential indicator of honey ripeness, botanical origin, and sugar adulteration.
- A proline value >180 mg/kg is globally recognized as the minimum threshold for natural, unadulterated honey, whereas a proline concentration <180 mg/kg typically indicates that the honey is immature, overheated, or adulterated with artificial sugars. Premium (high-quality) honey, fully ripened, typically yields values between 300 and 500 mg/kg.

Testing methods

Testing proline content is a primary biochemical method for determining honey purity, maturity, and potential adulteration.

- Proline is quantified using established analytical chemistry procedures, primarily involving UV-Vis spectrophotometry (such as the DIN 10754/TS 13357 standards).
- High-performance liquid chromatography (HPLC)- separates and measures proline and other amino acids with high accuracy.⁴⁷
- Stable Isotope Ratio Mass Spectrometry (IRMS)- Often combined with proline testing to detect specific C₃ and C₄ plant sugars (like cane or corn syrup) to definitively expose sugar fraud.
- Advanced Spectroscopy: Techniques like Fourier transform infrared (FTIR) spectroscopy and NMR spectroscopy analyze the molecular structure to accurately identify foreign sugars.^{43,48}

⑤ Rice syrup (RS)

- White rice syrup (WRS) and brown rice syrup (BRS) are among the most prevalent and challenging sugar syrups used for the illicit economic adulteration of honey worldwide (**Photos 16-18**).
- Because rice is a C₃ plant, its sugars match the same photosynthetic carbon isotope signature of natural blossom honey, allowing it to easily bypass standard purity screens that catch corn or cane sugars, making it difficult to detect with basic sugar tests.
- RS is a product of rice polysaccharide hydrolysis, originating from a C₃ plant (like beet syrup), which is one of the most popular honey adulterants in China.
- RS contains three sugars: malt-triose (52%), maltose (45%), and glucose (3%). Since maltose is two molecules of glucose, and malt-triose is three molecules of glucose, rice syrup acts like 100% glucose inside the body. Thus, RS, as a honey adulterant, is a critical issue affecting quality assurance and food safety.⁴⁹



Photo 16: Homemade white rice syrup



Photo 17: Commercial brown rice syrup



Photo 18: Homemade brown rice syrup

- Rice syrup can be engineered to pass basic authenticity tests such as C_3 and C_4 carbon isotope tests.
- Syrup dilutes the natural antibacterial and antioxidant properties of real honey. Furthermore, rice syrups can contain heavy metals such as arsenic and pesticide residues.
- The unethical substitute for brown rice syrup with HFCS, and baby formulas that contain organic brown rice syrup (OBRS) have an increased arsenic concentration, above the drinking water standard, and there is no regulation to govern this scenario.⁵⁰
- White rice syrup (WRS) or brown rice syrup (BRS) can be used for honey adulteration. The characteristic molecule in BRS was identified as sorbic acid. Of the 107 samples analyzed, 21 were found to be adulterated with BRS, and 3 contained WRS in Turkey.⁵¹

Why rice syrups are used

- **Anatomical mimicry:** Manufacturers use WRS to blend into light-colored honey and BRS for darker honeys, preserving the target color perfectly.
- **Testing Evasion:** Unlike cane sugar or corn syrup (C_4 plants), rice syrup naturally passes basic C_3/C_4 sugar purity tests, allowing up to 50% adulteration to slide by undetected under standard regulatory protocols.
- **Economic incentive:** These industrial syrups cost a fraction of the price of real honey, allowing fraudulent bands to undercut honest beekeepers.

Detection methods

- **Chemical Marker Identification:** Researchers use Liquid Chromatography (UHPLC-MS/MS) to isolate unique markers. A compound called 2-acetylfuran-3-glucopyranoside (AFGP) serves as an excellent marker for identifying WRS. Adulteration: Since BRS contains very little AFGP, scientists use sorbic acid as a specific marker to flag BRS contamination.⁵¹
- **NMR (Nuclear magnetic resonance) Spectroscopy:** Laboratories use ^1H -NMR fingerprinting to spot structural shifts in the carbohydrates (such as peak variations at δ_H 5.39), offering definitive proof of adulteration even when samples clear local regulatory hurdles. This is considered the gold standard, creating a chemical 'fingerprint' of the honey to identify specific marker molecules in syrups.⁵²
- **DNA Barcoding:** Novel molecular diagnostics utilize DNA markers to trace plant materials left behind in the syrup, validating the presence of rice genetics within the honey.⁵³

⑥ Inulin syrup

- High fructose inulin syrup (HFIS) is an industrial sweetener used as an economically motivated adulterant to dilute pure honey because its sugar profile closely mimics the natural fructose and glucose levels found in bee honey.

- The common source of inulin is a naturally occurring polysaccharide (fructan) found in plants.
- Industrial manufacturers produce this syrup through the partial enzymatic or acidic hydrolysis of inulin, a polysaccharide class of fructans naturally extracted from plants like chicory roots or Jerusalem artichokes.¹⁸
- Because these syrups are designed to closely mimic the physical and chemical properties of natural honey, they allow fraudsters to bulk up product volumes and increase illicit profits.
- Added different proportions (5, 10, and 20%, W/W) of high fructose inulin syrup to a nectar honey sample to intentionally simulate honey adulteration.
- These syrups mimic the physical properties and sugar ratios of pure honey, allowing them to easily evade basic purity tests.
- Adulterators formulate these syrups to pass standard markers like C₃ and C₄ sugar tests (Photo 19(3)).



Photo 19(3): Inulin syrups are used for adulteration of pure honey

Why inulin syrup?

Inulin is a naturally occurring storage carbohydrate (a type of fructan) found in plants such as chicory, Jerusalem artichoke, and agave.

- High fructose content:** Inulin can be hydrolyzed (broken down) into High Fructose Inulin Syrup (HFIS).⁵⁴
- Evading detection:** Fructose and glucose are the primary sugars in natural honey. Because inulin syrup contains these exact same foundational sugars, standard or basic sugar tests often fail to catch the adulteration.
- Consistency:** When added to honey, hydrolyzed inulin syrup modifies the fluid's rheological parameters, increasing viscosity to perfectly match the thickness of genuine honey.

Detection methods

The inulin-derived syrups are engineered to closely resemble natural honey; basic tests are often insufficient. Identifying this specific type of adulteration requires advanced analytical techniques.

- Gas chromatography-mass spectrometry (GC-MS)**- can be used to identify inulotriose, a specific trace marker found in inulin syrups that is entirely absent in natural honey.^{54,55}
- High-performance liquid chromatography (HPLC)**- Used to detect specific oligosaccharides and sugar profiles that point to syrup addition.
- Advanced Spectroscopy:** NMR (Nuclear Magnetic Resonance) spectroscopy: Considered the gold standard for analyzing and detecting modified or synthetic syrups, successfully mapping the molecular fingerprints of the honey to identify abnormal carbohydrate profiles.

Health implications

While pure honey provides natural antioxidants, enzymes, and trace nutrients, inulin syrup reduces the

honey's bioactive profile, significantly diluting its health benefits. For consumers, particularly those with conditions like irritable bowel syndrome (IBS) or fructan sensitivities, concentrated amounts of inulin can lead to unwanted digestive distress like bloating and gas.

Fake and adulterated honeys in Facebook Ads in Bangladesh

Fake and adulterated honey is highly prevalent in Facebook Ads in Bangladesh. Unscrupulous sellers heavily utilize social media to market 100% pure Sundarbans or Village honey, but frequently deliver heavily processed sugar syrups or molasses mixed with artificial thickeners and flavors.

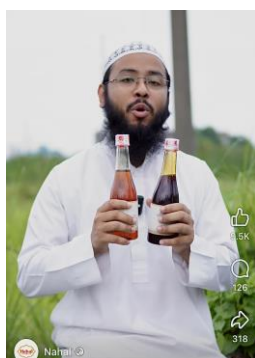
Most Facebook honey vendors in Bangladesh use a deliberate mix of visual aesthetics and religious vocabulary to establish trust and market their adulterated or fake honey as 100% pure. By leveraging 'Islamic marketing,' they tap into the cultural and religious values of their consumer. The important characteristics of Facebook honey vendors in Bangladesh are as follows:

a. Visual and dress characteristics

- Attire: Facebook honey vendors often wear traditional Islamic dress such as a Panjabi or Jubba (a long tunic), pajama, and a topi (prayer cap), or a sunnah beard to project an image of piety, honesty, and devoutness (Photo 20(4)).



Nectar drops honey



Kalo Jeera honey (Nahl)



Kalo Jeera honey (Amanat)



Pure honey (Takwa shop)

Photo 20(4): Facebook honey vendors wearing Islamic dress to attract honey buyers, from whom honey was purchased for this experiment

- Setting: Promotional photos and live videos frequently feature them in natural, rural settings, such as near lush forests or beside traditional beehives to visually reinforce the authenticity and organic origins of the honey (Photo 21(4)).

b. Linguistic tactics

- Religious terminology: They frequently intersperse their marketing copy with Islamic terminology and greetings. Phrases like Assalamu Alikum Rhmatullah, Alhamdulillah (praise be to Allah), Inshallah (Allah willing), and Mashallah (as Allah has willed) are heavily integrated into posts and captions.
- Islamic endorsement: Vendors often cite honey as a sacred or blessed food, sometimes referring to Quranic verses or the Sunnah (the teaching of the Prophet Muhammad) regarding its healing properties. This frames the transaction not just as a commercial sale, but as a path to health and spiritual blessing.
- Trust-evoking language: The captions rely on emotionally resonant, trust-building adjectives. Words like kalis (pure), khalis (100% natural), and shahi (royal) are used repeatedly to assure buyers of the honey's authenticity and high quality.



Bee sucking nectar from Black cumin flower



Moulis travel by boat to collect honey in Sundarbans



Moulis is collecting honey from honeycomb



Honey thickness test by using stick

Photo 21(4): Facebook honey vendors use these photos to prove that they are really collecting pure honey from the Sundarbans

c. Marketing claims

- **Direct-from-source claims:** Vendors market directly on platforms like Facebook, claiming the honey is harvested by local beekeepers (moulis) from wild reserves like the Sundarbans (Photo 21(4)).
- **Proof of purity:** To consider widespread concerns over adulterated or sugar-syrup-based honey in the Bangladeshi market, vendors will often stage 'purity tests' in their live videos. These demonstrations include burning a matchstick dipped in honey, seeing how it settles in a glass of water, or observing how the thick liquid spreads across a thumb or pours from the stick to the container (Photo 1-3)
- They often hook buyers using viral tactics, such as claiming the honey comes directly from the Sundarbans, offering heavily discounted prices, or performing misleading home-based authenticity tests in video ads.

Global status of fake and adulterated honey

China produced 485,960 tons of honey, almost five times the amount produced in Turkey, the second-largest producer that year. Iran, Argentina, and Ukraine rounded out the top five producers in 2021 (Table 4). A list of the 115 largest honey-producing countries in the world is available in the literature.⁵⁶

Table 4. The 10 largest honey-producing countries in the world (Production in tons)						
SN	Countries	Production in 2021 ⁵⁶	SN	Countries	Production in 2025	Honey exporting countries
①	China	485,960	01.	China	5,00,000-650,000	Japan, US, Europe
②	Turkey	96,344	02.	Turkey	118,297 (in 2024)	US, Germany, Saudi Arabia, Iraq, and Austria, China, Middle East
③	Iran	77,152	03.	Iran	79,000	US, Germany, and Spain
④	Argentina	71,378	04.	India	74,000	Poland, Germany, France, US
⑤	Ukraine	68,558	05.	Argentina	70,000-75,000	US, Saudi Arabia, UAE, BD, Canada
⑥	India	66,278	06.	Russia	67,000	China, Kazakhstan, CIS countries
⑦	Russia	64,533	07.	Mexico	40,000-64,000	US, Germany, UK
⑧	Mexico	62,080	08.	Brazil	60,000	Canada, Japan and EU
⑨	USA	57,364	09.	Ukraine	63,000-75,000	US, Germany, UK
⑩	Brazil	55,828	10.	New Zealand	20,000-22,000	India, Japan, US, Singapore, Malaysia, Australia, Brunei & Italy
			11.	Bangladesh	15,000-25,000	

*No national statistics

Note: • China and India have long used honey in traditional medicine to manage a variety of ailments.

- The variety of honey produced differs by region and is affected by the flowers and plants from which bees collect nectar.
- Foraging bees must travel approximately 55,000 miles and visit about 2 million blossoms to produce one pound of honey.
- Honey comes in various hues, from nearly transparent to nearly black. Darker honey contains more antioxidants.
- Real honey takes hundreds of hours of bee labor to produce, making it one of the most counterfeited foods globally, alongside olive oil and saffron.

Table 4 shows that up to 93% of commercial honey worldwide is adulterated with cheap plant syrups (e.g., corn, rice, sugar beet) or artificially ripened through unnatural beekeeping practices. It's estimated that 30% of honey sold in the global market is mixed with plant sugars, and that up to 70% of honey sold in the US could be fraudulent (Photo 22).⁶⁷ All the honey obtained via Facebook was found adulterated in Bangladesh (Photo 23).

Fake or adulterated honey is honey that has been tampered with, either diluted with sugar syrups, chemically processed, or produced through unnatural methods like force-feeding bees' sugar instead of allowing them to forage in nature, which exploits the natural biological rhythm of bees. It also lacks the natural properties and health benefits of real, pure honey.⁶⁸ Honey can be fraudulent in the following five primary ways:

① Factory or lab-made fake honey (Chemical engineering)

Factory-made or artificial 'honey' relies on chemical engineering principles and mass-balance formulations to replicate the physical and sensory properties of natural bee-produced honey. Because genuine honey is essentially a supersaturated solution of inverted sugars and water, it can be chemically emulated and cut (adulterated) on an industrial scale.⁶⁹

a. The sugar matrix

Natural honey is primarily composed of fructose and glucose at a roughly 1.2:1 ratio, with water making up about 17-20% of its mass. Fake honey mimics this through:

- Inverted sugar syrup: Chemical engineers use acid or enzymatic hydrolysis to break down sucrose like cane or beet sugar) into its monosaccharide components (glucose and fructose).
- High-fructose corn syrup (HFCS): Industrial corn syrup is isomerized using enzymes to replicate the high fructose levels found in real honey.

b. Viscosity and rheology

Real honey is a non-Newtonian fluid: its thickness changes based on how much it's stirred. To duplicate this mouthfeel, artificial honey manufacturers use specific combinations of:

- Dextrin and maltose to control thickness
- Thickeners and hydrocolloids (like pectin or carboxymethyl cellulose) to achieve the right pour rate and 'thumb test' properties.

c. Flavor, color, and trace compounds

Pure honey contains complex compounds such as amino acids, pollen grains, and trace minerals (e.g., potassium) that contribute to its distinct taste. To artificially recreate these, factories use:

- Caramel coloring: Added for the characteristics of amber and golden hues.
- Artificial aromas and flavors: Synthetic chemical compounds (e.g., benzaldehyde for floral undertones, or organic acids like gluconic acid) are added to mimic the sharpness and scent of flower nectar.
- Trace pollen: Sometimes, factories filter out all pollen to hide an artificial mix in low-grade pollen

② Adulteration of honey by direct dilution

Direct dilution is a primary method of direct honey adulteration. It involves adding cheap, foreign sweeteners to natural honey after harvest to artificially increase its volume. Fraudulent producers select substances that closely mimic the color, density, and sugar profile of authentic honey.

- C₄ plant syrups: High-fructose corn syrup (HFCS) and cane sugar syrup.
- C₃ plant syrups: Rice syrup, wheat syrup, and beet sugar syrup.
- Invert sugar syrup: Chemically or enzymatically broken-down sucrose.
- Colorants: Additives like caramel color to make diluted mixtures appear darker and falsely signify premium quality.



Photo 22. Fake and adulterated honey in an overseas grocery store



Photo 23. Adulterated and contaminated honey purchased on Facebook in Bangladesh

Effects of dilution of honey

When honey is directly diluted with these external syrups, its chemical fingerprint changes systematically.

- Volatile suppression: Direct dilution strips away or masks the unique floral aromas. It creates a stark dilution effect that suppresses natural biological markers.
- Nutritional deprivation: The concentration of essential enzymes (like diastase), amino acids (like proline), and therapeutic antioxidants drops drastically.
- Optical shifts: Dilution with industrial syrups drastically reduces light absorbance in the ultraviolet (UV) and visible spectra.

Recently, Australia has been rocked by reports that many products labeled as honey are fake or adulterated honey. Capilano, Australia's largest honey producer, has been accused of selling products mixed with cheaper syrups. But Capilano has hit back, claiming the testing method is unreliable.⁷⁰

③ Direct syrup-blended honey adulteration (DSBHA)

DSBHA involves physically mixing exogenous sugar syrups directly into harvested pure honey during processing or packaging to artificially increase volume and slash production costs. Fraudsters engineer these syrup blends to replicate honey's natural fructose-to-glucose ratio (typically 1.0 to 1.2), making detection highly complex.

Common syrups used in direct blending

a. C₄ plant syrups: Derived from plants like corn and sugar cane.

- High-fructose corn syrup (HFCS): Extensively used because its glucose-fructose breakdown mirrors natural blossom, honey.
- Cane sugar /Industrial glucose syrups: Chemically inverted to eliminate large sucrose crystals, ensuring a smooth texture.

b. C₃ plant syrups: Derived from plants like rice, wheat, sugar beet, and agave.

- Rice syrup/ Brown rice syrup: Popularly leveraged as 'all-pass syrup' because it easily bypasses basic isotopic testing designed for C₄ sugars.
- Inverted beet sugar syrup: Highly resilient against traditional testing frameworks in countries where beet sugar is common.

c. Fruit and regional syrups

- Date and Jaggery syrup: Regionally dominant adulterants used due to low local raw material costs.

Blending methodology

- a. Thermal inversion: Industrial sucrose solutions (from cane or beet) are treated with heat, acids, or enzymes (invertase) to split sucrose into individual glucose and fructose molecules, mimicking honey's chemical foundation.
- b. Proportional density matching: Syrups are blended to match the exact density and moisture parameters of natural honey to pass hydrometer verification.
- c. Heat blending: The honey and syrup mixture is heated uniformly to roughly 45 °C (113 °F) while continuously stirred. This melts any lingering sugar crystals and creates a completely homogeneous, stable emulsion that will not separate on grocery shelves.

④ Moisture reduction and ultra-filtering honey

Moisture reduction lowers water content to stop fermentation, while ultra-filtering is a high-tech pressure filtration method. Fraudsters use ultrafiltration to strip away pollen and enzymes, allowing them to add large amounts of cheap sugar syrups to the honey undetected.

The mechanics of the process include the following:

a. Moisture reduction

- Authentic, ripe honey generally has a water content below 10%. If the honey is harvested prematurely, its moisture level rises above 20%, making it prone to fermentation.
- Processors use dehumidifiers, vacuum-evaporators, or heat treatment to dry out the 'unripe' honey, so it is stable on the shelf.
- Fraudulent reduction: Fraudsters and industrial packers use high heat to artificially dry out low-quality honey or bulk sugar syrups, which kills the natural enzymes in the honey and creates harmful byproducts like hydroxy-methyl-furfural (HMF).

b. The mechanics of ultra-filtering and adulteration

- Ultra-filtering: This industrial process pushes honey, often heated and thinned, through incredibly small filters at high pressures to remove all solid particles, such as bee pollen and propolis (**Photo 24**).
- The problem with pollen: Pollen is the fingerprint that proves exactly where and what flower the honey came from. Stripping it away erases the product's geographical and botanical identity.
- Masking adulteration: Once pollen is removed, it becomes scientifically difficult to identify added sugars like high-fructose corn syrup, rice syrup, or beet sugar using basic visual and pollen-based tests.

How they are used in adulteration

The combination of these two steps is the backbone of mass-market honey fraud:

- a. The cover-up: Pollen is the only fingerprint that proves a honey's geographical and floral origin. Ultra-filtering strips this pollen away, making it scientifically impossible to trace where the product came from.
- b. Dilution: Once the pollen signature is erased, processors can mix in large quantities of inexpensive, manufactured sugar syrups (e.g., corn syrup, rice syrup, or beet sugar) without raising suspicion.
- c. Consistency and viscosity: The added syrups generally have varying moisture levels and sugar profiles. Processors use moisture reduction techniques (such as multiple-effect evaporation) to achieve the thick, viscous consistency of natural honey, making the diluted product look identical to the real thing.

⑤ Indirect adulteration of honey (IAH)

IAH occurs when beekeepers intentionally overfeed honeybee colonies with industrial sugar syrups during the main nectar flow period, causing the bees to store modified sugar water in the honeycomb instead of natural floral nectar. Because the sugar syrup passes through the honeybee's digestive system and is processed by their enzymes, the resulting product closely mimics the physical texture and basic chemical appearance of real honey. This makes it significantly harder to detect than direct adulteration, where syrups are simply blended into harvested honey in a factory.

Mechanism of IAH

- Nectar replacement: Bees eagerly consume cheap, mass-produced industrial sugars like high-fructose corn syrup (HFCS), inverted beet sugar, cane sugar syrup, and rice syrup. (Photo 25)
- Enzymatic process: Bees ingest the artificial syrup and mix it with their own digestive enzymes (like invertase) to split the sucrose in the syrup into glucose and fructose before depositing it into the honeycomb.
- The illusion: Because the syrup passes through the bee's digestive system, the resulting product looks, tastes, and feels remarkably like genuine floral honey.

Types of syrup used

- C₄ plant syrups: High-fructose corn syrup (HFCS) and sugar cane syrups.
- C₃ plant syrups: Rice syrup, wheat syrup, and sugar beet invert syrup.

Impact on honey quality

- Diluted bioactive compounds: IAH shows a sharp drop in vital nutrients, including amino acids (such as proline), total antioxidants, essential vitamins, active enzymes, and polyphenols.



Photo 24: Mini honey processing plant used for filtration and reducing the moisture content of the honey



Photo 25. Indirect adulteration method of feeding sugar syrups to bees

- Altered sugar profiles: Prolonged overfeeding often skews the natural glucose-to-fructose balance, causing a decrease in natural monosaccharides and a buildup of un-inverted sucrose or complex oligosaccharides.
- Degraded physical traits: Overfed syrup results in a lighter-colored honey that lacks the natural pigments and complex plant volatile profiles of pure floral honey.
- Risks to bee biology: Feeding honeybees complex, non-floral industrial sugars over long periods can shorten worker lifespans and weaken colony immunity. Industrial syrups can introduce foreign chemical additives, residues from heavy processing, or localized contaminants into the hive matrix.
- It lacks the nutritional enzymes, pollen, and natural health benefits of real honey. This method weakened bee health, produced poor-quality honey, and prioritized profit over pollination.

Differences between natural honeycomb and honeycomb from sugar syrup-fed bees

Bees build natural honeycomb using pure flower nectar and natural wax, while syrup-fed honeycomb comes from bees that consume artificial sugar water. Natural comb contains rich flower pollen, enzymes, and diverse nutrients, whereas syrup-fed comb is mostly simple sucrose with very few natural compounds (Table 5).⁷¹

Table 5. Main differences between natural honeycomb and honeycomb from sugar-fed bees

SN Features	Natural honeycomb (Nectar-fed)	Honeycomb from sugar-syrup-fed bees
① Primary food source	Flower nectar and plant secretions.	Processed sugar syrup (sucrose or high-fructose corn syrup)
② Nutritional profile	High in vitamins, amino acids, minerals, and live enzymes.	Low in nutrients; primary simple carbohydrates.
③ Flavor and aroma	Complex, floral taste unique to local plants	Plain, flat, or overly sweet taste without floral notes. growth
④ Pollen and propolis content	Contains visible traces of pollen, propolis, and royal jelly.	Little to no pollen or beneficial hive compounds.
⑤ Color and texture	Varies from golden-yellow to dark amber; rich and varied.	Often lighter, uniform, or pale; wax may feel different.
⑥ Cost and purpose	Premium product used for raw, unprocessed honey consumption.	Often used by keepers to sustain colonies during food shortages.

The facts about fake honey

- Honey is the third-most-faked food behind milk and olive oil.⁷² The world is selling more ‘honey’ than bees can make. Since 2011, global honey exports have increased by 67%, while total world honey production has increased by only 15%. A sharp mismatch between high export growth and low real production points to widespread global honey fraud.⁸ Estimates suggest that between 30 and 50% of the honey circulating in the global market is adulterated or fraudulent.⁷³
- About 80% of the honey Australia imports is from Asia, including China (38%), Malaysia (19%), Thailand (16%), and Vietnam (7.0%). Their prices are below the cost of production, indicating adulteration.⁷⁴
- Reports show up to 46% of internationally traded honey fails authenticity tests in Europe.⁷⁵
- Studies by the Department of Science and Technology-Philippines Nuclear Research Institute found that 75 to 86.5% of local honey brands in the markets are adulterated. (GOVPH 2020)⁷⁶
- The latest results of a multi-year, targeted inspection program by CFIA have shown that 17 of 74 samples (22.9%) of imported honey collected were determined not to be authentic honey. In addition, the 2021-2022 Food Fraud Report resulted in the detention, denial of entry into Canada, or destruction of 184,921 kg of honey. However, all commercially tested domestic honey is 100% authentic and unadulterated.⁷⁷
- It’s estimated that 30% of honey sold in the global market is mixed with other sugars and that up to 70% of honey sold in the US could be fraudulent,⁷⁸ whereas the FDA survey found only about 4% of domestic and imported honey tested positive for added sugar syrups like corn syrup, or other unapproved.⁷⁹

Comparison between pure, adulterated, and fake honey

Pure honey is made naturally by bees from flower nectar and contains rich nutrients, pollens, and enzymes. Adulterated honey is natural honey diluted with additives like sugar syrups. Fake honey contains no real honey at all and is made entirely of artificial sweeteners, sugars, and thickeners. Table 6 shows the differences between pure, adulterated, and fake honey.

Global status of honey frauds

Honey is the third most frequently counterfeited food globally, after milk and olive oil. Driven by the economic gap between the high cost of natural honey and cheap industrial syrups, honey fraud incidents surged by over 1,311% between 2020 and 2024 (digicomply.com). Global supply chains rely heavily on blending and transshipment and are highly vulnerable to dilution and mislabeling, creating an international crisis that threatens legitimate beekeepers' livelihoods and consumer trust.⁸⁰ Honey fraud is a truly international problem that thrives in countries with complex import/export supply chains and lower regulatory enforcement. Fraud typically flows from areas with massive, low-cost sugar and honey production to high-demand, affluent markets.

Table 6. Comparison of pure, adulterated, and fake honey ⁸¹				
SN	Features	Pure honey	Adulterated honey	Fake honey
①	Composition	100% natural; nectar gathered by bees. Contains natural enzymes, pollen, and trace nutrients.	Mostly pure honey mixed with added water, starch, cane sugar, or other syrups.	Artificially flavored and colored syrups (e.g., corn syrups, fructose). Contains zero real honey.
②	Consistency/Texture and viscosity	Thick, sticky, viscous, and smooth. It feels like a rice oil or serum when rubbed between the fingers, between the fingers	May be thick, but often runny and watery. If rubbed on the fingers, it feels very sticky and syrupy	Uniformly thin, watery, or unnaturally sticky, it does not form natural crystals
③	Aroma & Taste	Carries a distinct floral or woody note that it depends on the flowers the bees visited. It provides a natural tingling or mild burning sensation in the throat due to natural enzymes	Smells overwhelmingly like plain sugar. It lacks complex floral tastes. Sweet without the natural, complex the aftertaste of honey.	Simple, one-dimensional sweet taste; may have a sour odor or no smell at all.
④	Crystallization	Real, raw honey crystallizes naturally due to its high glucose content and pollen traces, turning into a grainy, solid texture in cold.	Adulterated honey (partially real) crystallizes unevenly, forming a separated, layered, or gritty mess rather than a uniform, creamy solid.	Fake honey, made of sugar syrup, usually never crystallizes and remains perfectly clear.
⑤	Pollen content	Pure, raw honey features an abundant, diverse mix of naturally occurring pollen grains (100 to >700,000 grains/g depending on the floral source.	The overall pollen count and diversity is significantly lower than pure honey because of the added syrups or micro-filtering processes.	Completely fake or artificial honey is made entirely in a lab or factory from sugar syrups and artificial flavors. It contains absolutely zero natural flower pollen.
⑥	Reaction to water	Drops to the bottom of a glass and sits intact as a solid lump. It does not dissolve easily or quickly.	Dissolves easily, or creates a cloudy mixture very quickly.	Dissolves immediately and disperses completely into water.
⑦	Reaction to flame	Flammable; a dipped cotton wick or matchstick will ignite and burn easily.	Sputters or won't light easily due to added moisture.	Will not strike or burn; produces sputtering and black smoke due to high water content.
⑧	Nutritional value	Rich in antioxidants, vitamins, amino acids, minerals, and enzymes.	Lower nutritional value due to the zero-calorie syrup.	Zero nutritional value with no natural health benefits.

① Asian exporters

- Honey fraud- often called 'honey laundering' -plagues the global supply chain, with many cases linked to the rerouting, dilution, or mislabeling of Asian honey exports to avoid tariffs and regulations. Fraudsters typically use cheap artificial syrups to dilute real honey or falsify paperwork and country-of-origin labels.⁸²
- Major export hubs in Asia, particularly China, which is the world's largest producer and exporter of honey, frequently face scrutiny. Shipments of inexpensive bulk honey often undergo extensive processing and filtration, then repackaging in these regions to mask the addition of syrups before being exported worldwide.
- Destination markets: High-consumption and lucrative markets like the European Union (EU) and the United States are the primary targets for fraudulent imports. For instance, a European Commission (EC)-wide investigation (From the Hives), analyzed hundreds of imported shipments and found that nearly 46% were suspicious of being adulterated with unauthorized artificial sugar syrups. A massive 74% of these suspicious samples originated from China.⁸³
- Honey laundering: To avoid steep anti-dumping duties initially placed on Chinese honey, exporters have historically transshipped Chinese honey through various Asian and transcontinental nations (e.g., India, Vietnam, Malaysia, Thailand, and Indonesia). These shipments often carry falsified documents masking the true country of origin.⁸²
- Global market impact: With 30-40% of the global honey supply estimated to be fraudulent, legitimate beekeepers in the US and Europe have faced severe financial collapse due to artificially cheap counterfeit products flooding the market.^{84,85}

② North America

Honey fraud (or economically motivated adulteration) remains a pervasive global issue, with an estimated 30-40% of the honey supply adulterated or mislabeled.⁸⁴ North America is highly vulnerable due to its reliance on imports and the absence of a strict federal ‘standard of identity’ for honey in the United States. Counterfeit honey diluted with cheap syrup or artificially ‘laundered’ to hide its true country of origin suppresses market prices and directly threatens domestic beekeepers’ livelihoods. Driven by cheap imports, fraudsters dilute pure honey with inexpensive corn or rice syrups and conceal the true geographic origin to avoid trade tariffs.⁸⁶

- Import reliance: The U.S. relies heavily on imports, sourcing approximately 73% of its honey supply from overseas markets like India, Argentina, Brazil, and Vietnam.⁸⁶
- Laundering tactics: Fraudsters employ ‘honey laundering’ by heavily filtering out pollen and blending cheap foreign syrups with small amounts of authentic honey to mask the product’s true origin and bypass tariff or quality regulations.⁸⁶
- Economic threat: The flood of ultra-cheap, adulterated pseudo-honey artificially drives down wholesale prices. This makes it difficult for legitimate North American beekeepers to cover production costs, risking the collapse of the beekeeping operations needed to sustain vital agricultural pollination.⁸⁷
- Pollination threats: Because fraud artificially devalues honey, it threatens sustainable beekeeping operations. A decline in beekeepers directly endangers honeybee populations, which are critical for the region’s food security and crop pollination.⁸⁸

③ Premium honey fraud hubs

- Regions known for premium honeys (such as Manuka from New Zealand or specific blossoms from the Mediterranean) frequently suffer from geographic and botanical mislabeling worldwide.
- Premium Manuka honey comes from the nectar of the manuka bush flower, which only grows in New Zealand, and it’s known for its antibacterial properties and associated perceived health benefits (Photo 26).
- Manuka honey fraud is a major international issue, driven by a simple arithmetic: New Zealand produces roughly 1,700 to 2,000 tons of authentic Manuka honey annually, yet over 10,000 tons are sold globally under the Manuka label (Fig. 2). It indicates that global sales of Manuka significantly exceed New Zealand’s total annual production, making it a primary target for counterfeiters. This massive supply-demand imbalance creates high price premiums that invite sophisticated, international food fraud (Photo 27).⁸⁹

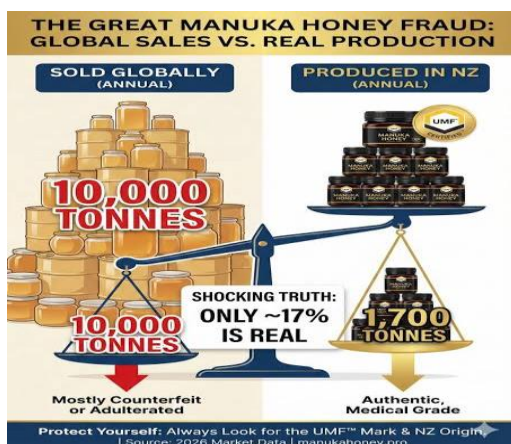


Fig. 2. Manuka honey fraud: Global sales vs. real production¹⁰



Photo 26. Manuka raw honey in the New Zealand



Photo 27. Manuka honey in the Bangladesh market

Common methods of honey fraud types

The most common methods of honey fraud involve diluting pure honey with cheap industrial sugar syrups, mislabeling botanical or geographical origins to command premium prices, indirectly adulterating by overfeeding bees with sugar water to artificially inflate production volume, and harvesting immature honey. Because honey is a high-value item with complex global supply chains, it ranks among the most frequently faked foods. Fraudsters use highly sophisticated technologies that make it exceptionally difficult to detect adulterated honey without advanced laboratory testing. The most common methods used to perpetrate honey fraud are production, processing, and labeling (Table 7).⁸⁵

① Direct adulteration (Syrup dilution)

This is the most common method of honey adulteration, and fraudsters blend pure honey with cheap, industrially manufactured sugar syrup to increase volume. Common sweeteners used include:

- C₄ sugar syrup addition: Blending syrup derived from C₄ metabolic pathway plants, such as high-fructose corn syrup (HFCS) and sugar cane syrup.
- C₃ sugar syrup addition: EU tests found 100% of UK honey samples adulterated. They use advanced syrups from C₃ plants, such as rice syrup, wheat syrup, and sugar beet syrup. Fraudsters increasingly use C₃ syrup because it shares an isotopic fingerprint similar to that of natural flower nectar, making it much harder to detect with conventional laboratory tests such as carbon isotope ratio analysis.⁹⁰

SN Methods	How it works	Primary objective
① Direct adulteration	Blending honey directly with rice, corn, or beet syrups	Lowers costs and increases volume
② Indirect adulteration	Intentionally feeding bees sugar syrup during a nectar flow.	Artificially inflates hive yield.
③ Ultrafiltration	Passing honey through resin technology to remove pollen.	Hides country of origin and botanical source.
④ Mislabeling	Falsifying origins, nectar types, or blending statistics	Commands higher premium prices

- Artificial colorants and additives: Adding caramel coloring to make diluted or low-quality honey appear darker, mimicking high-value, antioxidant-rich varieties.¹³
- Water dilution: Mixing water directly into honey to reduce costs, often requiring thickeners or extra sugars to restore the expected viscosity.

② Indirect adulteration (Overfeeding bees)

- Instead of mixing syrup into harvested honey, some producers overfeed honeybee colonies with sugar solutions or inverted syrup during the active nectar-flow season.
- The bees rapidly convert this cheap sugar into honey in the honeycomb instead of foraging for natural nectar.
- This yields a product that mimics real honey on paper but completely bypasses the complex, natural superfood production cycle.⁸⁰

③ Geographical and botanical mislabeling

High-demand, premium honeys are frequently falsified to command higher retail prices.

- Origin masking: Lower-quality or cheap honey imported from one nation is mixed or transshipped through a secondary country to evade traffic or disguise its actual source.⁹⁰
- Floral fraud: Cheap multi-floral (polyfloral) honey is falsely labeled as a premium, single-flower (monofloral) luxury variety, such as Manuka honey from New Zealand.⁸⁰

④ Processing and filtration fraud

- Ultrafiltration: Honey is pushed through extremely fine filters to remove impurities, wax, and, crucially,

all traces of pollen. Removing pollen strips away the natural geographical 'fingerprint' of the honey, preventing laboratories from verifying where the honey came from.⁹¹

- **Artificial evaporation (Wet honey):** Real honey requires bees to reduce the water content in the hive naturally before capping the cells. To speed up production, some industrial operations harvest wet or immature honey early and manually dehydrate it using industrial dryers. These include international food standards frameworks such as the Codex Alimentarius Honey Standard.

⑤ **Lab evasion tactics**

Modern fraud operations have evolved to manipulate laboratory assessments. Illicit operator pre-test their customized sugar blends in accredited laboratories to adjust the chemical profile, thereby deliberately evading standard testing protocols before shipping them to the global market.⁹²

Fraud methods used by the top honey-producing countries

Honey fraud is a massive global issue driven by the large gap between the limited natural supply and soaring global demand. Major global exporters often tailor their methods to circumvent regional purity tests, posing a significant challenge for regulatory bodies such as the European Anti-Fraud Office and the FDA. The specific fraud methods used vary significantly depending on local crop availability, technological capabilities, and targeted export markets.¹⁸ The world's top honey-producing and exporting nations utilize highly sophisticated methods.⁹²

① China: High-Tech 'All pass' syrups and honey laundering

China produces only 180,000 tons of honey a year, of which 82,000 tons are exported, with none imported. That leaves only about 100,000 tons of honey for the Chinese market. Yet 500,000 tons are sold each year in China as honey, suggesting that 400,000 tons, or 80%, are made with cane sugar syrup and alunit. ⁹³

China is the world's largest honey producer and exporter, yet its industry is notoriously plagued by food fraud, with high rates of adulteration. Industrial plants in regions like Zhejiang mass-produce cheap corn, beet, and rice syrups to dilute, bulk up, or completely mimic honey. Unethical producers use cheap, plant-derived sweeteners (e.g., high-fructose corn syrup, rice syrup, and beet syrup) to dilute or entirely replace authentic floral honey. Industry insiders estimated that in 2014, some 60-70% of Chinese honey was adulterated.⁹⁴ As the world's largest honey producer and exporter, its fraud methods are highly industrialized and technologically sophisticated.^{95,96}

- Custom-engineered C₃/C₄ syrups:** Fraudulent lab-produced syrups specialize in high-fructose syrups derived from rice, wheat, sugar beet, and chicory (C₃ plants). These syrups are modified to mimic the fructose-to-glucose ratio of natural honey. Known colloquially in the industry as 'all-pass syrup,' they are chemically engineered to slip right through traditional C₃/C₄ isotope testing undetected⁶⁴ and use unapproved processing to mask the true geographical origin.⁹⁷
- Resin technology and ultrafiltration:** Industrial packers use microporous specialized resin columns and ultrafiltration to strip honey of its color, odor, wax, heavy metal residues, impurities, and, critically, pollen. This eliminates the honey's geographical footprint, making it impossible to trace its true Chinese origin.⁹⁸
- 'Wet honey' dehydration:** Harvesting immature, highly diluted honey (wet honey) saves time and increases hive output. Factories mechanically dry this watery, unripe liquid using vacuum evaporators to meet moisture standards, rather than letting bees naturally ripen and evaporate it in the hive.⁸⁷
- Honey laundering (transshipment):** To evade high customs tariffs and origin tracking, fake or adulterated Chinese honey is shipped to intermediary countries (like Vietnam, Thailand, or parts of Europe). There, it is repackaged, relabeled, and legally re-exported to major consumer markets like the United States.⁹⁹
- Illegal antibiotic masking:** To combat bee diseases under crowded conditions, some producers use unapproved antibiotics like chloramphenicol. When caught by customs, fraudsters blend or chemically

filter the honey to drop antibiotic residues below detectable limits.

- Up to 75% of Chinese honey has been estimated to be adulterated through ultra-filtering, feeding bees sugar water, and mixing in cheap rice, beet, or corn syrups (Photo 28).¹⁰⁰
- An investigation reveals a global honey fraud that begins in China and ends with allegations of adulterated jars on UK supermarket shelves.¹⁰¹
- Because the US and other countries impose heavy tariffs on Chinese honey, illicit operations circumvent trade laws by shipping the product through third countries. This honey is often ultra-filtered to strip away identifying pollen, making it nearly impossible to trace the origin or botanical source.⁹⁴
- Beyond replacing natural nectar with sugar syrup, Chinese honey has frequently been flagged for contamination with banned antibiotics (like chloramphenicol), which are used in apiaries to manage bee diseases.⁹⁴
- Police in Chongqing's Heuchan district have discovered a production site for fake honey and confiscated about 500 kg of the fake nectar, and the artificial honey contained zero per cent real honey, but such honey contained 187 mg of aluminum residue per kilogram of honey (Photo 29).¹⁰²
- Honey imported from China to Bangladesh is widely available through local e-commerce platforms and various retail shops with an online guarantee of pure Hosen honey (Photo 29) by Excellent Food,^{103,104} and others (Photo 30), where up to 75% of Chinese honey is adulterated.¹⁰⁰
- Apimondia (World Beekeeping Congress) officially discontinued the honey category in the World Beekeeping Awards. The decision came after laboratory tests revealed 45% of entries failed in Montreal in 2019, and similar disqualifications happened in Istanbul in 2022. Organizers cited the impossibility of adequately screening all samples for global adulteration.¹⁰⁵



Photo 28. Fake honey production in China involves 500 kg of fake nectar.



Photo 29. Hosen brand honey imported from China to Bangladesh



Photo 30. Tiptree brand honey imported from the UK to Bangladesh

🇹🇷 Turkey: Extreme fraud rates and therapeutic infusions

Turkey is the world's second-largest honey supplier after China. The Turkish honey sector has an annual volume of about US\$283.4 million, according to estimates, with Germany and the United States being the largest importers of Turkish honey. Increasingly, though, Turkish honey is being adulterated with sugar syrup or other ingredients and most certainly sold in Europe. A coordinated action report by the European Union found that 93% of honey samples from Turkey tested were suspicious or counterfeit.⁹⁹

- Sugar beet and corn syrup dilution:** Given its massive domestic sugar beet industry, direct adulteration with fructose/glucose syrups from corn and beet sugar is highly prevalent.¹⁰⁶
- Adulteration with inverted syrups:** Turkish operations frequently extend by blending high amounts of cheap industrial inverted sugar syrups.

- c. **Botanical mislabeling:** Lower-value multifloral honeys are routinely enhanced with synthetic additives, colorings, and aroma compounds. They are then falsely labeled and sold as premium, expensive monofloral varieties (such as Pine or Citrus honey) to achieve a higher market price.⁹⁰
- d. **Illegal additives:** Law enforcement actions have seized large shipments of imported Turkish honey illegally laced with prohibited chemical compounds like colorants and artificial flavoring to simulate premium dark forest honey.
- e. **Illicit medical additives:** A highly specific type of fraud emerging from illegal Turkish supply chains involves laced honey marketed as a therapeutic aphrodisiac (erectile honey). European authorities have seized bulk quantities of Turkish honey illegally infused with active pharmaceutical chemicals like Viagra (Sildenafil).⁹⁹
- Tailored lab manipulation: Exporters have been caught utilizing on-site, private laboratories to test their own adulterated batches before export. They systematically tweak the precise fructose-to-glucose ratios to specifically evade detection parameters set by European border authorities.
- One raid in the capital, Ankara, in September 2024, found 8,150 tons of glucose, fructose, and sugar, along with 1,00,000 labels for different honey brands. The Turkish Ministry of Agriculture released lists indicating that 43 honey producers in Turkey had adulterated honey.⁹⁹

③ The United Kingdom and European hubs

Only 14% of the honey consumed in the UK is made locally, and the rest is imported. In a coordinated EU investigation in 2021, 46% of imported honey samples were suspected of being adulterated with exogenous sugars (Table 8).¹⁰⁷ The UK and certain EU hubs serve as major processing hubs, yet official investigations have flagged re-exported shipments with extremely high suspicion rates.⁹⁰

The laundering hub method

Large-scale packers import cheap bulk honey from various international sources (often already adulterated). They blend it together, perform heavy microfiltration, and re-export the final product under ambiguous labels such as ‘Blend of non-EU honeys’ to completely hide the original geographical supply chain.

- Recently, honey fraud and adulteration were major issues in the UK, with investigations revealing that over 90% of blended honey samples from major UK supermarkets and large retailers fail advanced authenticity tests due to dilution with cheap sugar syrups (e.g., rice or corn syrup) and misleading country-of-origin labeling.¹⁰⁸

SN	Region	Adulteration rate	Common methods	Key findings
①	Europe (2023) ¹⁰⁷	46.0 %	Sugar syrups (corn, beet, rice)	Nearly half of the samples were adulterated.
②	USA (2021-23) ¹⁰⁹	3-10 %	Imported bulk honey, adulterated	FDA confirmed adulteration in imports
③	Bangladesh (2024-2025) ¹¹⁰	33% unsafe food samples (honey)	Dilution, contamination, low nutrition.	BFSA surveillance confirmed honey adulteration.
④	Global trade ¹⁰⁵	Widespread	Honey laundering, pollen removal	Apimondia stopped competitions due to fraud.

- The UK imports 38,000 tons of honey from China, where the adulteration of honey is a known risk. In a broad European Union-led investigation spanning 18 countries, 100% of samples exported from the UK failed to meet authenticity standards. This was largely driven by cheap foreign honey (China: 74%; Turkey: 93% adulteration) being bulked, blended, and re-exported through the UK.¹¹¹
- Recent forensic tests on 30 honey samples purchased from major UK retailers and local beekeepers revealed that while 100% of the authentic UK beekeeper samples passed, 24 out of 25 (>90%) supermarket jars failed, suspected of being stretched with extraneous syrups.¹¹²
- Exploitation of vague labeling: These products are legally designated under ambiguous terms like ‘Blend of EU and non-EU honeys.’ This masks the origin of suspicious batches and allows heavily engineered

‘technical honey’ to sit on supermarket shelves at prices that undercut authentic local beekeepers.

- Bangladesh is importing Tiptree honey from the UK, but the brand is caught in a wider, highly public technical honey global honey fraud scandal involving UK-blended honey. It is frequently sourced from overseas (e.g., China, Turkey) and then blended and packaged in Britain. European Union investigations found that 100% of honey samples tested from the UK failed authenticity checks, primarily because of the addition of cheap sugar syrups derived from rice, wheat, or sugar beet (**Photo 30-33**).⁹⁰ Because Tiptree (manufactured by Wilkin & Son) is a premium imported brand widely sold in Bangladeshi super shops. These international findings have raised significant concern among local consumers about the purity of imported products (**Photo 30**).



Photo 31. Approximately 90% honey in the supermarkets is adulterated,



Photo 32. A woman showing an abnormal appearance with fake honey



Photo 33. The Great British honey scandal showing the victim appearance

④ The United States of America (USA)

- Honey fraud- encompassing fake, ultra-processed, and adulterated products- is a major issue in the United States, and millions of dollars of honey sold annually are adulterated or mislabeled.



Fig. 3. Tests reveal 50-70% of US honey is fake or adulterated in markets (Cho)

Tests and industry investigations do reveal that an estimated 50-70% of honey sold in the U.S. market is either fake, adulterated with cheap syrups, or ultra-filtered to strip out its natural pollen (**Fig. 3**).¹¹³

- Fraud ranges from ultra-filtered products with no traceable origin to ‘fake honey’ made entirely of high-fructose corn syrup, rice syrup, or artificial sugars.
- Adulterated and fake honey are frequently sold at lower prices, usually diluted with high-fructose corn syrup, beet invert sugar, or

completely artificial substitutes flavored to mimic floral notes, or are heavily filtered and processed, destroying natural enzymes and pollen and making it impossible to trace their true origin, depriving consumers of natural pollen and nutrients (**Fig. 4**).

- While the label might claim ‘raw,’ ‘local,’ or ‘organic,’ the reality is that many products on the market have been tampered with in one or more of the following ways:

☞ **Dilution of sugar and syrup:** One of the most common forms of adulteration involves diluting with

cheap sugars such as high-fructose corn syrup, rice syrup, glucose, or beet sugar. These additives not only reduce honey purity but can also cause it to ferment over time, creating alcohol levels that are unsafe, especially for children.

- ☞ **Overheating during processing:** Many manufacturers heat honey to high temperatures to prevent crystallization and improve shelf appeal, yet still market it as 'raw.' Heating destroys the naturally occurring enzymes, antioxidants, and antimicrobial compounds that give raw honey its health benefits.
- ☞ **Feeding bees sugar syrup:** Instead of letting bees forage for nectar and pollen, some products feed them high-fructose corn syrup. This shortcut results in nutritionally inferior honey that lacks the complex plant compounds found in naturally foraged honey. (Photo 8)
- If a label omits the floral source or specific country of origin, the pollen was likely removed to obscure where the honey came from.
- Industry experts and consumer watchdog groups estimate that up to 76% of commercially available honey on the U.S. grocery shelves (supermarkets) is either adulterated (diluted with corn/rice syrups) or ultra-processed to remove natural pollen (Fig. 3 & 4).^{114,115}
- Manuka honey is a brand from New Zealand and Australia, with nearly 85% of cheap fake honey labeled in the Western market (Fig. 5)



Fig. 4. Ultra-filtrate processed honey that removes all-natural pollen, hiding the origin of the honey.¹¹³



Fig. 5. Manuka honey brand of New Zealand and Australia, with nearly 85% cheap fake honey labeled in the western market

- In its sampling assignments, the FDA tested 102 samples of domestic and imported honey in the USA, and they found an overall violation rate of about 4%.¹¹⁶
- FDA testing in the United States found that 3-10% of imported honey was adulterated, with imports mainly from India, Argentina, Brazil, and Vietnam.¹¹⁶
- The FDA defines 'economically motivated adulteration' in honey as a serious food fraud problem, as it cheats consumers and undercuts domestic beekeepers.
- Much of the suspected adulterated honey enters through international channels. Importers sometimes filter out all pollen to hide the honey's true geographical origin- often evading trade tariffs- before diluting it with ultra-processed sweeteners.
- Real honey isn't cheap, and cheap honey isn't real. More than 96% of honey in UK supermarkets is likely adulterated with cheap syrups or blends; 46% of imported honey in the UK is adulterated. So, if that honey costs less than a coffee, it's probably not from bees.¹¹⁷

Fake honey brands to avoid in the US

More than 1,100 honey brands are sold in US markets. More than three-fourths of the honey sold in U.S. grocery stores isn't exactly from what the bees produce (Photo 34 & 35).¹¹⁸



More than 1,100 brands of honey are sold in the U.S. These are some of the brands Food Safety News had analyzed to see if the pollen had been removed. Photo ©Food Safety News

Photo 34. Different brands of adulterated and fake honey are sold in grocery stores in the U.S. markets



Photo 35. $>3/4^{\text{th}}$ of the honey sold in the U.S. market is adulterated and fake, which indicates that the honey market has collapsed

- 76% of the samples purchased at grocery stores had all the pollen removed, including TOP Food, Safeway, Giant Eagle, QFC, Kroger, Metro Market, Harris Teeter, A&P, Stop & Shop, and King Soopers.
- 100% of the honey sampled from drugstores such as Walgreens, Rite Aid, and CVS Pharmacy contained no pollen.
- 77% of the honey sampled from big box stores like Costco, Sam's Club, Walmart, Target, and H-E-B had the pollen filtered out.
- 100% of the honey packaged in small individual servings by Smucker, McDonald's, and KFC had its pollen removed.

Brands and types of honey that have faced scrutiny, lawsuits, or failing marks in independent testing include:¹¹⁹

- Great Value** (Walmart): Lab testing and consumer investigations have repeatedly flagged Great Value (including its Organic Raw Honey) for high HMF levels (indicating it has been overheated) and the presence of marker compounds that suggest syrup adulteration stripped of natural enzymes.
- Trader Joe's Manuka Honey**: Class action lawsuits and independent testing revealed that Trader Joe's 100% New Zealand Manuka honey tested at only around 57-63% Manuka pollen, indicating it was heavily blended or processed.
- Sue Bee**: A major brand historically linked to controversies surrounding the importation of adulterated foreign honey.
- Nature Nate's**: While a top seller, it has faced criticism and consumer scrutiny regarding its heavy processing practices, which can strip away natural pollen and nutrients.
- Billy Bee**: Subject to class-action lawsuits accusing the brand of mixing its honey with corn and rice syrups.
- Highland Naturals**: Flagged in investigations for questionable sourcing despite carrying 'pure honey' labeling.
- Berry Hill (Aldi)**: Often ultra-filtered, a process used to mask the origins of cheap imported honey (such as from China) by stripping out natural pollen.
- Publix Private Label Honey**s (especially clover and orange blossom): Store-brand honeys named in Florida fake honey lawsuits for being ultra-filtered to the point of removing all-natural pollen, which makes it impossible to verify their floral origin.
- Store-brand/Private label honey**: Brands like Good & Gather (Target), Nice (Walgreens), Signature Select (Safeway), Whole Foods 365 Organic, and Member's Mark (Sam's Club) are heavily processed or

have historically tested poorly for authentic, pollen-rich honey.

⑤ India: Starch-derived syrups and bypassing national tests

India is a major supplier of bulk honey to Western markets. The crisis of fake and adulterated honey in India remains a major concern. Investigations reveal that many packaged honey brands are adulterated with cheap, factory-engineered sugar syrups (such as rice and corn syrups) designed to bypass basic purity tests. Investigations by groups such as the Center for Science and Environment (CSE) have highlighted systemic issues involving tailored adulterants. India has established itself as an export heavyweight, acting as a crucial supply mode for North American and European packers.

The 'fake honey factory' crisis in India centers on a major food adulteration scandal where an estimated 77% of honey samples from top Indian brands failed purity tests (Photo 36). Landmark investigations and ongoing laboratory crackdowns reveal that mass-market honey is often factory-engineered rather than bee-made nectar.¹¹

- a. Rice and inverted sugar syrups: Indian brokers utilize highly clear, cheap high-fructose rice syrup (HFRS) and inverted cane sugar syrups. These syrups are mixed into genuine multifloral honeys to increase volume by 30-50% without altering viscosity or immediate taste profile.



Photo 36. 77% of Indian honey is actually sugar syrup



Photo 37. Adulterated honey seized in India.



Photo 38. What syrups are mixed in fake honey in India

- b. Pollen stripping and botanical fraud: Because India possesses highly varied floral zones, operators mask low-value or chemically altered honey by blending it with premium floral batches, using microfiltration to intentionally muddy the geographic fingerprints.¹²⁰
- c. Exploiting testing loopholes: Many major Indian brands have been caught utilizing golden syrups engineered in China or produced locally that easily clear the national Food Safety and Standards Authority of India (FSSAI) testing regulations, even though advanced German laboratory tests using Nuclear Magnetic Resonance (NMR) reveal them to be highly adulterated.
- Adulteration is so advanced that imported syrups are engineered to perfectly replicate the parameters required to pass basic Indian food tests. Foreign-made 'Chinese' syrups designed to bypass basic domestic safety tests have contributed to this food fraud.¹¹
- The German Lab findings: Landmark investigations by the Center for Science and Environment (CSE) found that up to 77% of major Indian honey brands (like Dabur, Patanjali, Baidyanath, Zandu, Hitkari, and Apis Himalaya) failed internationally accepted Nuclear Magnetic Resonance (NMR) Spectroscopy purity tests, which can detect adulteration at the molecular level.¹¹
- India mandates stricter NMR screening for honey meant for export (to countries like the US and Europe), but until recently, this high-tech testing was not universally enforced for honey sold on domestic supermarket shelves.¹²¹ However, the FDA detected adulteration in imported Indian honey.

- Uttar Pradesh Food Safety Department seized 15,000 kg of adulterated honey worth Rs 22 lakh in Hapur, India (Photo 37).¹²² Photo 38 shows the different syrups used to make fake honey in India.

Australia

The Australian honey industry, including pollination services, is estimated to be worth at least \$ 4-6 billion per annum.¹²³ The Australian honey market faces significant issues with adulterated and fake honey, often involving cheap imported syrups (like rice or corn syrup) mixed with or sold as genuine honey. Because Australia imports thousands of tons of honey, primarily from countries like China, Malaysia, and Thailand, strict authenticity and labeling have become major consumer concerns.^{124,125} Blended honey of unknown origin has been known to contain antibiotics, toxins, irradiated pollen, or even alkaloids that can cause organ damage.¹²⁶

The scale of the problem

- Important vulnerability:** In 2024, Australia imported 9 million kg of honey from countries like China, Argentina, Brazil, and India. Much of this imported honey is produced at prices below the cost of producing genuine honey, raising strong suspicion of adulteration.^{127,128}
- Imported products:** Australian border authorities test only about 5% of imported honey shipments. They largely rely on the 'C₄ sugar test,' which is decades old, and fails to detect modern adulterants like rice syrup and beet sugar.^{124,127}
- Imported blends:** Industry testing of supermarket honey found multiple pre-packed imported products were diluted with syrups instead of containing pure honey.¹²⁷
- Domestic products:** Independent scientific studies, including research by Macquarie University, previously identified that around 18% of tested Australian-branded honey samples on the market showed signs of adulteration (Fig. 6).¹²⁹

Taste test

Of the 38 honey samples sourced from supermarkets and markets, 18 per cent, or almost one in five, detected adulteration.

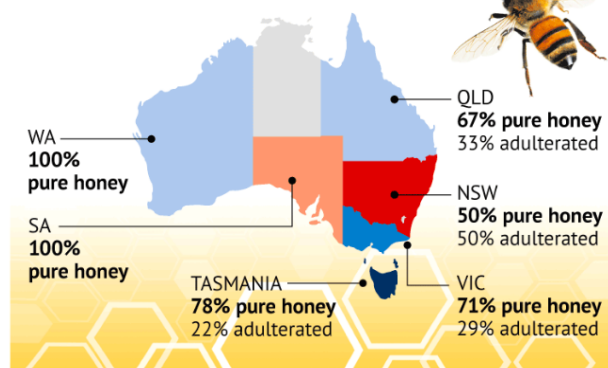


Fig. 6. Status of honey adulteration in Australia

WA = Western Australia SA = South Australia QLD = Queensland
NSW = New South Wales VIC = Victoria



Photo 39. Australian Capilano fake honey in the supermarket

- Supermarket brands:** Previous investigations, including QSI laboratory testing, highlighted adulteration in several private-label and blended brands. Affected levels included IGA's Black & Gold, Aldi's Bramwell's, and Capilano's Allowire (Photo 39).¹²⁴

Summary of honey fraud used by different countries

Honey fraud is a global issue where genuine honey is diluted with cheap sweeteners or mislabeled to mask its true origin. Fraud networks operate internationally, using tactics ranging from direct syrup adulteration to complex ‘honey-laundering’ schemes⁵⁷ Fraud mechanisms among top-producing and exporting nations generally involve dilution, origin deception, and bee manipulation. Table 9 summarizes the most common honey fraud methods and the regions or countries associated with honey fraud and adulteration.

Table 9. Summary of the most common honey fraud methods and region or countries associated with them		
SN Country/Region	Honey fraud methods	Description and impact
① China & East Asia (Major exporters)	Syrups adulteration & origin masking	Bulking honey with C ₃ /C ₄ plant syrups (rice, wheat, corn) and feeding bees sugar water. Massive amounts of technical honey’ are produced and often routed through third-party countries to avoid tariffs.
② Transshipment Hubs (e.g., India, Thailand, Malaysia, Russia)	Paperwork fraud & ‘honey laundering’	Acting as middlemen to disguise the geographical origin of cheap or contaminated Chinese honey. Counterfeit documents are used to evade anti-dumping duties and hide potential antibiotic contamination.
③ European Union (e.g., UK, Germany, Austria)	Ultrafiltration and bulk blending	Stripping honey of pollen and wax through ultra-filtration so its botanical origin feature cheap ‘blends’ cut with foreign artificial syrups.
④ United States	Bypassing tariffs & syrup dilution	Historically the site of the largest honey fraud cases (‘operation honey-gate’). While major import crackdowns have occurred, undeclared added syrups remain an issue in imported bulk and retail batches.
⑤ Australia	Mislabeled origin & syrup dilution	Dilution with foreign/cheaper syrups and mislabeling standard honey as highly premium, native varieties (e.g., Manuka or specialized eucalyptus honey (Capilano).
⑥ South America (e.g., Argentina)	Counterfeiting and mislabeling	Exporting genuine but cheaper bulk honey used by international packagers to dilute local, higher-priced honeys or mislabeled entirely in destination markets.

Honey contamination

Honey contamination encompasses both environmental pollutants (pesticides, heavy metals) and intentional food fraud (dilution with cheap sugar syrups). Honey can also harbor harmful bacteria; it poses severe health risks and is particularly dangerous for infants under one year old, who are highly susceptible to botulism.¹⁹ Understanding the types and primary sources of contaminants, their health risks, and prevention strategies is essential for identifying potential risks in the food supply chain.

Common contaminants and hazards

- Sugar syrups and adulterants: Cheap syrups (like corn or cane sugar) are frequently used to dilute or launder honey. This cheats consumers and robs honey of its natural health benefits.¹⁷
- Antibiotics: Beekeepers sometimes use veterinary drugs and antibiotics to treat hive diseases, leaving chemical residues in the final product.¹³⁰
- Pesticides and heavy metals: Because bees forage across wide areas, honey can absorb toxins like lead, cadmium, and neonicotinoid pesticides from the surrounding environment.¹³¹
- Microbial risks: Raw honey can contain *Clostridium botulinum* spores. While harmless to adult digestive systems, it can cause severe, life-threatening infant botulism.¹⁹

① Agricultural pollutants

Agricultural pollutants contaminate honey when foraging bees collect nectar, pollen, and water from

treated or polluted environments. Key pollutants include pesticides (neonicotinoids, organophosphates), heavy metals (lead, cadmium), microplastics from agricultural films, and antibiotics (Fig. 7).¹³² Bees passively collect pollutants from their surroundings, which include:

Synthetic pesticides and herbicides:

- Insecticides:** Neonicotinoids (e.g., acetamiprid, clothianidin), organophosphates, and pyrethroids applied to crops are frequently tracked back into the hive by bees, resulting in chemical residues in the final honey products.
- Herbicides and Fungicides:** Weed killers (such as glyphosate) and crop fungicides can also accumulate in beebread and honey during foraging (Fig. 7).¹³³

② Heavy metals and toxic elements

- Pollutants from synthetic fertilizers, livestock manure, and nearby agro-industrial runoff introduce toxic heavy metals, such as lead (Pb), cadmium (Cd), copper (Cu), and zinc (Zn) into soils and water sources.
- Bees collect contaminated water or forage on plants that have absorbed these elements, passing them into the honey (Fig. 7).¹³²

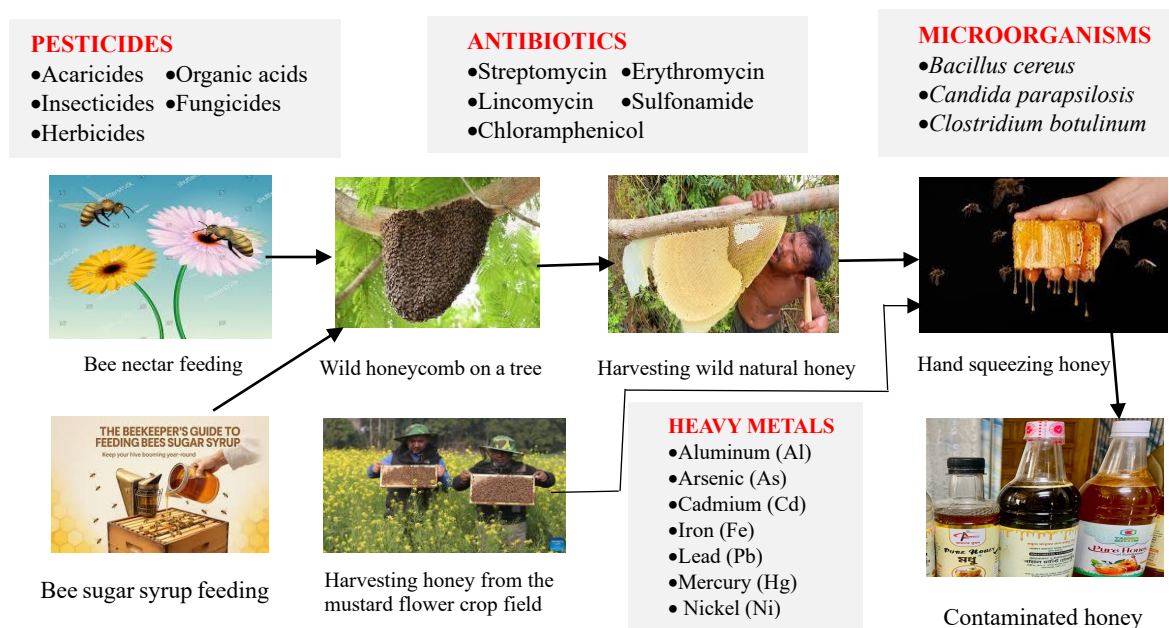


Fig. 7. Main sources of bee honey contamination and residues

③ Veterinary residues

- Medications:** Using antibiotics (e.g., tetracyclines, sulfonamides) to treat bacterial diseases in agricultural livestock can contaminate soil and water, inadvertently transferring these drugs into honey.¹³⁰
- Miticides:** Although beekeepers use miticides to protect hives from parasites, residues from these treatments also significantly contaminate commercial honey.

④ Microplastics and agricultural plastics

- Sources:** The heavy use of polyethylene films and biodegradable plastics in modern agriculture breaks down into microplastics
- Impact:** Bees inadvertently carry airborne microparticles and microfibers back to the hive, physically contaminating the honey supply.¹³⁴

⑤ Persistent organic pollutants (POPs)

- Sources:** Legacy chemicals and certain synthetic compounds that degrade very slowly persist in agricultural soils and water.
- Impact:** Compounds like polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCs) bioaccumulate in the environment and eventually find their way into honey.¹³⁵

⑥ Industrial adulteration (Fake honey)

- Industrial honey adulteration is the practice of diluting or completely replacing natural bee honey with cheap syrups like corn, rice, or beet syrup.
- It is one of the most common food frauds globally, with some studies and regulatory actions finding adulteration rates in commercial products ranging from 10 to 50%.¹³⁶

⑦ Safety tips and guidelines

- Infant safety:** Never feed raw honey- regardless of the brand- to babies under 12 months old, as their digestive tracts cannot process *Clostridium botulinum* spores, which can lead to infant botulism.
- Quality and spoilage:** Watch for spoilage such as unusual separation, layers of foam on top, or a fermented odor.
- Buying smart:** To avoid diluted or low-quality products, consider sourcing honey directly from local beekeepers or reputable brands with transparent testing records.

Honey contaminants and consumer health risks

Honey is a high-value natural product that is often adulterated or contaminated during production and processing, thereby reducing its nutritional and medicinal value and posing significant health risks to consumers (Fig. 8).¹³⁷ It is a growing global concern and is usually unintentional, arising from environmental or handling factors. Studies show that honey can be contaminated with pesticides, heavy metals, antibiotics, and persistent chemicals such as PFAS, often due to environmental pollution, agricultural practices, or processing adulteration.¹³⁸

① Pesticides

- Examples: acaricides, organic acids, insecticides, fungicides, and herbicides (Fig. 7).
- Environmental pesticide contamination in honey occurs when bees forage on crops treated with chemicals, or when beekeepers use medications to treat hive mites. Pesticide contamination in honey, often transferred from flowers or agricultural pollen, poses significant health risks.
- Acute exposure to higher concentrations can cause sudden toxic reactions like excessive sweating, nausea, vomiting, diarrhea, muscle twitches, and skin rashes, and in severe cases, shock or respiratory failure.
- Chronic exposure to pesticide residues is linked to more severe issues, including neurological disorders, endocrine disruption, an increased risk of certain cancers, and immune and cellular damage.¹³⁰
- Vulnerable populations- infants, pregnant women, and farm workers are highly susceptible to the effects of pesticide toxicity.

② Antibiotics

- Examples: Streptomycin, Erythromycin, Lincomycin, Sulfonamide, and Chloramphenicol
- Antibiotic contamination in honey primarily occurs when beekeepers use veterinary drugs to prevent or treat bacterial bee diseases, such as foulbrood (Fig. 7).
- Consuming these residues poses direct public health risks, including severe allergic reactions, the promotion of antimicrobial resistance, and long-term toxicity.
- Antibiotic resistance (AMR): Regularly ingesting trace amounts of antibiotics such as tetracyclines, sulfonamides, and fluoroquinolones can selectively kill susceptible bacteria in the human gut while allowing resistant strains to survive and multiply. This contributes to the global public health crisis of antibiotic ineffectiveness.¹³⁹

③ Microorganisms

- Examples: *Bacillus cereus*, *Candida parapsilosis*, and *Clostridium botulinum* (Fig. 7).
- Honey contains dormant or transient microorganisms, primarily originating from bee microbiomes, pollen, or environmental dust. The primary hazards are *Clostridium botulinum* spores, the *Bacillus cereus* groups, and various molds and yeasts. While honey's low water content and acidity inhibit bacterial replication, surviving pathogens and spores, most notably *Clostridium botulinum* and *Bacillus cereus*, pose significant public health risks.¹³¹

a. *Clostridium botulinum*

- Honey is a primary dietary vehicle for *C. botulinum* spores, which can survive for years in a dormant state.

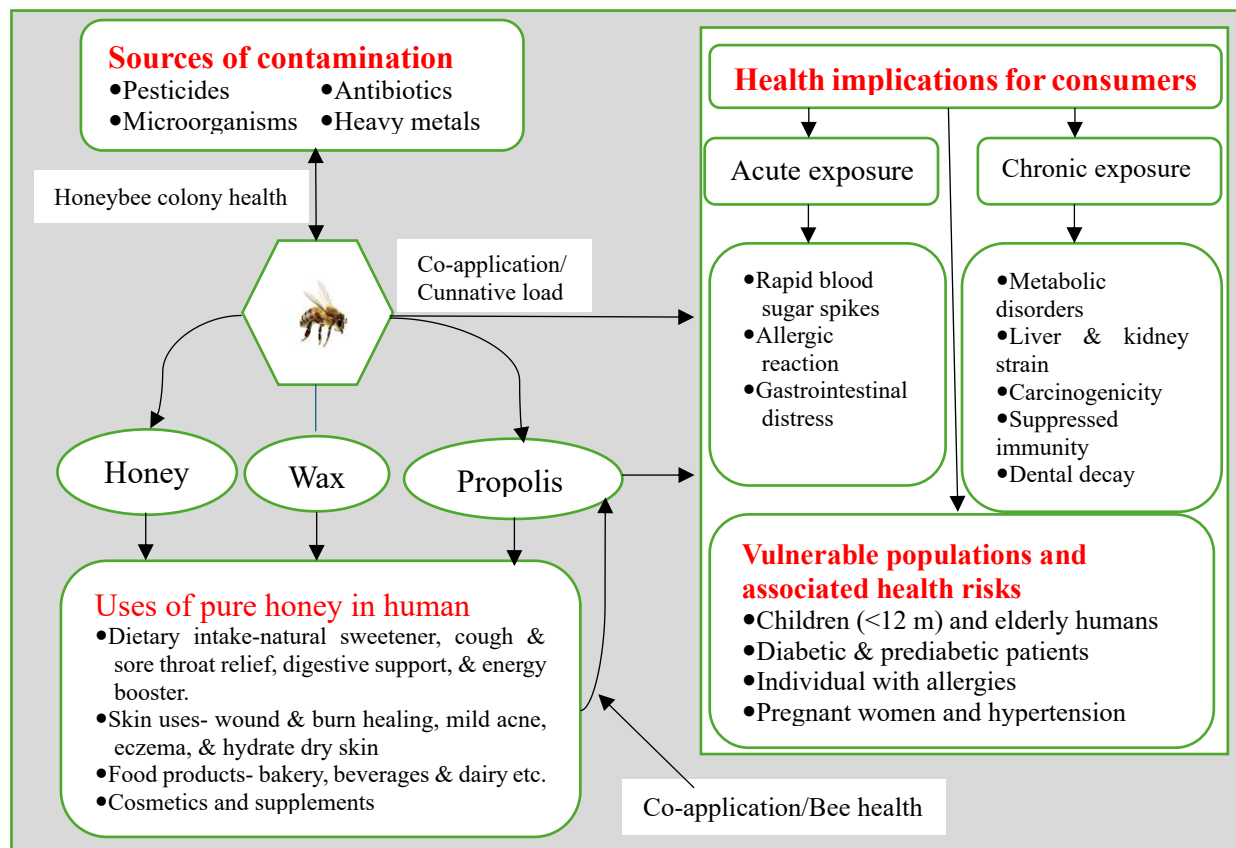


Fig. 8. Consumer health risks from contamination in bee products

- Ingestion of raw honey is strongly linked to infant botulism because infants lack fully developed intestinal microflora; these spores can germinate and produce botulism toxin in the gut, leading to paralysis, respiratory failure, or death.^{131,140}
- The Centers for Disease Control and Prevention and global health organizations explicitly recommend that no infant under 12 months be fed honey (raw or processed).

b. *Bacillus cereus* group

- As spore-forming bacteria, *B. cereus* and *B. pumilus* are highly prevalent in honeycomb, pollen, and commercial honey.
- While they typically do not multiply in properly stored honey, ingestion of high loads can cause foodborne illness characterized by vomiting or diarrhea due to toxin production.¹³¹

c. Molds and yeasts (Fungal contamination)

- Airborne fungal spores, yeasts, and molds are frequent secondary contaminants from dust, equipment, or unhygienic harvesting practices.
- While most are harmless, opportunistic molds like *Aspergillus* and *Penicillium* can produce mycotoxins, which pose severe long-term health risks, particularly for immunocompromised or vulnerable individuals.

d. Environmental and secondary pathogens

- *Escherichia coli* and *Salmonella* can contaminate honey through unhygienic handling, processing, or contact with contaminated water sources by beekeepers.¹⁹
- Although honey’s antibacterial properties generally inactivate these vegetative bacteria over time, they serve as key indicators of poor sanitary quality and can trigger acute gastroenteritis if consumed.¹⁴¹

e. Mitigation and safety

- While pasteurization (such as gamma irradiation or heat treatment) can eliminate certain spores and vegetative cells, it is generally impractical for eradicating highly resilient *C. botulinum* spores. Therefore, sanitary handling and consumer awareness remain the most effective methods to prevent illness.

④ Heavy metals

- Examples: Aluminum (Al), Arsenic (As), Cadmium (Cd), Iron (Fe), Lead (Pb), Mercury (Hg), and Nickel (Ni).
- Heavy metal contamination in honey, primarily from industrial pollution, mining, and agricultural pesticides, poses both non-carcinogenic and carcinogenic risks to human health. While bees naturally act as a partial barrier to heavy metal migration, chronic ingestion of contaminated honey can lead to severe cumulative toxicities.¹³¹

Key honey contaminants and human health impact

Chronic dietary exposure to these metals threatens to cause nephrotoxicity, cardiotoxicity, and elevated lifetime carcinogenic risks.¹⁴² The primary toxic heavy metals found in contaminated honey and their respective health risks include:¹³¹

- Lead (Pb): Prolonged exposure impairs the DNA repair system and is linked to renal cell carcinoma (kidney cancer). It also heavily contributes to developmental toxicity in children.¹⁴³
- Cadmium (Cd): Chronic ingestion is heavily associated with nephrotoxicity (kidney damage) and bone demineralization, leading to conditions like osteomalacia.¹⁴⁴
- Arsenic (As): Known to cause endocrine disorders, immune system dysfunction, and genetic toxicity.¹⁴⁵
- Chromium (Cr): Some oxidative states of chromium in the diet are associated with a moderate lifetime carcinogenic risk.¹⁴³
- Mercury (Hg): Bioaccumulates in the body and causes neurotoxicity, leading to symptoms like tremors, fatigue, and memory problems.¹⁴⁶

Honeybee diseases and human health risks

Honeybee diseases severely threaten colony health and agricultural pollination. The most common threats are classified as microorganisms and parasitic vectors, such as the varroa mite. These human infections with honeybee diseases are exceedingly rare and primarily affect individuals who are immunocompromised premature infants, or those with severe underlying conditions. Table 10 presents the specific honeybee diseases with their key symptoms.

① Bacterial diseases

a. American foulbrood (AFB)

AFB is caused by the Gram-positive *Paenibacillus* larvae, a spore-forming bacterium, and is highly contagious; it kills developing larvae, turning them into a dark, ropy mass.

Symptoms

Only a few honeybee brood cells may be affected in their early stages. So, AFB can be difficult to identify

early in the disease process. When infected brood cells are opened, they contain a creamy-to-dark brown liquid. Using a toothpick or matchstick to probe a brood cell during an inspection, you can draw out a dead larva along with dark brown, sticky, stringy liquid threads. This is called the matchstick test (Photo 40). Caps of infected brood cells become concave and punctured (arrows: Photo 41).

As infection severity increases, the colony population substantially decreases. Some colony members may become either lethargic or aggressive. The hive will have a distinct bad-smelling odor, giving the disease the name foul.¹⁴⁷

Table 10. Common pathogens causing diseases with symptoms in honey bees ¹⁴⁷⁻¹⁵¹

SN	Diseases	Causal agents	Target stage	Key symptoms
①	American Foulbrood	Paenibacillus larvae (Bacterium)	Brood (larvae/pupae)	Sunken, punctured cappings; decaying larvae turn into a dark gooey, ropey mass with a foul sulfurous odor.
②	European Foulbrood	Melissococcus plutonius (Bacterium)	Brood (mostly unsealed)	Uneven brood pattern; dead or discolored (yellow/brown) larvae twisted in cells; sour odor.
③	Chalkbrood	Ascosphaera apis (fungus)	Brood (larvae)	Larvae mummify and harden into chalky white or black lumps.
④	Stonebrood	Aspergillus spp. (fungus)	Brood & adults	Larvae turn into hard, stony, greenish-yellow or black ‘stones.’
⑤	Nosemosis (Nosema disease)	Nosema apis & N. ceranae (Microsporidian fungus)	Adults	Dysentery (fecal spotting in/on the hive); reduced honey production and shortened worker lifespan.
⑥	Deformed Wing Virus (DWV)	Deformed Wing virus (Flaviviridae)	Adults & Pupae	Shriveled or deformed wings; shortened abdomens, crawling bees near the hive entrance. Often vectored by Varroa mites.
⑦	Sacbrood	Sacbrood virus (Picornaviridae)	Brood (larvae)	Larvae fail to pupate, turning into a fluid-filled, sac-like structure with a pointed, dark head.
⑧	Chronic Bee Paralysis	Chronic Bee paralysis virus (Cripaviridae)	Adults	Shivering, hairless, dark, greasy-looking bees; inability to fly; trembling on the ground.
⑨	Varroosis	Varroa destructor (Parasitic mite)	All stages	Visible reddish-brown mites on adult bees; spotty brood patterns, vectors numerous viruses.

Treatment

- AFB shows widespread resistance to the antibiotics oxytetracycline and sulfathiazole, but not strong resistance to Terramycin or Tylosin.
- It forms highly resilient spores, and infected hives and equipment often need to be burned or scorched.

b. European foulbrood (EFB)

EFB is a disease of bee larvae caused by the Gram-positive, non-spore-forming bacterium *Melissococcus plutonius*, which mainly affects the capped brood and causes death globally.

- Adult bees and honey can act as vectors, transporting bacteria between hives and apiaries.
- Infection occurs when bees ingest contaminated food containing the bacterium.
- Once in the bee’s midgut, the bacterium multiplies and damages epithelial cells and the peritrophic matrix.
- Infected adult bees transmit it to younger larvae. Within the bee colonies, they exhibit abnormal distribution and undergo a progressive color change, transitioning from white to yellow and eventually turning brown as they enter the final decomposition phase.

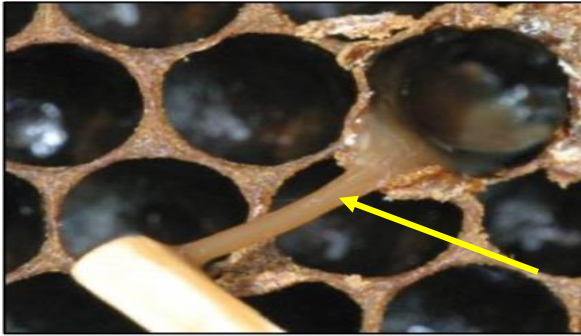


Photo 40. AFB: dead larva showing the dark brown sticky, stringy liquefied threads in a cell, demonstrated by the 'natchstick' test.¹⁴⁷

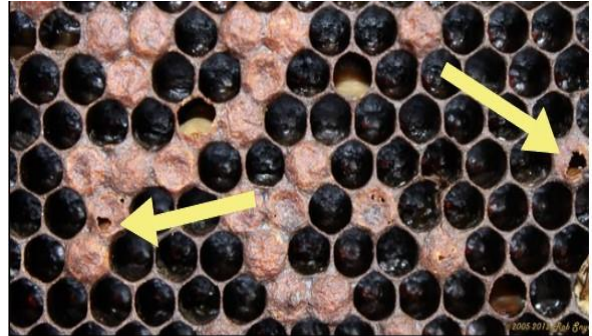


Photo 41. AFB: Caps of infected brood cells become depressed, concave, and some are punctured (arrows) as typical of AFB.¹⁴⁷

Symptoms

- EFB targets and kills non-capped brood, usually within 4-5 days, leaving them stretched and displaced in their cells. Infected larvae usually become soft and initially appear pearly white but later turn yellow and eventually brown or even dark brown (arrows: Photo 42).



Photo 42. EFB-affected honeybee larvae initially turn from white to yellow and eventually to a brown color.¹⁴⁷



Fig. 43. Spiroplasma-affected bees showing signs of crawling, paralysis, quivering, and an inability to fly.¹⁵²

- Larvae are always killed before pupation, generally 1-2 days before capping. The larvae dry out and shrink, forming malleable, flat scales within their cells.
- The brood pattern becomes spotty and erratic, and in severe cases, symptoms can resemble AFB.
- When large portions of the brood become infected, the colony emits a sour odor.

Diagnosis

- Accurate diagnosis of EFB relies on a combination of clinical examination and molecular methods.
- Characteristic symptoms exhibited by infected larvae include discoloration, sunken or disintegrated larvae, twisted larvae, foul odor, and a reduced brood pattern.
- Gram staining of the smears and microscopic examination of bacterial cells of *M. plutonius*.
- Molecular techniques like PCR, RT-PCR, or quantitative PCR, and DNA sequencing can identify the agent

Treatment

- Oxytetracycline is the only FDA-approved drug for treating EFB.
- EFB is less severe than some other bacterial diseases of bees; many beekeepers will try alternative approaches before resorting to antibiotics.
- In moderate cases, EFB can be treated by feeding protein-rich resources, such as pollen patties.

Human impact

Several species (such as *P. alvei* and *P. lautus*), which originate in bee hives or the broader environment, are increasingly recognized as opportunistic human pathogens. In adults, they have been linked to bacteremia, urinary tract infections, and localized wound or joint infections, often in patients with chronic kidney disease. In infants, they have been reported to cause severe conditions like neonatal sepsis, meningitis, and brain abscesses.¹⁵³

Differences between American and European Foulbrood

American and European foulbrood are highly contagious bacterial infections that affect developing honeybee larvae and differ primarily in their bacterial etiologies, the developmental stages they infect, and the management required (Table 11).

Table 11. Comparison of American foulbrood and European foulbrood in honeybees ¹⁵⁴			
SN	Feature	American foulbrood (AFB)	European foulbrood (EFB)
01.	Causative agent	<i>Paenibacillus larvae</i> (spore-forming)	<i>Melissococcus plutonius</i> (non-spore forming)
02.	Stage of larva affected	Older larvae or young pupae	Younger un-capped larvae (usually 4-5 days old)
03.	Brood pattern	Spotty, uneven, 'pepper box' or 'shotgun' pattern.	Spotty or irregular brood pattern
04.	Cell cappings	Sunken, darkened, greasy-looking, and often punctured/perforated.	Often uncapped (death occurs before capping); some sunken cappings in late stages
06.	Larva color	Dull white to light brown, then coffee brown, to dark brown or almost black.	Dull white to yellowish white, then turning to brown or almost black.
07.	Larva position in cell	Upright and uniform on the lower side of the cell wall	Curled, twisted, or controlled (often towards the front of the cell)
08.	Odor	Pronounced, distinctive gluepot or Sulfur-like smell.	Slightly sour to penetratingly sour/fishy.
09.	Ropiness test (Matchstick)	Highly ropy/stringy; can stretch out 3-5 cm when pulled.	Rarely ropy or sticky; if slightly ropy, threads are usually less than 1.5 cm.
10.	Scale characteristics	Black scale, brittle, and adheres tightly to the cell wall.	Black or dark brown scale rubbery, and easily removed
11.	Persistence and severity	Highly resistant; spores can remain viable for decades; generally fatal to the colony.	Less severe; can sometimes recover on its own or through improved nutrition.
12.	Standard management	Often requires the destruction of the colony (burning) and equipment.	Can often be cleared up by requeening or through the use of antibiotics.

c. Spiroplasma species

- Spiroplasma species are helical, cell-wall-less bacteria that can act as pathogens in honeybees, notably *Spiroplasma apis* and *S. melliferum*, which cause neurological conditions known as 'crawling disease' or 'May disease' in honeybees.¹⁵⁵
- Transmission occurs through the oral-fecal route via contaminated food sources like nectar, pollen, and royal jelly; flower surfaces; and occasionally through Varroa destructor mite bites or via vertical transmission.¹⁵⁶

Symptoms

- *Spiroplasma apis*: Linked historically to 'May disease,' primarily in Europe. Symptoms include neurological distress (paralysis, trembling), swollen abdomens, and an inability to fly (Photo 43), usually resulting in bees crawling on the ground outside the hive, and eventual high mortality, which can significantly drop honey production.¹⁵²
- *S. melliferum*: More prevalent in North and South America, as well as China (where it is known as 'bee

crawling disease’). It causes adult bee mortality and increases susceptibility to other pathogens.¹⁵⁶

- Spiroplasmas are ubiquitous in the environment and conditional pathogens; keeping colonies strong is the best defense. Experts recommend adhering to good veterinary practices, maintaining optimal colony immune health, and implementing general management procedures to mitigate stressors.¹⁵²

Human impact

In highly rare instances, particularly in immunocompromised individuals or patients with agammaglobulinemia (an immune disorder), these pathogens have caused disseminated infections. Cases have manifested as septicemia, arthritis, uveitis (eye inflammation), and tenosynovitis.¹⁵⁷

② Viral diseases of the honeybee

Single-stranded RNA viruses are highly infectious pathogens of honeybees; about 20 bee-identified viruses, that is, Sac-brood virus (SBV), Deformed-wing virus (DWV), Kashmir-bee virus (KBV), Israeli-acute-paralysis virus (IAPV), Chronic-bee-paralysis virus (CBPV), Acute-bee-paralysis virus (ABPV), and Black-queen cell virus (BQCV). KBV, IAPV, and ABPV complex viruses have been reported to cause several colony losses and bee mortality.¹⁵⁸

Mite-transmitted virus diseases in honey bees

Many honey bee viruses naturally persist as covert, harmless infections, but become lethal when transmitted or activated by parasitic Varroa mites. Varroa mites (*Varroa destructor* and *Varroa jacobsoni*) act as both mechanical and biological vectors for several viral diseases in honey bees. These viruses and Varroa mites are the most significant biological threats to honey bees globally. Feeding on the developing brood and adult bees, the mite weakens the host’s immune system and acts as an efficient vector for numerous viral diseases. They transmit these pathogens directly into the bee’s hemolymph while feeding. This combination of parasitism and viral infection compromises the bee’s immune system, which can frequently lead to colony collapse if left unmanaged.¹⁵⁹ Additionally, mites act as highly effective vectors for several devastating viruses, transforming otherwise mild covert infections into lethal, highly prevalent diseases.¹⁶⁰ Table 12 compares the specific virus diseases spread or exacerbated by Varroa mite infestations.^{159,161}

a. Deformed wing virus

- Adult honeybees are reservoirs of Deformed wing virus (DWV), and it is transmitted directly to honeybees by the Varroa mite (*Varroa destructor*). As Varroa mite numbers increase, virus spread also increases.
- Regular sampling for *V. destructor* is important. This virus reproduces and proliferates within the mite.
- This virus can also be spread directly by an infected queen to her eggs and may also be sexually transmitted by drones.

Symptoms

Wings are often deformed and stubby, and affected bees cannot fly (Photo 44). The abdomen is usually discolored and shortened. Guard bees may remove deformed bees from the hive. Pupae often die and may remain in uncapped cells. In uncapped cells, they may show signs of having been chewed on by other bees.

Treatment and Control

- To retard or stop virus spread, mites can be killed with commercially available insecticides called acaricides.
- Apply treatments before the honeybee colony enters its overwintering stage.
- Some commercial acaricides are formulated to slowly emit toxic miticidal vapors from acaricide-containing plastic or other types of absorbent strips. These strips emit mite-killing vapors while not harming honeybees.

Table 12. Comparison of viral diseases of honey bees transmitted by Varroa mite infestation ¹⁶²⁻¹⁶⁴				
SN	Virus disease	Target stage	Key symptoms in bees	Mite role and impact
01.	Deformed wing virus (DWV)	Pupae, Adults	Shriveled, stubby, or deformed wings; shortened abdomens, crawling bees unable to fly, and drastically shortened lifespan	Mites act as biological vectors, oral & vertical (queen to egg) transmission. Virus replicates inside the mite before being injected directly into hemolymph.
02.	Acute bee paralysis virus (ABPV)	Pupae, Adult	Inability to fly, trembling, and hair loss, & rapid mortality of both pupae and adult bees, contributing the colony's dwindling.	Mite vectoring- ingestion and vertical transmission. Mite vectors transmit virus directly into the hemolymph, by passing normal immune barriers.
03.	Kasimir bee virus (KBV)	Pupae, Adult	Often remains an inapparent infection but explodes to lethal levels when vectored by mites. Similar to acute paralysis, trembling, and paralysis.	Mite vectoring and oral-fecal transmission. The virus is highly lethal when injected directly into the hemolymph by mite feeding.
04.	Israeli acute paralysis virus (IAPV)	All stages	Trembling, hairless, and darkened bodies, and paralysis. Strong marker for colony collapse disorder (CCD).	Transmitted by mites across all life stages. Weakens adult bees and contributes to rapid colony decline.
05.	Sacbrood virus (SBV)	Larvae, Adults	Larvae fail to pupate and turn into a fluid-filled sac (easily removable scale); affects both brood and sometimes adults. Darken heads.	Mites, which mechanically carry direct vectoring by Varroa is less understood, than DWV or ABPV. Primary kills larvae, weakening the future worker population.
06.	Black queen cell virus (BQCV)	Pupae	Developing queen larvae turn yellow and then darken/turn black; pupae die.	Frequently present with high mite level; mostly transmitted orally. Kills developing queen pupae, Limiting colony reproduction.



Photo 44. DWV-affected worker bee showing deformed and stubby wings with a crumpled appearance compared with the wings of normal workers.¹⁵⁰



Photo 45. ABPV-affected hairless bodies of worker bees suffering from acute paralysis (arrows)¹⁵⁰

b. Acute bee paralysis virus (ABPV)

- ABPV reproduces and accumulates in the brain and the food-producing glands of honeybees.
- Adults and larvae infected by virus transmission from Varroa mites die quickly.

- Acute paralysis alone rarely kills entire colonies, but when transmitted by Varroa mites, ABPV can cause colony collapse.

Symptoms

- Honeybees are seen walking on the ground (usually in large numbers) around the hive rather than flying and gathering at the hive entrance.
- Abnormal wing positioning is apparent, with wings at different angles. Wings may exhibit trembling.
- Loss of abdominal hair also occurs along with a greasy look to the bee's abdomen (Photo 45)
- Abnormally high brood mortality in capped cells also occurs. ABPV also causes the early death of infected honeybees.

Prevention

- Good sanitary practices, good husbandry, and controlling Varroa mites can reduce or prevent virus spread.
- Sanitary practices include cleaning gloves and hive tools with alcohol before inspecting each new hive for disease, and freezing stored honeycomb for at least 24 hours to kill disease organisms.
- Use only sanitized (flame-treated or chemically disinfected) hive components and minimize transfer of frames between active hives.

c. Sacbrood virus (SBV)

- SBV is a common disease of apiaries worldwide; it is not fatal to a colony, but weakens colonies and slows their growth. SBV becomes particularly concerning when associated with severe Varroa mite infestations.
- Bees directly transmit the virus while tending larvae, contaminated bees return from foraging, and beekeeping activities spread it. The virus can spread rapidly, killing thousands of workers.

Symptoms

- Symptoms can be difficult to detect because healthy bees will quickly remove dead bees and dead brood from the hive. If present, the virus will cause fluid to accumulate in the sac around a dead larva, producing a pale-yellow appearance (Photo 46 & 47).



Photo 46. Tip of SBV-infected honeybee larva within its cell ¹⁵⁰



Photo 47. SBV-infected honeybee larva (in its sac) removed from its cell ¹⁵⁰

- The sacs are full of SBV liquid and are fragile and easily broken open, spreading the virus.
- If primary-infected dead bees are not removed from their cells, they soon become dark and sticky,
- Eventually, nearby healthy larvae become secondarily infected through contact with primary-infected larvae, then die, dry out, and shrink into a flattened, curved, gondola-shaped scale within their cell.

Prevention and Control

- Sanitary practices and food supplements, particularly protein, are usually enough to help a colony recover.

- Careful removal of infected brood and control of Varroa mites also help control SBV.
- If the infection of the brood increases to $\geq 20\%$ of the brood population, the entire colony should be burned to prevent the spread of SBV to other colonies.
- Sanitizing all equipment and tools and cleaning hives will limit the spread of SBV.
- Always use clean, sanitized hive boxes and frames when establishing new hives.

③ Fungal pathogens

Pathogenic fungal infections in honeybees primarily affect the developing brood (larvae and pupae) and the adult populations, causing significant colony losses and reduced honey yield. The most notable fungal pathogens include *Ascosphaera apis* (chalkbrood), various *Aspergillus* species (stonebrood), *Nosema apis* and *Nosema ceranae* (Nosemosis), and the recently studied *Rhizopus oryzae*.¹⁶⁵ Table 13 compares common fungal infections of honey bees

Table 13. Comparison of common fungal infections in honey bees ^{166,167}				
SN Disease	Pathogen	Target stage	Key symptoms/ Physical signs	Environmental triggers
① Chalkbrood	<i>Ascosphaera apis</i>	Larvae (typically 3-4 days old)	Dead larvae turn swollen, covered in white fluffy mold, and eventually dry out into hard, chalk-like mummies (white, brown, or black).	Cool, damp, and poorly ventilated hive conditions.
②. Stonebrood	<i>Aspergillus</i> spp. (e.g., <i>A. flavus</i> , <i>A. fumigatus</i>)	Larvae, pupae, and adult bees	Larvae shrink, mummify into hard, brittle 'stones' and turn dark. The interior may be filled with powdery green or yellow fungal spores.	High humidity, which facilitates spore germination and fungal growth.
③. Nosemosis	<i>Nosema apis</i> , <i>N. ceranae</i>	Adult bees	Shortened lifespan, crawling/flightless bees, dysentery/fecal spots on the hive, and rapid dwindling of colony population.	Highly prevalent worldwide. Fungal species multiplying in the mid-gut.
④ Mucomycosis (Brood rot)	<i>Rhizopus oryzae</i>	Worker larvae	Infected larvae change color from dark brown to black and die rapidly (within 24 hours of high-concentration exposure)	Exposure to high spore concentrations and potentially other environmental stresses on pollinators.

Note: While *Nosema* disease is an economically devastating pathogen of adult honeybees and is frequently classified as a fungal pathogen (microsporidia), it is biologically distinct from brood-killing fungi and targets the digestive tract.¹⁶⁸

① Chalkbrood (*Ascosphaeriosis*)

Chalkbrood is a fungal disease of honey bee larvae caused by the spore-forming fungus *Ascosphaera apis*, and it causes developing larvae to die and turn into hard, chalk-like 'mummies,' ultimately weakening the colony and reducing honey yield.^{169,170}

Epidemiology

Stress and environmental factors, such as dampness, cold conditions, or poor hive ventilation, trigger the disease. It commonly affects weak or less populated colonies that struggle to maintain optimal brood temperatures.¹⁷¹

- **Infection:** Larvae ingest fungal spores along with their food. The spore germinates in the larva's gut, producing cotton-like threads (mycelium) that feed on the larva for food and eventually kill it.
- **Mummification:** After the larva dies (usually after the cell is capped), the fungus completely engulfs the body, transforming it into a hard, shrunken, chalk-like 'mummy' (Photo 48).
- **Spreading:** The mummies turn from white to gray or black as the fungus produces fruiting bodies that can remain infectious in the hive for several years. Nurse bees spread spores throughout the hive while

feeding larvae, or between hives via drifting drones, robbing, and contaminated combs.



Photo 48. Chalkbrood-affected worker honeybee with mummified larvae, in which the infection kills affected bees, giving their bodies a chalky white appearance ¹⁷²

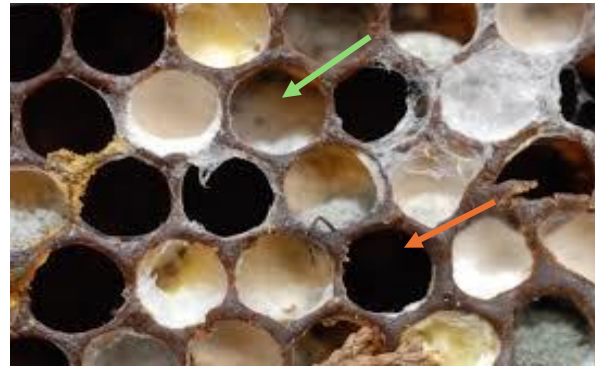


Photo 49. Stonebrood- affected dead honeybee larvae become difficult to crush, resembling small stones covered with powdery conidia, which are yellow, brown, and black in color

Triggers and susceptibility

- **Stress and climate:** The disease is often triggered by environmental stressors, such as dampness, cold, or poor nutrition. Outbreaks are highly driven by cool, damp weather and temperature stress, which compromise the colony's ability to keep the brood warm. ¹⁷³
- **Weak colonies:** Hives or colonies lacking enough adult bees to maintain a consistently warm brood temperature are highly susceptible.
- **Drone brood:** Drone larvae are frequently the most affected, as they tend to develop on the cooler margins of the brood chamber. ¹⁷¹

Symptoms

Larvae ingest spores with their food, and the fungus grows in the midgut, eventually killing the larva and turning it into a hard, chalk-like, white, brown, or black mummy. ¹⁷⁰

- **Mummies:** The first obvious sign is the presence of hard, white, gray, or black mummies scattered in the cells, on the bottom board (floor), or piled outside the hive entrance. As they dry out and the fungus produces spores, they shrink and turn grey or black.
- **Brood pattern:** The brood pattern looks patchy and uneven. Capped cells may appear perforated. Hives often show a spotty brood pattern with perforated cappings.
- **Rattle:** If a frame with infected cells is carefully shaken, a characteristic rattle may be noticed from the loose cells.
- **Bottom board debris:** Adult bees attempt to clean out dead larvae, resulting in piles of mummified larvae or bees that accumulate on the bottom board or outside the hive entrance.

Management and Control

No specific chemical treatment cures chalkbrood. Instead, control focuses on good beekeeping practices to reduce stress and improve the bees' natural defenses.

- **Strengthen the hive:** Add frames of capped brood and bees from a stronger, healthier colony to help the bees maintain hive temperature and clean out infected cells.
- **Requeening:** This is widely considered the primary long-term solution. If a colony is chronically susceptible, replacing the queen introduces genetics with better hygienic behavior to remove the mummies.
- **Improving ventilation and sunlight:** Ensure the hive is in a sunny area, and consider reducing the entrance size or increasing ventilation to help bees manage damp, stagnant air.
- **Clean the hive:** Remove and safely dispose of old combs that act as spore reservoirs, and clean out accumulated mummies from the bottom board.

② Stonebrood

- Stonebrood is a rare, fatal fungal disease affecting honey bee brood and adults, primarily caused by the fungi *Aspergillus flavus* and *Aspergillus fumigatus*, which is characterized by larvae turning into hard, stone-like ‘mummies’ covered in powdery spores.¹⁷¹
- *A. flavus* has most frequently been reported to cause the disease, followed by *A. fumigatus*, but *A. niger* and other aspergilli can also affect honey bees.
- Species of *Aspergillus* that produce aflatoxin are suggested to be the primary cause of death in stonebrood-infected honey bees.

Epidemiology

- Larvae typically become infected by ingesting fungal spores with their food or by direct penetration of the cuticle. Millions of spores (conidia) are easily released into the hive air and can spread between colonies during robbing or drifting.¹⁷¹
- Worker bees often discard the dead brood, but the spores can remain infectious in the environment for years.¹⁷¹
- These fungi are typically present in the environment (e.g., in soil) and often live harmlessly in the hive.
- Outbreaks occur only when the colony is weakened by other stressors (such as poor nutrition, bad weather, or other pests) or when the hive temperature drops, making larvae more susceptible.¹⁷¹

Symptoms and Diagnosis

Diagnosis of stonebrood involves detecting the following key signs:

- **Larval stage:** Infected larvae lose their pearly white appearance, becoming yellowish or greenish, and finally black, depending on the species, and then turn into hard, difficult-to-crush mummies (Photo 49).¹⁷¹
- **Adult stage:** Adult bees can carry the spores in their guts and are occasionally killed by the fungal infection.¹⁷⁴
- **Hard mummies:** Larvae infected with stonebrood harden into small, crunchy stones that are very difficult to crush. Dead individuals become rock-hard, black mummies covered in powdery fungal spores (Photo 49). This distinguishes it from chalkbrood, which leaves behind sponge-like mummies.
- **Location:** Diseased larvae can be found within the brood combs, on the hive’s bottom board, or on the landing board.
- **Adult impact:** Unlike many other brood diseases, *Aspergillus* spores can also infect and kill adult honey bees.¹⁷¹

Management and Prevention

No specific medication or chemical cure exists for stonebrood. Beekeepers can manage and prevent the disease by reducing hive stress and removing sources of infection.¹⁷⁵

- **Requeen:** Replace the hive’s queen with one from a hygienic line to naturally purge infected brood.
- **Hive hygiene:** Remove and burn frames with heavy infections. Clean away any mummified larvae from the bottom boards, hive entrance, and affected combs. Replace combs badly infected with mites with new foundations.
- **Combine/Strengthen:** Combine weaker colonies so there are enough adult bees to maintain a consistent hive temperature and actively clean out infected cells. Provide adequate nutrition and ensure the colony is strong enough to regulate the brood nest’s temperature.
- **Ventilation and moisture:** Since fungi thrive in damp, stagnant air, ensure hives have adequate ventilation and are tilted forward so rainwater does not pool on the bottom brood.

Human health risks

- A major concern with *Aspergillus* in hives is that the fungal spores can become airborne and cause severe respiratory illnesses (e.g., allergic bronchopulmonary aspergillosis) in humans who inhale them.¹⁶⁶
- Beekeepers should wear protective masks when handling infected bee colonies¹⁷⁶

③ Nosemosis

Nosemosis (Nosema disease) is a highly prevalent intestinal disease in adult honey bees caused by microsporidian spore-forming fungi, *Nosema apis* and *Nosema ceranae*; it weakens hives, shortens bee lifespans, impairs digestion, and can severely impact honey production and colony survival if left untreated.¹⁷⁷

The causal agents

- *Nosema apis*- Historically more common, it predominantly impacts bees in the spring and causes noticeable dysentery (brown spots on the hive).¹⁷⁸
- *Nosema ceranae*- A more recently emerged, highly aggressive species that can affect bees year-round, often without outward signs of diarrhea.

Transmission

- Exclusively affects adult honey bees. The disease spreads rapidly through the fecal-oral route or direct food exchange (trophallaxis).¹⁷⁹
- Bees ingest spores that destroy epithelial cells in the midgut. This leads to digestive disturbances, shortened lifespan, and higher overwintering mortality.¹⁶⁷

Symptoms

- **Depopulation:** A mysterious and rapid decline in the adult bee population without finding many dead bees in front of the hive.
- **Dysentery:** A colony suffering from this disease may display signs of dysentery, which can be seen in runny yellow or golden drop marks that can measure 0.25 to 2 inches in length. Fecal spotting (a ‘chain of dots’) along the combs or on the hive entrance and the front of the hive (Photo 50 & 51).



Photo 50. Nosema directly affects the honey bees’ digestive system, displaying signs of dysentery with a running yellow or golden chain of drops marks



Photo 51. Nosema-affected sick or crawling bees outside the hive entrance, dead bees on the ground, and excreta (dysentery) on the hive component¹⁷⁷

- **Crawling bees:** Stressed bees congregating on the ground, unable to fly.
- **Failed queens:** Affected queens may stop laying eggs and die prematurely.

Diagnosis

- Symptoms easily overlap with other bee ailments; a microscopic evaluation is the only way to confirm an infection and identify the exact Nosema species present.
- Beekeepers commonly crush a sample of approximately 100 bees, mix it with water, and examine the resulting homogenate with a hemocytometer to count spores.
- PCR tests are also frequently used to distinguish between *N. apis* and *N. ceranae*.

Management and Treatment

- **Antifungal treatments:** Beekeepers have historically used treatments like fumagillin, though some regions restrict its use because of regulatory and toxicity concerns. Always check local beekeeping regulations for permitted treatments.

- **Hive hygiene:** Routinely rotate out old, dark, and potentially contaminated comb frames with fresh foundation.
- **Placement and Ventilation:** Position colonies in sunny, well-ventilated apiaries to minimize internal hive moisture, which favors spore survival and germination.
- **Nutrition:** Provide high-quality pollen and feed to build strong bee immunity, helping colonies better tolerate the pathogen load.

Prevention and Control strategies of fungal infections in honeybees

Beekeepers typically use management and sanitation practices rather than synthetic pesticides to combat fungal outbreaks, as chemicals can harm bee health and contaminate honey. Beekeepers rely on integrated pest management (IPM) rather than chemical cures. The most effective strategies emphasize strict hive sanitation, maintaining dry, well-ventilated hives, replacing old brood combs, utilizing hygienic queen genetics to naturally clear infections, and proper nutritional support.^{166,180,181}

Key prevention and control strategies

a. Colony management and hive environment

- **Environmental management:** Fungal spores thrive in damp, cold environments. Position hives in sunny locations and tilt them slightly forward to prevent rainwater accumulation. Adequate ventilation reduces the damp, cool environment fungi thrive in.
- **Remove mummies and debris:** Regularly scrape and clean the bottom boards and the hive entrance. Clearing out dead, mummified larvae prevents the spread and accumulation of infective fungal spores.
- **Nutrition:** Provide sugar syrup and fresh pollen supplements during poor weather or nectar dearths. A well-nourished colony develops a robust immune system to fight off initial fungal spores.

b. Equipment sanitation

- **Comb replacement:** Replace at least a third of old brood combs annually. Old comb acts as a major reservoir for fungal spores, which can survive in hive materials for years.
- **Disinfecting tools:** Always flame or sterilize hive tools, gloves, and smoker between inspecting different hives to avoid cross-contamination.
- **The ‘Shook swarm’ method:** For severe infestations, shake all adult bees into a completely new, clean hive with new foundation frames, removing them from the spore-heavy environment.

c. Genetic improvements

- **Hygienic queens:** Re-queen colonies with stocks specially bred for ‘hygienic behavior’ (e.g., Buckfast or Italian lines). These bees are adept at detecting and removing infected larvae before the fungus releases spores.
- **Hygienic breeding (Genetic selection):** Selecting queens from colonies with pronounced hygienic behavior, which is the most promising long-term solution for removing infected mummies. Requeen hives using queens sourced from breeders selected for hygienic traits (e.g., F1 Buckfast or Italian stock). Hygienic bees easily detect and remove infected (mummified) brood.

d. Controlling secondary parasites

- **Varroa mites:** High varroa mite loads weaken the bees’ immune system, making them highly susceptible to fungal diseases. Mite infestations are proactively managed using IPM strategies outlined in the NC State Disease Management Guide.¹⁸²

e. Nutritional support

- **Strong, well-nourished colonies** naturally resist fungal outbreaks. Supplement bees' feed with sugar syrup and uncontaminated, fresh pollen during poor nectar flows.
- **Supplementing food** helps ensure a strong, healthy immune system in the hive.

④ Honey contaminants (Clostridium and Bacillus)

Honey contaminants include agricultural pesticides (such as neonicotinoids), veterinary antibiotics, heavy metals, and economic adulterants such as cheap sugar syrups. These pollutants often enter the hive through foraging bees or poor processing, posing unique health risks to consumers.¹⁹

While not diseases of the honeybee itself, beehives and raw honey can act as reservoirs for environmental bacteria. Honey commonly contains spores of *Clostridium botulinum*, which can cause botulism in infants. Additionally, *Bacillus cereus* originating from hives can cause food poisoning if ingested in large quantities.¹⁸³

Honey contamination in Bangladesh

Honey contamination in Bangladesh poses significant risks to quality and human health. Honey contamination in Bangladesh primarily involves toxic heavy metal exposure (such as cadmium and lead), commercial adulteration with water or cheap sugars, and traces of agricultural pesticides and microbiological pathogens.^{184,185}

Key contamination issues

- **Heavy metals:** Studies of local and imported honey samples in the Dhaka region reveal that some samples exceed allowable limits for toxic heavy metals like cadmium. This usually stems from localized industrial pollution and agricultural inputs, such as contaminated fertilizers, in foraging areas.¹⁸⁵
- **Adulteration:** Raw and commercial honeys in the local markets are frequently diluted with water or cheap sugar syrups and molasses to increase volume.¹⁸⁶ High moisture content in certain floral honeys (such as litchi honey) often falls outside strict international quality standards.
- **Pesticide residues:** The indiscriminate use of agricultural insecticides, especially neonicotinoids, in Bangladesh not only poisons bee populations but also leaves chemical residues in hive products.¹⁸⁷
- **Microbiological presence:** Studies on raw and commercial honeys have isolated unwanted microorganisms, including strains of *Escherichia coli* and *Klebsiella pneumoniae*, reflecting poor extraction and handling hygiene.¹⁸⁴

Honey contamination in Bangladesh is a significant concern, with studies revealing widespread presence of bacteria and reporting the presence of *Micrococcus luteus* (100%), *Streptococcus* (92%), *Staphylococcus aureus* (77%), *Bacillus* (23%), *Lactobacillus* (15%), *Klebsiella* (8%), and *Escherichia coli* (8%) in commercial honeys in Bangladesh.¹⁸⁴ Recently, clinical signs of digestive disorders caused by online-purchased Nahal Kalo-Jira honey have been recorded. This finding supports that consuming contaminated or toxic honey can cause severe gastrointestinal distress in humans, ranging from mild stomachaches and diarrhea to life-threatening conditions. However, the specific source of the contamination determines the type of gastrointestinal or systemic illness that follows.¹³⁰ Recently, in Nepal, consuming 1 to 2 teaspoons of wild honey caused poisoning in humans within 30 to 45 minutes.¹⁸⁸ Poor hygiene during honey collection and storage can lead to contamination with bacteria, yeasts, and molds.

- Contamination of honey in Bangladesh affects overall quality and purity and requires better management of microbial loads and adulteration.

Status of fake and adulterated honey in Bangladesh

Fake and adulterated honey is highly prevalent in the Bangladeshi market, largely driven by cheap sugar syrups, molasses, and artificial colors. The honey market in Bangladesh suffers from severe adulteration, with the Bangladesh Food Safety Authority estimating that a large fraction of food products, including honey, fail basic quality tests. Illicit factories produce large quantities of 'fake' honey by boiling water, sugar, molasses, artificial thickeners, and artificial coloring like caramel. While pure, locally sourced honey from the Sundarbans and floral farms is adulterated, unbranded street vendors and budget brands

often substitute it with cheaper industrial sugar syrup, corn syrup, and caramel colorings. Commercial adulteration also involves feeding bees sugar syrup to artificially bulk up yields or mixing pure honey with cheaper syrups.

Why does Bangladesh export honey while also importing it?

Bangladesh produces an estimated 20,000 to 40,000 tons of honey annually, with reports indicating recent annual yields of around 25,000 tons. Production is split between traditional, wild-harvested honey from the Sundarbans mangrove forest and cultivated honey (mostly from nomadic beekeepers farming mustard and litchi flowers).¹⁸⁹ Bangladesh exports premium natural honeys to global markets like Japan, Germany, India, the USA, and the Middle East.

- Exporting the Surplus:** Bangladeshi honey, particularly from Sundarbans and various crop fields, meets stringent European Union and international standards. Because it commands a good price abroad, beekeepers export a significant portion of their harvest.
- Price arbitrage:** Sometimes, the price of raw honey in Bangladesh is very similar to prices in neighboring countries like India. As a result, traders find it commercially viable to both export local harvests and import different types of honey to meet local consumers' varying price points.
- Table 14** presents the top-tier honey brands and suppliers exporting from Bangladesh.

Table 14. Top verified honey suppliers in Bangladesh in year 2025: export trends and market insights- proven export performances ¹⁹⁰					
SN	Honey suppliers	Specificity	Certifications	Export markets	Fredhi highlight/Strength/Insight
①	Chironto Trading Co.	Natural raw honey	HACCP, ISO 22000	Japan, UAE, India	Rated 4.9/5 by international buyers
②	Bangla Beekeepers Ltd.	Mustard flower honey	Organic, GMP	Japan, Germany	Direct from farm, traceable supply chain
③	Sundarban Apiculture Enterprise	Sundarbans wind honey	GI certification pending	India, UAE	Collected from the mangrove forest
④	Golden Hive Agro	Organic black cumin honey	Halal, Organic	Saudi Arabia, Qatar	Frequently featured in RFQ trends
⑤	BeePro Bangladesh	Multiflora and dark honey	BRC, ISO 9001	USA, Malaysia	Focus on premium-grade honey for health-conscious markets
⑥	Madhuban Natural Honey	Filtered & unfiltered honey	GMP- compliant production	India, Oman	Small batch, artisanal approach
⑦	Apicella Exports	Industrial-grade honey for cosmetics & food	FSSC 22000	South Korea, Vietnam	Bulk packaging expertise
⑧	NatureNest Honey BD	Raw forest honey	EU Organic	EU, Japan	High repeat order rate

HACCP = Hazard Analysis and Critical Control Points

GMP = Good Manufacturing Practice

ISO 9001 = International Organization for Standardization

ISO 22000 = International Organization for Standardization

GI = Glycemic Index

FSSC 22000 = Food Safety System Certification

BRC = British Retail Consortium

EU = European Union

Why does Bangladesh import honey while also exporting it?

Bangladesh imports honey because domestic production is largely seasonal and frequently insufficient to meet local consumer demand, particularly for highly processed, standardized, or organic commercial variants. Imported honey also fills specific gaps in variety and pricing that local beekeepers do not currently provide. Several specific factors drive the need for honey imports to Bangladesh:

- Domestic supply constraints:** Although Bangladesh produces honey (predominantly during the mustard and lichi seasons), overall apiculture yields are still developing. Local supply cannot meet growing year-round domestic demand, making imports necessary to fill the gap.
- Consumer demand for variety:** Local Bangladeshi honey is mostly mono-floral (like mustard or black cumin). Consumers often look for diverse floral origins, such as Manuka honey from New Zealand or Acacia honey from Europe, which cannot be harvested locally.
- Commercial processing and packaging:** A large share of the honey consumed in urban Bangladeshi households is commercial grade, which requires specific pasteurization, moisture reduction, and uniform packaging. Many imported brands have invested heavily in this processing infrastructure, allowing them

to dominate retail shelves.

- **Quality assurance and standardization:** While Bangladesh produces high-quality pure honey, the domestic market suffers from a high prevalence of adulterated or artificial products sold by unverified traders. Premium imported honey provides certified quality control that health-conscious consumers trust. However, this review indicates that most of the imported and locally produced certified honey on the market is adulterated or fake.
- Because roadside and unverified vendors are known to sell heavily diluted sugar-water, consumer trust has plummeted. Buyers are increasingly shifting toward certified local and foreign brands found in supermarkets.
- Some unscrupulous traders take advantage of the high retail honey price to maximize profit margins by mixing in cheap sugar, particularly during honey production off-seasons.

Imported honey brands to Bangladesh

Popular imported honey brands available in Bangladesh include premium options like Al Shifa (Saudi Arabia), Langnese (Germany), and Comvita (New Zealand). These brands are widely available across local grocery stores and e-commerce platforms in Bangladesh for their purity and rich flavors.



① **Al Shifa** (Saudi Arabia): Known for its natural and black forest varieties, it is one of the most widely consumed imported honey brands in the Middle East and South Asia. e.g., Al Shifa Black Forest Honey and Al Shifa Natural Honey.

Adulterated status:

- “The decision to suspend circulation of Al Shifa honey products in the market across Oman pertains to two specific batches and not all of our products.”- Company Statement Explains.¹⁹¹
- PCA identified honey adulteration in five types of Saudi wild honeys, with the most common syrups (sugar cane, brown rice, maple, and pancake syrup) at concentrations from 2 to 20%.¹⁹²
- More than 30 thousand containers, of different sizes, had been seized in the plants located in Al Shifa, Aziziyah, and Al Kharj roads in Riyadh.¹⁹³



② **Langnese honey** (Germany): Globally known for premium, golden, clear honey and varieties infused with Royal jelly, e.g., Langnese pure bee honey, Langnese Black Forest honey, and Langnese Acacia honey.

Adulterated status:

- The report indicates that even major market leaders like Langnese were implicated in producing or selling honey mixed with cheap sugar syrups or lack genuine genetic pollen profiles rather than being 100% pure.¹⁹⁴



③ **Comvita: Manuka honey** (New Zealand): Highly regarded internationally for authentic, medical-grade UMF (Unique Manuka Factor), e.g., Manuka honey.

Adulterated status:

Manuka honey is one of the most heavily adulterated foods globally, driven by its premium pricing and limited annual production capacity of roughly 1,700 tons in NZ compared to over 10,000 tons sold worldwide under the Manuka label. This massive supply deficit fuels rampant, economically motivated fraud, which ranges from simple dilution to chemical tampering.^{195,196}



④ **Capilano** (Australia): A widely recognized brand known for pure Australian eucalyptus and flora honey, e.g., Capilano honey.

Adulterated status

- The ACCC (Australian Competition & Consumer Commission) followed allegations in the media that a number of honey products, including Capilano's honey labeled pure and 100% honey, were adulterated with sugar syrup.¹⁹⁷
- Capilano, Australia's biggest listed honey company, and some of the country's largest supermarket chains face accusations of unintentionally selling fake honey.¹⁹⁸



⑤ **Tiptree Honey (UK)**: A premium heritage brand offering organic and specialty fruit-floral honey, e.g., Tiptree Pure Clear Honey, Tiptree Set Honey, and Tiptree English Blossom Honey

Adulterated status

- Reports of adulteration of the Tiptree brand of honey are unfounded.
- Some studies suggest up to 90% of tested supermarket honey samples were suspicious or failed authenticity tests.¹⁹⁹



⑥ **Hosen Honey (Singapore)**: A popular pantry staple offering natural, quality-assured honey, e.g., Hosen pure honey and Hosen pure honey jar.

- Hosen is a widely available commercial honey brand globally and in Bangladesh. While marketed as pure products, large-scale commercial honeys may be blended or adulterated with syrups (such as corn or rice syrup) during manufacturing.^{200,201}



⑦ **Super bee honey** (Australia): Known for raw, unheated, and unprocessed honey packed directly from the hive, e.g., Super bee raw Australian honey, Super bee pure Australian honey jar, and Super bee raw Australian honey.

- Independent testing by bodies such as Macquarie University found that up to 18% of honey samples sold on Australian shelves (including domestic blends) were adulterated with non-honey substances such as rice, beet, or corn syrups.²⁰²



⑧ **Dabur honey** (Indian honey): Dabur Shop Bangladesh launches Dabur honey in Bangladesh. Known for its easily accessible range of pure, no-added-sugar honey, e.g., Dabur honey.

- The Center for Science and Environment (CSE) in New Delhi stated that Dabur was among the brands that failed to pass standard tests for honey purity, showing signs of adulteration with syrups used to dilute natural honey.²⁰³

Studies confirm that a significant portion of imported honeys in Bangladesh is adulterated with cheap sweeteners (such as high-fructose corn syrup) and probably other adulterants. The economic fraud poses severe consumer health risks, including obesity, diabetes, and organ damage.¹⁷

Food fraud in low- and middle-income countries like Bangladesh is constrained by weak regulatory enforcement, limited quality control systems, and inadequate analytical laboratory capacity, which collectively impede sectoral growth and competitiveness.



Photo 52 (1-9): Adulteration of imported honey brands in Bangladesh

Research findings on adulteration of honey in Bangladesh

- Honey adulteration in Bangladesh is a serious issue, primarily involving the addition of cheaper sweeteners such as sugar syrup (corn or cane) or molasses to increase volume, as well as artificial caramel coloring, which is further contaminated by poor processing and storage practices.
- The direct addition of sugar syrup is one of the most common methods of honey adulteration because they are inexpensive and has a chemical composition like natural honey, which makes its detection challenging.
- Adding caramel is a known practice to make lower-quality or diluted honey appear darker, as consumers often associate darker honey with higher quality and antioxidants.
- The integration of UV-Vis-NIR spectroscopy with SHAP-guided ensemble learning successfully decoded the complex spectral fingerprints of honeys that have been developed at the research level in Bangladesh.¹⁴
- Random Forest (RF) method achieved the highest performance, with classification accuracies of 100% for botanical origin, 99% for adulteration presence, and 100% for adulterant type.¹³
- Studies reveal that over 40% of branded honeys fail standard safety thresholds, containing excessive HMF (hydroxy-methyl-furfural) levels, while farm-fresh options generally remain within permissible limits.²⁰⁵
- Recent research reports indicate that a significant proportion of honey sold in local markets and online is adulterated, particularly in urban centers such as Dhaka.
- The choice of 10-20% sugar syrup adulteration levels is a common practice within the honey industry in Bangladesh.⁷
- A study has compared the quality of mustard, lichi, and Sundarbans (multiflora) honeys, of which the moisture content of litchi honey (20g/100g) was higher than that of the Sundarbans (17.7g/100g) and mustard (19.5g/100g) honeys. The hydroxy-methyl-furfural (HMF) content was found to be higher in Sundarbans honey (200.5 mg/kg), but negative in the litchi honey. The highest invertase activity (99 IU/kg) was recorded for litchi honey, compared with mustard (2.0 IU/kg) and Sundarbans (0.0 IU/kg) honeys. The Sundarbans and mustard honeys had failed to reach the quality standard of honey in Bangladesh.²⁰⁶
- Honey samples of eight different commercial brands were analyzed for different biochemical parameters. The highest total soluble solids (TSS) and total reducing sugars were recorded in the premium honey brand from Australia, whereas the moisture, protein, and ash percentages were the lowest.²⁰⁷
- Three different floral honeys, viz., khalsi (*Aegiceras corniculatum*), mustard (*Brassica juncea*), and litchi (*Litchi chinensis*) honeys, have been analyzed for the different constituents, especially heavy metals. The mean pH, EC (electrical conductivity), ash, moisture, and total sugar contents were 3.6, 0.51mS/cm, 0.18%, and 68.30%, respectively. Iron content was abundant (13.51 to 15.44 mg/kg), and manganese (0.28

mg/kg) and zinc (2.99 mg/kg) were within standard levels.²⁰⁸

- A study was conducted to detect the different constituents of 28 samples of honeys in Bangladesh. The highest pH (6.0) was recorded in mustard honey (Sample No. 15) and foreign honey (Sample No. 20), and the lowest pH (1.0) in fake honey (Sample No.18). The highest moisture content (29%) was recorded in Olive honey (Sample No. 13) and the lowest (15.47%) in mustard honey (No. 15). Some honey samples were steamed manually and processed in a processing plant, and their moisture content was found low (< 20%). The highest fructose level (64.33%) was recorded in Khoilsa (Alwoan) (Sample No. 1), and a lower level in mustard honey (34.03%).²⁰⁹
- The honey samples stored for 1.5 years at room temperature still have 5-hydroxy-methyl-furfural (HMF) values within the recommended mean of 10.93 mg/kg, indicating that the rate of HMF production in Bangladeshi honey is low. The low rate of HMF formation may be attributed to the acidic, low-moisture content of the samples.²¹⁰
- Honey adulteration is highly common, with syndicates and dishonest middlemen often cutting premium or Sundarbans honey with corn syrup, cane sugar, jaggery, and molasses. Law enforcers and the Rapid Action Battalion (RAB) regularly bust clandestine fake-honey factories in Bangladesh.

Fake honey production in Bangladesh

Fake honey factories in Bangladesh are clandestine operations that produce counterfeit honey using heated mixtures of sugar, molasses, water, carboxymethyl cellulose (CMC) as a thickener, citric acid, and artificial colors and flavors, and package it to look like authentic brand honey. These fake honeys are frequently sold in local markets and online. These unregulated facilities bypass quality standards and pose severe health hazards to consumers. Law enforcement regularly busts these unregulated operations, which often market fake batches as premium wild honey from the Sundarbans, and these large-scale operations frequently operate out of illegal factories, as seen in recent major busts in Jeshore, Keraniganj (Dhaka), and Khulna.²¹¹

Bismillah Madhu Trading (Jessore)

Fake honey production and marketing in Jessore typically involve processing sugar, molasses, unhygienic chemical mixtures, and thickeners, then packaging and selling them illegally as pure honey.

- A joint mobile court operation involving Rapid Action Battalion (RAB-6), BSTI, and executive magistrates raided a fake honey factory in the Sheikhhathi area of Jessore. The factory owner was sentenced to six months' imprisonment and fined Tk. 50,000 for producing artificial honey in highly unsanitary conditions (Photo 53 & 54).^{212,213}



Photo 53. Raided a fake honey factory in the Sheikhhathi area of Jessore in Bangladesh



Photo 54. Ingredients used to make fake honey in the Sheikhhathi area of Jessore in Bangladesh

Keraniganj (April 2026)

- Keraniganj, an industrial hub near Dhaka, is a known hotbed for counterfeit food production, including large-scale fake honey operations. The core ingredients mixture is typically made by boiling sugar, water, corn syrup, and liquid glucose. To achieve the authentic amber color and thickness, producers mix in arrowroot, food-grade chemicals, artificial honey flavoring agents, and artificial colors like molasses or caramel coloring to make the syrup visually and aromatically indistinguishable from real honey. They repack the fake honey into containers bearing labels from well-known, established brands. This mass-produced syrup is distributed through wholesale and retail channels, capitalizing on bulk demand, especially during periods like Ramadan or winter, when honey consumption spikes.
- Rapid Action Battalion (RAB) and local authorities raided a major fraudulent factory in Keraniganj, which led to the seizure of roughly 100,000 kg (1 lakh kg) of fake honey. Law enforcement also detained multiple individuals involved in this large-scale illegal operation (Photos 55, 56).^{214,215}



Photo 55. Huge storage of fake honey at the Bismillah Modhu Ghor and Moo Khamar in Keranigonj Dhaka



Photo 56. Fake honey ingredients are packaged as a brand with fake honey storage for sale in Keranigonj

Selling fake honey by street honey vendors

Street vendors in Bangladesh frequently sell fake or adulterated honey by submerging genuine or artificial honeycombs into thick, colored sugar syrup. The honeycomb is simply a prop to trick buyers into believing the honey was just harvested and is 100% natural.

Honey processing plant in Bangladesh

A honey processing plant in Bangladesh by CADSON offers complete solutions for honey filtration, moisture reduction, storage tanks, bottling systems, and custom honey processing equipment for commercial production.²¹⁶ The filtration systems that remove impurities like wax, debris, and pollen, whereas the moisture reduction equipment achieves the desired moisture levels. This method results in the loss of the source of honey due to the absence of pollen, and heating honey to reduce moisture increases the MHF, which poses a high health risk to consumers.

Health risks due to the consumption of fake and adulterated honeys

Pure honey is highly beneficial for human nutrition and health because it contains simple sugars (glucose and fructose) and essential nutrients such as proteins, antioxidants, minerals, vitamins, and antibacterial properties. Fake and adulterated honey poses serious human health risks. However, the effects of consuming fake and adulterated honey on human health are not well established, largely because of a lack of systematic scientific studies and low public awareness.

- The mixture of inverted sugar or jaggery can sometimes restrict the antibacterial properties of honey and lead to stomach disorders.²¹⁷

- Regular consumption of fake or adulterated honey can cause increased blood sugar followed by the release of insulin (triggering rapid blood sugar spikes, insulin resistance), type 2 diabetes, abdominal weight gain, obesity, elevated blood lipid levels, and high blood pressure.²¹⁸
- Fake honey often contains artificial additives, undisclosed chemicals, and even traces of heavy metals or industrial processing, which present several critical dangers.
- Consumption of sugar (glucose) adulterated honey may elevate insulin secretion, which activates the plasma membrane enzyme system with the properties of NADPH oxidase, resulting in the production of H₂O₂, fructose, and uric acid in humans.²⁸ Uric acid generation in the body has unfavorable effects, particularly by reducing the ability to scavenge lipophilic radicals and break radical chain propagation within the lipid membrane.²¹⁹
- Glucose and fructose of sugar-adulterated honey produce ROS through various mechanisms in the body, which is detrimental to human health and causes chronic diseases, such as atherosclerosis, diabetes, obesity, hypertension, coronary artery diseases, and finally heart failure.
Consuming adulterated or contaminated honey can lead to various health problems, ranging from metabolic disorders, allergic reactions, and toxicity to potential long-term risks like cancer and organ damage (Table 15)

① Metabolic disorders and insulin resistance

- Blood sugar spikes: Many counterfeit products are made with high-fructose corn syrup or commercial glucose. These sugars spike blood glucose levels faster than natural sugars, increasing the risk of developing type 2 diabetes.
- Obesity and weight gain: Because fake honey behaves like empty calories, it contributes to visceral fat accumulation and abdominal weight gain.¹⁸

② Internal organ damage

- Liver and kidney strain: Studies show that consuming artificial honey can lead to the accumulation of fat in the liver (leading to non-alcoholic fatty liver disease (NAFLD) and place undue stress on the kidneys.
- Cardiovascular risks: Adulterated honey has been linked to elevated blood lipids, increasing levels of bad cholesterol (LDL) and triglycerides.

③ Experience with toxic contaminants

- Chemical additives: Some fake honey relies on artificial dyes, flavors, and caramel coloring, which can cause allergic reactions in sensitive individuals.
- Heavy metals and antibiotics: Investigative reports have found that many fraudulent imports contain traces of pesticides, heavy metals, and veterinary medicines that are harmful to the nervous system and organs over prolonged exposure.
- Hydroxy-methyl-furfural (HMF) toxicity: HMF is a potentially carcinogenic compound that forms when sugars are heavily processed and heated. Fake honeys often show severely elevated HMF levels.

④ Zero nutritional value

- Lacking antioxidants and enzymes: Pure honey is celebrated for its natural enzymes, vitamins, minerals, and antibacterial compounds. Fake honey acts only as a concentrated dose of sugar and entirely deprives the body of these therapeutic benefits.

Table 15. Status of adulteration and contamination of honey with health impact in Bangladesh^{186,220}

SN Issue	Details in Bangladesh	Health Impact
① Adulteration with sugar syrup	Common in the local market	Raises blood sugar, reduces nutritional value
② Microbial contamination	Due to poor hygienic practices	Gastrointestinal disorders
③ Heavy metals	From environmental/Pollution	Toxicity, organ damage
④ Antibiotic residues	From hive treatments	Anti-microbial resistance
⑤ Poor packaging	Cheap plastics	Chemical leaching

Risks and challenges

- **Consumer deception:** Adulterated honey can look and taste like pure honey, making it difficult to detect without lab testing.
- **Health hazards:** Long-term consumption of contaminated honey can contribute to chronic disease, especially among vulnerable populations.
- **Regulatory gaps:** Bangladesh lacks strong enforcement mechanisms for honey quality standards, allowing adulterated products to circulate widely.

There is no known method for adulterated or contaminated honey to become pure, and consuming boiled, adulterated, or contaminated honey can cause toxic effects such as gastrointestinal irritation, liver and kidney damage, metabolic stress, and increased risk of chronic diseases due to harmful byproducts like hydroxy-methyl-furfural (HMF) and contaminants like heavy metals, pesticides, and antibiotics (Table 16).

SN	Factor	Mechanism	Potential health effects
①	Boiling honey	Heat converts sugar into HMF, a toxic compound	GI irritation, DNA damage, liver stress, possible carcinogenic risk.
②	Adulteration with sugar syrup	Addition of glucose, rice syrup, or HFCS alters the natural composition	Obesity, insulin resistance, diabetes risk, loss of antioxidant/antibacterial benefits
③	Heavy metal contamination	Lead, arsenic, & cadmium from poor processing, or storage.	Neurotoxicity, kidney disease, developmental issues in children.
④	Pesticide residual	From contaminated nectar sources	Endocrine disruption, immune suppression, increased cancer risk
⑤	Antibiotic residues	Used in bee colonies to prevent infections	Allergic reactions, antibiotic resistance, gut microbiome imbalance.
⑥	Microbial contamination	Poor hygiene during processing	Food poisoning, diarrhea, infant botulism (especially dangerous for babies).

Why boiling honey makes it worse

- **Loss of nutritional value:** Heat destroys enzymes (like glucose oxidase) and antioxidants that give honey its medicinal properties.
- **Formation of HMF:** Even moderate heating accelerates HMF production, which is linked to mutagenic and cytotoxic properties.
- **Synergistic toxicity:** When adulterated honey is boiled, contaminants such as pesticides or heavy metals may interact with HMF, thereby amplifying toxicity.

Risks of long-term consumption of adulterated honey

- **Metabolic disorders:** Regular intake of adulterated honey mimics high-sugar diets, raising risks of diabetes and cardiovascular disease.
- **Organ damage:** Chronic exposure to heavy metals and HMF stresses the liver and kidneys.
- **Cancer potential:** HMF and pesticide residues have been associated with DNA damage and carcinogenesis in experimental studies.

Evaluation of the locally produced honeys in Bangladesh

Social media platforms like Facebook have become popular channels for vendors across Dhaka and Bangladesh to market different consumer products, including pure natural honey. However, this booming e-commerce trade lacks oversight. Unscrupulous traders frequently capitalize on high consumer demand by repackaging commercial sugar syrups or selling low-grade, heated honey at premium

prices, thereby severely undermining the market's medicinal and nutritional value. Honey advertisements on Facebook in Bangladesh focus heavily on purity, organic sourcing, and health benefits, with the market expanding toward both premium and affordable options.

Common advertising themes and strategies

- Health and immunity:** Many ads highlight honey as an 'immunity booster' and a healthy, natural sweetener, positioning it as a remedy for cold and cough.
- Purity assurance:** Ads frequently emphasize that the honey is 100% pure, natural, unadulterated, untouched, unfiltered, and organic, often contrasting their products with unhygienic, open-market honey.
- Source and transparency:** Marketing often highlights that the honey is directly collected from beekeepers and sources like the Sundarbans.
- Visual appeal:** High-quality imagery featuring honey jars, honeycombs, and golden dews is common, often set against floral or natural backgrounds to evoke organic quality.
- Visual style:** Ads typically feature warm, golden, and natural imagery, often using close-ups of honey jars, bees, and flowers to emphasize the raw, natural aspect.
- Product photography:** Close-up shots of honey jars, often in innovative, high-quality, or rustic setups.
- Try it approach:** Many ads use a 'try it and see' approach, urging consumers to test the purity themselves.

Evaluating honey sold through Facebook advertisements requires distinguishing between the ad's credibility and the product's actual quality. Because social media is rife with misleading claims and unauthorized vendor practices, a thorough assessment is crucial. This study characterized the physicochemical properties of eight honey samples purchased from Facebook Ads and the local market in Dhaka, Bangladesh. A total of seven (① to ⑦) sources of honey were evaluated as follows:



① Nectar Drops (Sundarbans honey)

Nectar Drops offers premium, 100% pure Sundarbans honey directly from the deep mangrove forests of Bangladesh, specializing in Kholisha and mixed-flower varieties, with a 1-year guarantee. Website: nectardropsbd.com; and Facebook: Nectar Drops BD

Advertisement of the Features of Nectar Drops honey

- Pure and Raw:** 100% pure and unprocessed, unheated, and directly collected from the Sundarbans by experienced MO walls (honey collectors).
- Variety:** Specialized in Kholisha (light color) and natural wild mixed flower honey.
- Quality guarantee:** 1-year guarantee- if it freezes in the deep freezer, it is returnable.
- Texture:** Often thin with a high moisture level, indicative of pure forest honey.
- Health benefits:** Rich in antioxidants, enhances immunity, and boosts natural energy.

The Nectar Drops honey one kg bottle received online was very thin and watery. Normal, pure honey has a moisture content between 14 and 18%. Honey with a moisture level above 20% is widely considered fake, adulterated, or improperly ripened, as excess water leaves it susceptible to rapid yeast fermentation and spoilage.²²² When this honey was boiled, milk-like bubbles formed, and they took a long time to remove. Ultimately, the boiled honey was scientifically unfit for human consumption, which was thrown down the drain.²²³ I tried to contact the honey supplier by phone, but no one answered.



② Aussie Bee Organic Honey (Australia)

- Aussie Bee is an Australian honey brand, including organic varieties, known for sourcing honey from native Australian bees (such as stingless bees) and marketing it internally, especially in Bangladesh, through distributors. It was found to be better than any online-purchased inland honey in a home test, though it was expensive. However, 1 in 5 Aussie honey samples adulterated in Australia.²²⁴
- Detecting adulteration of imported honey in Bangladesh requires a combination of home verification, retail awareness, and professional laboratory analysis, all of which are readily available in the country.



③

③ Saffola Active Plus honey (India, Marico BD Ltd)

- Marico BD Ltd. markets Saffola Active honey in Bangladesh, bringing the Indian brand's promise of pure, antioxidant-rich honey to local retailers and department stores. However, independent lab analyses of Saffola Active Honey have detected traces of exogenous sugars (such as rice syrup) and citric acid. This suggests that the non-NMR-tested active variant may contain added syrups rather than being 100% natural nectar.²²⁵
- Honey samples were tested at two laboratories: CALF and NDDB in India for FSSAI parameters, and a German lab for advanced tests such as NMR and TMR. Test results showed that 77% of samples (17 out of 22) were adulterated. Only three brands- Saffola, Markefed Sohna, and Nature's Nectar had all samples passing all tests. Major

Brands like Dabur, Patanjali, Baidyanath, and others failed multiple parameters, especially NMR and TMR tests.²²⁶

- The Saffola honey sample from the market has failed the NMR test. Test reports clearly indicate the presence of sugar syrup in Saffola honey. Their claim about the NMR test is misleading consumers.²²⁷



④

④ Dabur honey (Dabur India Ltd.)

- The Center for Science and Environment (CSE) tested samples sent to a German laboratory and alleged that many top brands, including Dabur, were adulterated with modified sugar syrups designed to bypass Indian purity tests.²²⁸
- Tests, especially Nuclear Magnetic Resonance (NMR) spectroscopy, alleged that a significant majority of the tested Dabur samples failed to meet global standards for 100% pure honey.
- A recent study found that 10 of the 13 brands it sent to a German lab for testing failed to meet the standard for honey purity.^{229,230}
- The Department of Food Technology and Quality Control (DFTQC) has declared Dabur-brand honey unfit for consumption and has directed an immediate recall from the

Market,²²⁸ but imported honey is still widely sold in the Bangladeshi market.

- Following laboratory tests in Nepal, the Department of Food Technology and Quality Control (DFTQC) ordered an immediate market recall of Dabur honey (Batch No. NB00477). Testing revealed the batch contained high hydroxy-methyl-furfural (HMF) levels (50 mg/kg), suggesting it was overheated, improperly stored, or old.²³¹

⑤ Kalo-Jeera Honey (Many producers in Bangladesh)

Fake and adulterated kalo jeera (black seed) honey is heavily targeted on Facebook and across online businesses because of its premium medicinal reputation, high market demand, and dark color, which allows scammers to use cheap, artificial syrups, especially molasses, without arousing immediate suspicion.¹⁴ Real kalo jeera honey has a characteristically dark, rich color and a pungent, earthy flavor. Fraudsters can easily mimic this by mixing cheaper, pale honeys (or sugar syrups) with artificial darkening agents like caramel color or even molasses. Consumers may mistake the dark color for purity. Sellers use flashy ads, stolen farm photos, and terms like '100% pure' or 'stone-tested' to build false credibility. Unregulated online sales make it easy for scammers to block disgruntled buyers, delete fake reviews, and operate without legal consequences.

Numerous brands and individual beekeepers actively advertise Kalo jeera honey on Facebook in Bangladesh, offering home delivery directly to buyers' locations. Here is a quick reference list of popular Facebook-advertised brands and retailers offering Kalo jeera honey in Bangladesh.

- [Nahal] Kalo Jeera flower honey
- [Vitanur] Kalojira honey
- [Panash Food] Blackseed honey
- [Green Harvest] Black seed honey
- [Ghorer Herbal] Black seed honey
- [Modern Herbal] Black Qumin honey

- [Farmer's Gold] Black seed honey
- [Khaas Food] Black seed flower honey
- [Active Food] Kalojira honey
- [Falaq Food] Kalojira honey
- [Amanot Foods] Black seed flower honey

Among these, Kalo Jeera flower honey advertised on Facebook, only two brands of Kalo Jeera honey, including Nahal Kalo Jeera honey and Amanot Foods Black seed flower honey, were purchased to evaluate their quality.



Discarded ⑤ Unopened

⑤ Kalo-Jeera Honey (Nahal Multi-products)

- “Nahal multi-products is a well-known Bangladeshi brand specializing in natural, organic, and health-focused food products. They offer a wide range of goods, including premium dates, organic honey, dry fruits, homemade pickles, and traditional spices”- Nahal company profile.²³²
- Nahal honey in Bangladesh is advertised as a 100% pure, natural, and premium-quality superfood. Their marketing heavily emphasizes superior thickness, authenticity, and health benefits to stand out in the local market.

Attract customers online with Facebook videos

- High-grade Nahal honey combos special discount! thick, and pure.
- Every day, Nahal is getting extraordinary customers.
- A grade honey means Nahal honey, Nahal honey, moisture grade 17-18%
- Buy only Nahal honey and get a chance to win Omra Palon in Saudi Arabia.

- Pure Goodness in Every Drop! Introducing NAHAL-16 Certified Premium honey that's natural, genuine, and purified as it gets. Order now from Nahal Pure Honey (Photo 57), but it looks like rice syrup.
- Upon purchase, you will receive a Nahal voucher for BDT 200/- per kg of honey (Photo 58).



Photo 58. Two vouchers of BDT 200/- (two hundred) each were obtained from Nahal on the purchase of two bottles (2kg) of Kalo jeera honey.



Photo 57. An advertisement method to prove pure honey

In the Qur'an, 'Nahl' (Arabic: An-Nahl) translates to 'The Bee.' It is the name of the 16th chapter (Surah) of the Qur'an. The term comes from the Arabic root for the honey bee, which serves as a central symbol of the Surah's message (16:68-69).

- Surah An-Nahl (16:68): 'And your Allah inspired the bee, 'Take for yourself among the mountains, houses, and among the trees and [in] that which they construct.'
- Surah An-Nahl (16:69): 'Then suck from all the fruits and follow the ways of your Allah laid down [for you]. From their bellies emerges a drink of varying colors, in which there is healing for people. Indeed, that is a sign for a people who give thought.'

In the Qur’an, honey produced from all types of flowers is effective for medicinal benefits, but it is not mentioned that only kalo jeera honey would be medically effective (Fig. 9). However, as narrated by Abu Huraira (RA), the Messenger of Allah (PBUH) said: “There is healing in black cumin for all diseases except death.” Sahih al-Bukhari 5688). Accordingly, believers believe that Kalo Jeera honey offers greater medicinal benefits (Fig. 10). Pure honey is essential for believers to obtain medicinal benefits, whereas fake or adulterated honey poses health risks.



Fig. 9. Attract by showing Kalojira honey along with Kalojira seed, which has no relation to honey



Fig. 10. Attract by showing a test of pure honey by keeping the Qur’an open for increased belief

As a believer, I ordered two bottles (2 kg) of high-grade Kalo-Jera Nahal honey on Facebook. A company representative called me on my mobile to confirm the order. I asked him, ‘I will only confirm the online purchase order if the honey is pure,’ but he did not reply. Accordingly, I thought my honey order was not processed. But after one week, I received 2 kg of honey in 2 separate bottles (photos discarded and unopened, page 60), along with 2 gift vouchers of Taka 200 each (Photo 58), via courier service. For breakfast, I had some honey from a bottle, and then my digestive trouble, with diarrhea, started, and the symptoms looked like an *E. coli* infection. Ultimately, the diarrhea resolved after taking antibacterial therapy. However, pure honey is usually prescribed to treat gastrointestinal disorders.

I conveyed this message about adulterated and contaminated honey to the company via email and mobile, commented on their Facebook page about their products, and asked them to replace it with their Khalisha honey as advertised. However, the person who received my message informed me that Khalisha honey is of lower quality than Kalo-Jera honey. This indicates that all Nahal honey is either fake or heavily adulterated with molasses or sugar syrups. These conventional home tests showed that the honey was adulterated with contaminated molasses or other sugar syrups, or that contamination occurred during processing. However, a modern, advanced molecular laboratory test would be required to detect the specific contamination and adulteration of this honey.

Under these conditions, the company has made the email address inactive (mail delivery failure), set its Facebook status to closed (Error: Not a valid Facebook Page URL), reduced the high-grade and popular-grade online advertisements, and closed or deleted comments in the product comment section. Some company mobile receivers sometimes reply that they will communicate the message to the authority, or that they will reply very soon.

© Kalo-Jira Honey (Amanot Foods)

Kalo-Jira honey from Amanot Foods (Bangladesh) is their premium, pure, black seed (Kao Jira) flower honey, often promoted as natural and high-quality, available for online purchase with local delivery options

in Bangladesh, featuring flavors from the distinct kalo Jira flowers, a specialty product from this Bangladeshi food supplier. Amanat Foods offers BSTI-approved 100% pure Kalo-Jira (Black cumin) flower honey. It is a raw, natural, and unprocessed honey sourced directly from the nectar of black seed flowers.²³³

- Purity: Unprocessed, free from added sugar, artificial colors, and preservatives.
- Health benefits: Traditionally used to boost immunity, improve digestion, help with respiratory issues, and assist in weight management, but actual status is shown in Fig. 11.

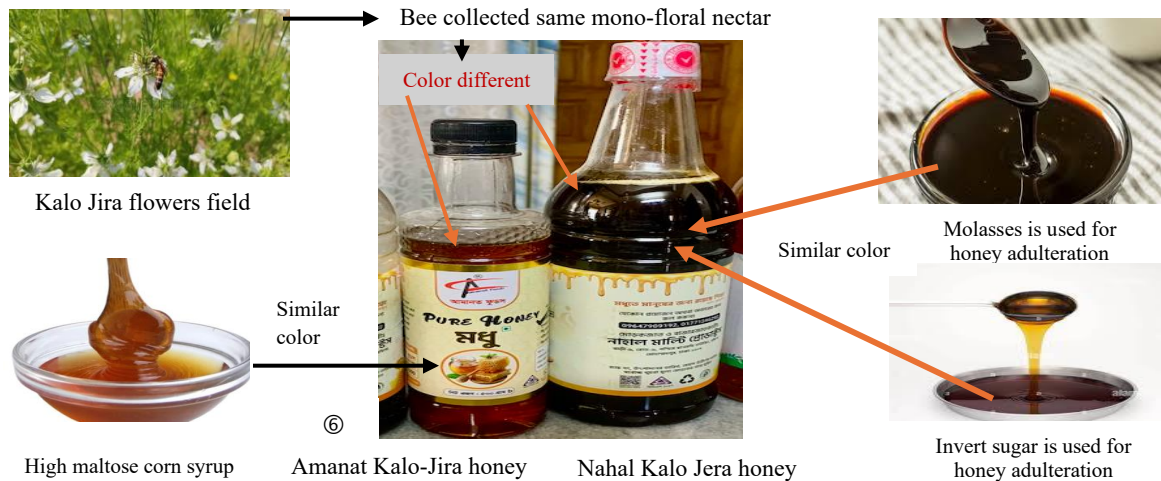


Fig. 11. Status of Kalo Jeera honey purchased on Facebook from Nahal honey and Amanat honey

⑦ Pure Honey of Sundarbans (Takwa Shop), Rupsha, Khulna

Taqwa shop, based in Rupsha, Khulna, offers authentic, raw Sundarbans honey harvested directly by their experienced Moyal (honey hunter) team. As of May 2026, they sell this pure, naturally collected mangrove forest honey to ensure quality and health benefits for families, including children and the elderly.²³⁴ The product offers pure, natural, unprocessed forest honey (Fig. 12), with a guarantee of purity (Photo 59). Customers can order through their Facebook page (Takwa Shop/Khulna) and other digital pages.

Advertisement devices to prove the Sundarbans, pure honey



Fig. 12: Left- 1kg Sundarbans honey with a natural pain relief oil of BDT 200 as free; Middle- Showing test to prove pure honey, and Right photo- Sundarbans (Takwa shop) honey for 1 year guarantee



Photo 59: Left photo- Takawa Shop honey for a one-year guarantee, and if proven adulterated, payment of BDT 20,000/- (twenty thousand) in cash; Right photo- Takwa Shop honey for a lifelong guarantee

Pure Sundarbans honey from Bangladesh is highly sought after for its natural, chemical-free quality, sourced from flowers, and is sold by various online shops and directly online. One kg of Takwa Shop Sundarbans honey was purchased via Facebook and was found to be immature or highly adulterated with water and sugar syrups (Photo 60).



A 1-kg bottle of Sundarbans honey was purchased on Facebook from the Takwa Shop. When the honey bottle was opened transferred to two smaller containers, it began to ferment, and the contents of both containers overflowed, as if boiling.

Photo 60. Takwa Shop honey 1kg bottle when divided into two separate containers started like boiling automatically and falling like foams and bubbles on the ground

- Pure, unadulterated honey has a very low moisture content (usually around 17%) and high acidity, creating an environment where bacteria and yeast cannot survive.
- Ripe honey (moisture < 17) could be preserved for a long time without fermentation. Honey will ferment if the moisture in it increases $\geq 19\%$, especially when cutting away honey that is not ripe, or adulterated with water or sugar syrups.
- Raw honey naturally contains dormant osmophilic yeast spores from pollen and the hive environment (air and dust), which activate in high moisture-containing honey, consuming sugars and producing alcohol and carbon dioxide.²³⁵

- The yeasts present in honey may secrete enzymes that convert sugars into alcohol and carbon dioxide. Bacteria and oxygen in the air may break down these alcohols into acetic acid and water. Fermented honey loses its natural smell and taste and develops a sour smell. As a result, a sour, off-putting taste and foamy texture that no beekeeper or consumer wants (**Photo 60**). However, adulteration causes significant issues: When sugar syrups and water are added, the water activity of the honey increases significantly. This dilution activates osmophilic yeasts that naturally exist in honey. These yeasts consume the added sugars, breaking them down into ethanol and carbon dioxide gas. This fermentation process ruins product quality, causing a sour, alcoholic smell, surface bubbling or foaming, and an altered taste (**Photo 60**).¹⁸

Foam Vs. Fermentation: The key differences

- Bubbles:** Foam has fine, uniform micro-bubbles on the surface. Fermentation shows large, vigorous CO₂ bubbles throughout the honey.
- Taste and Aroma:** Foam means honey smells and tastes fresh. Fermentation produces sour, yeasty, or 'boozy' notes.
- Cause:** Foam means physical agitation and natural oxygen release. Fermentation comes from yeast consuming sugars and producing alcohol and carbon dioxide (CO₂).

⑧ ACI Pure Honey (Multifloral)

ACI Pure Multifloral honey from Bangladesh is a natural, premium honey product by ACI PLC, sourced from various flowers and packed with antioxidants and nutrients, offering energy, boosting immunity, and aiding digestion. It is available through major Bangladeshi online retailers and departmental stores. I've purchased a 250g package of this honey from a department store, but its viscosity and color are indistinguishable from those of some adulterants (**Photo 61**). Pure honey has a distinct, sweet, floral or plant-based aroma; the taste is intensely sweet with a slightly acidic or acidic finish and should not taste like artificial additives, but these characteristics were absent in this honey; accordingly, it was not processed for further testing.



ACI pure multifloral honey

High-maltose-corn syrup

ACI: Honey purity test

Invert sugar syrup

Photo 61. Comparison of ACI pure multifloral honey with similar color adulterants

Effects of fake and adulterated honey on consumer health

Fake and adulterated honey pose serious human health risks because they replace nutrient-rich, pure honey with cheap industrial sugar syrups, such as high-fructose corn syrup or molasses, and contaminants, and they lack the genuine nutritional and antimicrobial properties of pure honey. Consumers face heightened dangers of severe metabolic, cardiovascular, and toxicity hazards, often worsening conditions like Type II diabetes and obesity (**Fig. 13**).^{18,140}

① Metabolic and endocrine risks

- Blood sugar spikes:** Rapid absorption causes sharp, dangerous elevations in blood glucose, placing severe strain on insulin production.

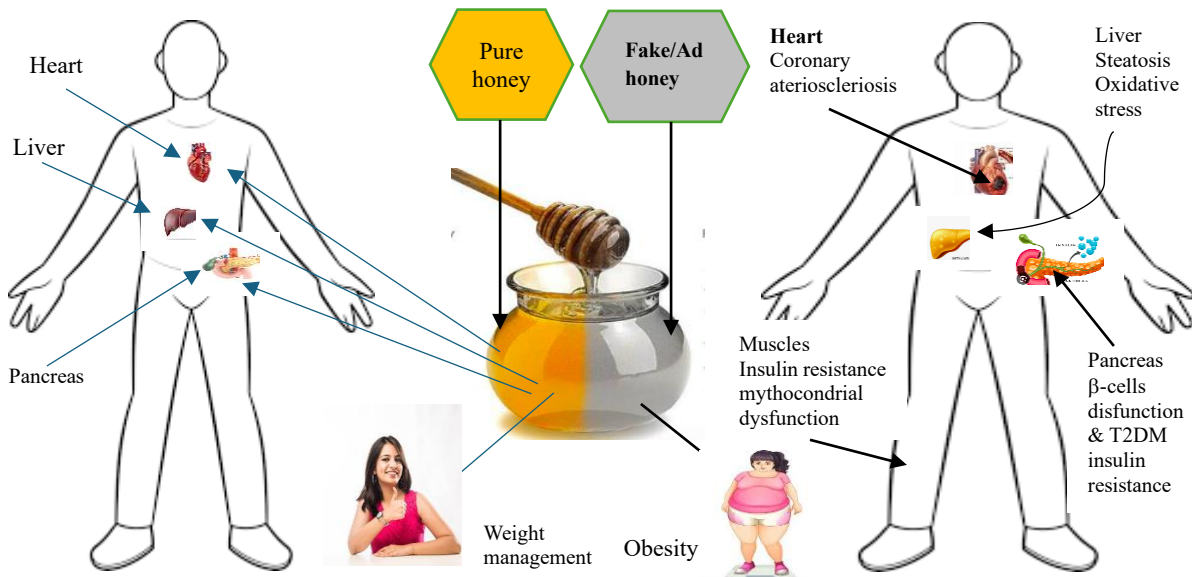


Fig. 13. Beneficial effects of pure honey and detrimental effects of fake/adulterated honey on human health

- Diabetes and obesity: Unlike pure honey, which can support weight management and metabolic regulation, regular consumption of adulterated honey promotes visceral fat storage, leading to abdominal obesity, high blood pressure, Type II diabetes, and elevated blood lipid levels.¹⁸

Role of adulterant and pure honey in obesity and weight

Polyphenols and fructo-oligosaccharides (FOS) aid in body weight control primarily by modulating the gut microbiome, reducing inflammation, and regulating energy metabolism. Combined, these dietary components help reduce visceral fat accumulation, curb appetite, and prevent physiological weight gain. (Fig. 14).²³⁶

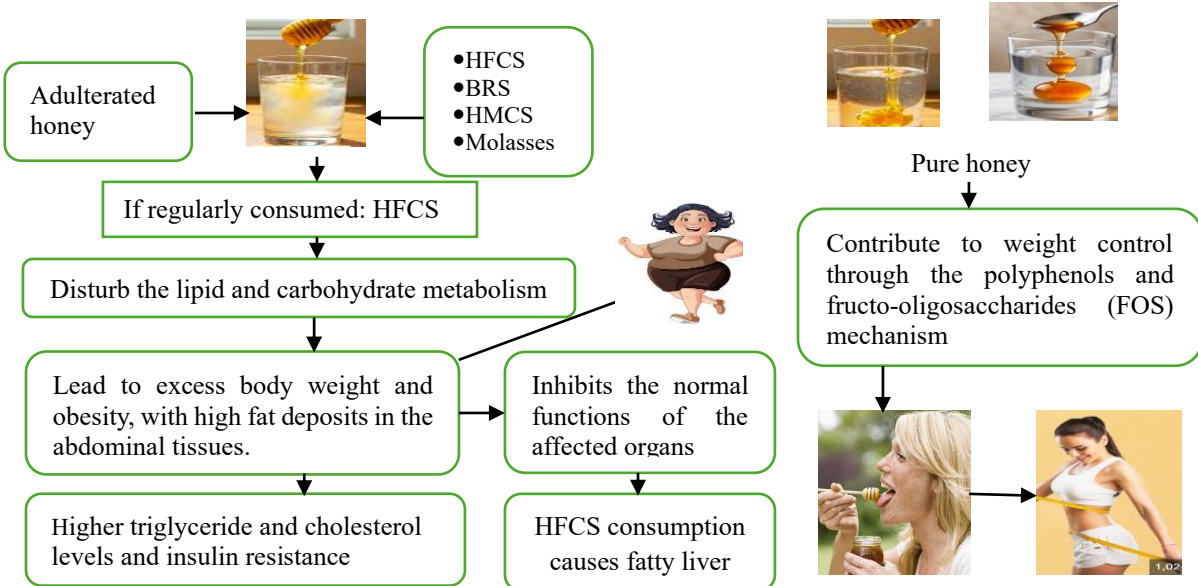


Fig. 14. Effects of regular consumption of fake/adulterated and pure honey on human health

Pure honey vs. Fake honey on Type 2 diabetes

Fake honey is highly dangerous for people with Type 2 diabetes because it causes severe, unpredictable blood sugar spikes. While pure honey contains natural sugars mixed with beneficial antioxidants, fake (adulterated) honey is chemically stripped or stretched with cheap, high-glycemic sugar syrups. This directly undermines blood glucose management.¹⁸ Table 17 highlights how differences between pure and fake honey impact Type 2 diabetes management.

Table 17. Pure honey vs. fake honey in Type 2 diabetes*			
SN	Metric/Features	Pure honey	Fake/adulterated honey
①	Primary Composition	Natural fructose, glucose, water, and micronutrients.	High-fructose corn syrup (HFCS), cane sugar syrup, or glucose syrup.
②	Glycemic index (GI)	Typically lower (~50-58) due to natural fructose ratios.	Significantly higher (~65-80+), matching or exceeding table sugar.
③	Blood sugar Impact	Causes a gradual rise, still requires strict portion control.	Causes immediate, aggressive, and unhealthy blood sugar spikes.
④	Metabolic effects	<i>In vivo</i> studies show it may support better lipid profiles over time.	Research shows it dramatically increases lipid accumulation and triglycerides.
⑤	Antioxidant value	Rich in polyphenols that fight inflammation and oxidative stress.	Stripped of protective compounds; acts purely as an inflammatory refined sugar.

*Even if it is 100% pure, honey is still a carbohydrate. Limit intake to small portions (e.g., ½ to 1 teaspoon) and always count it toward daily carbohydrate budget.²³⁷

② Cardiovascular and organ damage

Pure honey acts as a cardioprotective and organ-protective agent, reducing inflammation and oxidative stress. Conversely, fake (adulterated) honey acts like refined sugar, promoting metabolic disorders, cardiovascular disease, and liver or kidney damage. Table 18 highlights how the differences between pure and fake honey impact cardioprotective and organ-protective management.¹⁸

Table 18. Pure and fake /adulterated honey impact on cardioprotective and organ-protective mechanisms ²³⁸			
SN	Health parameter	Pure (raw/natural) honey effects	Fake (adulterated) honey effects
①	Cardiovascular system	Protective: Lowers LDL and triglycerides increases HDL, prevents LDL oxidation, and dilates blood vessels.	Damaging: Increases total cholesterol, promotes arterial plaque buildup, and elevates blood pressure.
②	Systemic inflammation	Lowers C-reactive protein (CRP) and inhibit pro-inflammatory enzymes.	Pro-inflammatory: Spikes inflammatory cytokines (e.g. IL-6, TNF-α) due to added refined sugars.
③	Blood sugar and metabolism	Regulates: Has a lower glycemic index (~55); can improve fasting glucose and insulin sensitivity.	Spikes & Strains: High glycemic load; spikes blood sugar, causing insulin resistance and Type II diabetes risk.
④	Liver function	Protective: Rich in antioxidants that protect hepatic cells.	Damaging: Leads to hepatic lipid accumulation (fatty liver) and metabolic stress.
⑤	Kidney function	Protective: Trace antioxidants prevent oxidative damage to nephrons.	Damaging: High concentrations of foreign sugars (like HFCS) can cause acute or chronic kidney injury.
⑥	Toxicity profile	Clean & Natural: Free from heavy metals and toxic byproducts (when sourced from reputable beekeepers)	Hazardous: Often contains undisclosed heavy metals caramel dyes, and harmful residues (e.g., antibiotics)
⑦	Nutrients and enzyme value	High: Contains pollen, amino acids, enzymes, and flavonoids.	Zero: Stripped of vital enzymes and pollen, providing only ‘empty calories.’

③ Chemical contaminants and carcinogens

Authentic honey is prized for its therapeutic and antibacterial benefits. Unregulated honey processing and the use of artificial syrups introduce dangerous pesticides, heavy metals, and elevated levels of hydroxymethyl-furfural (HMF).¹⁸

- Chemicals and heavy metals: Counterfeit or mass-blended honeys frequently contain traces of illegal antibiotics, pesticide residues, and heavy metals.
 - Cancer risks: Fake and adulterated honeys often contain traces of heavy metals, pesticides, and unapproved antibiotics. Prolonged consumption of these residues can be linked to genetic abnormalities and carcinogenic effects.¹⁴⁰
 - Antibiotic resistance: Many fraudulent honeys are produced using techniques or synthetic bulk ingredients that are contaminated with trace amounts of veterinary antibiotics. Repeated, low-level exposure can contribute to the development of antibiotic-resistant bacteria in the human body.¹⁴⁰
- The roles of both pure and fake honey in chemical contaminants and carcinogens vary widely (Table 19).

Table 19. Comparison between pure honey and fake honey in chemical contaminants and carcinogens ^{18,19,221,239}			
SN	Contaminants	Pure (authentic) honey	Fake (adulterated) honey
①	Heavy metals (e.g., Lead, Cadmium)	Low to moderate risk: Can be absorbed from contaminated soil or water near the hive. Traces can act as systemic toxins and carcinogens.	Low risk: unless contaminated water was used to dilute the sugar syrups.
②	Pesticides (e.g., Neonicotinoids)	Moderate risk: Bees foraging on treated crops can bring residues into the hive, carrying mutagenic and cellular degradation risks.	Low risk, as it is typically manufactured from corn, rice, or cane sugar rather than floral nectar.
③	Veterinary drugs/ Antibiotics	Moderate risk: Beekeepers sometimes use medicine to treat bee diseases; residues persisting in the honey have been linked to potential nephrotoxicity and carcinogenic effects.	Low risk: Generally lacks residues associated with apiculture, though may contain traces of processing chemicals.
④	HMF (hydroxy-methyl-furfural)	Low risk: Naturally forms very slowly over time. Elevated levels usually only occur if pure honey is overheated.	High risk: The acid inversion process used to break down cheap corn or cane sugars into fake honey Generates high levels of HMF, a recognized mutagen and carcinogen.
⑤	Added sugars and artificial syrups	Zero risk: Contains only naturally occurring sugars like fructose and glucose.	High risk: Adulterated with HFCS, refined cane sugar, and molasses, which are linked to obesity, metabolic issues, and inflammation.

Potential toxic effects of honey adulterated with brown rice syrup

Honey adulterated with brown rice syrup poses severe health hazards, primarily due to dangerous heavy metal contamination and metabolic risks. Because rice naturally absorbs toxins from the soil, the syrup often contains high levels of inorganic arsenic. Long-term consumption of tainted honey increases the risk of organ damage, cancer, and diabetes (Photo 62).²⁴⁰



Arsenic contained brown rice



Brown rice syrup (Arsenic-containing)



Adulterated Honey +BRS



Regular ingestion of honey



Signs of arsenic poisoning in humans

Photo 62. Honey adulterated with brown rice syrup has toxic effects on consumer health

Consuming honey blended with brown rice syrup poses notable health risks, including heavy metal exposure and metabolic disruptions.²⁴¹

① Heavy metal exposure (arsenic)

Because rice absorbs arsenic from soil and water far more than other crops, brown rice and its derivative syrup can accumulate concerning levels of arsenic. Prolonged consumption of adulterated honey containing high amounts of brown rice syrup can lead to chronic arsenic toxicity, characterized by:

- Skin anomalies: Dark spots or lesions
- Gastrointestinal issues: Abdominal pain and vomiting.
- Nerve/Muscle tissues: Muscle cramps and numbness.
- Long-term threats: Elevated risk of cancer and cardiovascular complications.

② Metabolic and chronic disease risks

Brown rice sugar is primarily composed of complex sugars such as maltose and maltotriose, which act similarly to pure glucose in the body. When masked as a ‘healthy’ sweetener, the sudden spike in intake can lead to:

- Insulin resistance: Contributing to the development of Type 2 diabetes.
- Weight gain: Promoting obesity and abdominal fat accumulation.
- Liver and kidney stress: Increased risk of non-alcoholic fatty liver disease (NAFLD) and visceral organ strain.¹⁸

③ Loss of medical benefits

Genuine raw honey contains beneficial natural enzymes, antioxidants, amino acids, polyphenols, and trace nutrients that provide antimicrobial and anti-inflammatory properties and real therapeutic and health benefits. Adulterated honey is diluted with brown rice syrup, refined sugars, or syrups, offering no nutritional value or eliminating these health benefits, leaving consumers with only ‘empty’ sugars and potentially causing adverse metabolic effects.²⁰⁰ Table 20 compares the nutritional values and health benefits of pure and adulterated honey.

Table 20. Comparison of medical values and health benefits between pure honey and adulterated honey		
SN Medical/Health benefits	Pure honey	Fake/ Adulterated honey
① Blood sugar control	Contains a lower glycemic index and slower absorption rate, avoiding sharp glucose spikes.	Contains added sugars/corn syrup, leading to sudden insulin spikes and dangerous blood sugar fluctuations.
② Antibacterial and wound healing	Possesses natural hydrogen peroxide and bee propolis that prevent bacterial growth and promote healing.	Lacks antimicrobial properties; can introduce infection risks if applied to open wounds.
③ Antioxidant protection	High in polyphenols and flavonoids which reduces cellular damage from free radicals and lower inflammation	Generally devoid of antioxidants, providing empty calories instead of cell protection.
④ Gut and digestive health	Acts as a natural prebiotic, promoting healthy gut flora like Lactobacillus.	Can disrupt the digestive system, as artificial sweeteners can feed bad gut bacteria and cause bloating.
⑤ Cough and sore throat	Coats and soothes the throat effectively while offering immune-boosting vitamins.	Only provides temporary physical relief from the syrup, lacking natural immune support.

Medical-grade honey (MGH)

While all raw honey possesses some antibacterial properties due to natural hydrogen peroxide, only specific mono-floral honey contains high levels of non-peroxide compounds that allow it to be sterilized and certified for clinical medical-grade wound and ulcer care. MGH is a highly purified, specially sterilized

via gamma irradiation to eliminate spores and bacteria while preserving its natural antimicrobial and healing properties. It promotes healing by lowering wound pH, reducing inflammation, and drawing out fluid. It is primarily used to manage chronic wounds, burns, and surgical incisions.

Key characteristics of MGH

- Sterilization: MGH is sterilized using gamma irradiation to ensure it is completely safe to apply directly to open wounds, burns, and ulcers.²⁴²
- Purity standards: It means stringent clinical safety benchmarks and is guaranteed to be free of toxins, herbicides, pesticides, and heavy metals.²⁴³
- High antimicrobial activity: It naturally inhibits bacteria and fungi through its own pH (high acidity), high osmolarity (which draws fluid and debris from wounds), and, in some varieties, hydrogen peroxide production.²⁴⁴
- Bioactive properties: It is often standardized for specific compounds, such as methylglyoxal (MGO), which is found in high concentrations in Manuka honey and drives strong antibacterial action against resistant bacterial strains.²⁴³

The US FDA has approved some products originating from MGH, especially those formulated on Manuka honey, including dressings, pastes, ointments, and gels.²⁴⁵ Table 21 outlines the most globally recognized raw honeys utilized in clinical, medical, and advanced wound-care settings.

SN	Name of honey	Country of origin	Botanical source	Key active compounds	Bee species	Clinical applications	Ref. No.
01..	Manuka	New Zealand, & Australia	<i>Leptospermum scoparium</i>	MGO, DHA	<i>Apis mellifera</i>	Surgical wounds, burns, and ulcers.	246
02.	Sidr (Beri)	Saudi Arabia, Yemen & Pakistan	<i>Ziziphus spinachristi</i>	MGO, High polyphenols	<i>Apis</i> spp.	Antibacterial and anti-inflammatory properties	247
03.	Tualang	Malaysia, & South East Asia	<i>Koompassia excelsa</i>	Flavonoids, Phenolic acids	<i>Apis dorsata</i>	Burn-healing efficacy and antioxidant properties.	248
04.	Buckwheat	USA, Canada & Eastern Europe	<i>Fagopyrum esculentum</i>	Hydrogen peroxide Phenolic compounds	<i>Apis mellifera</i> <i>Apis cerana</i>	High antioxidant, Cough suppressant, wound healing	249
05.	Thyme	France, Greece, Spain, NZ	<i>Thymus vulgaris/ capitatus</i>	Phenol, Flavonoids Thymol, H ₂ O ₂	<i>Apis mellifera</i>	Broad-spectrum antimicrobial, skin infections, RTI	250
06.	Eucalyptus	Australia and South Africa	<i>Eucalyptus globulus</i> <i>E. camaldulensis</i>	Eucalyptol (Cineole) Quercetin	<i>Apis mellifera</i>	Traditional & homeopathic medicine- RTI, burns, abrasions	251
07.	Kanuka	New Zealand	<i>Kunzea ericoides</i>	AGPs, H ₂ O ₂ , Phenolic acids	<i>Apis mellifera</i>	Anti-inflammatory, non-per-oxide antibacterial for skin	252-254
08.	Revamil®	The Netherlands	Unspecified	High enzyme content	<i>Apis mellifera</i>	Used in recalcitrant wound Medical honey ointment	255
09.	Gelam	Malaysia	<i>Melaleuca cajupati</i>	Potent antibacterial	<i>Apis dorsata</i>	Effective against Gm +ve bacteria, tissue regeneration	256-258
10.	Chestnut	Slovenia	<i>Castanea sativa</i>	Polyphenols	<i>Apis mellifera</i>	Wound, infection and RTI	259,260
11.	Multiflora	Chile	Mixed	Flavonoid	<i>Apis mellifera</i>	Wound, antimicrobial, skin	261,262
12.	Kelulut	Indonesia	Multiflora	High antioxidant components	<i>Trigona</i> sp.	Indigenous people used to treat canker sores.	263,264
13.	Ulmo	Chile	Ulmo tree (<i>Ucryphia cordifolia</i>)	Equal to munuka UMF25+	<i>Apis mellifera</i>	Antibacterial activity	265

Current status of MGH in the world

The global medical-grade honey (GMGH) market was valued at \$1.2 billion in 2025 and is projected to expand to \$2.6 billion by 2034, advancing at a compound annual growth rate of 9.1% over the forecast

period of 2026 to 2034.²⁶⁶ Regulatory approvals from agencies like the US FDA, the European Medicines Agency, and the Therapeutic Goods Administration of Australia have reinforced product credibility, enabling broader integration into formal healthcare protocols. The increasing prevalence of antimicrobial resistance (AMR) and drug-resistant bacterial infections is now responsible for an estimated 1.27 million global direct deaths annually in 2019, and contributed to 4.95 million deaths.²⁶⁷ The global diabetic population, which surpassed 537million adults in 2025 and is projected to exceed 789 million by 2045, represents a massive and growing patient pool at elevated risk for chronic non-healing wounds, creating a sustainable pipeline of demand for advanced wound care solutions, including MGH products (Table 22 & 23).²⁶⁶

Table 22. Medical-grade honey market: segment comparison ²⁶⁶				
SN Metric	Wound care	Skin care	Cough and throat	Digestive health
① Market share (2025)	47.8%	20.3%	14.6%	10.5%
② CAGR (2026-2034)	08.8%	10.7%	09.3%	09.8%
③ Key driver	Chronic wound Prevalence	Cosmeceutical demand	Respiratory health awareness	Prebiotic recognition
④ Primary end user	Hospitals and clinics	Homecare and retail	Consumer retail	Consumer retail
⑤ To distribution channel	Hospitals	Online stores	Retail pharmacies	Online stores

Table 23. Medical-grade honey (MGH) market research report forecast period 2025-2034 ²⁶⁶	
SN Attribute	Details
① Base year and Historical period	2025 and 2019-2025
② Market size in 2025	\$ 1.2 billion
③ Market forecast in 2034	\$ 2.6 billion
④ CAGR	9.1% (2026-2034)
⑤ Product types	Manuka honey, Other MGH
⑥ Therapeutic application	Wound care, skin care, cough and throat treatment, digestive health, others
⑦ End users	Hospitals, clinics, homecare settings, others
⑧ Regions covered	North America, Europe, Asia Pacific, Latin America, Middle East, & Africa
⑨ Key companies	•Comvita Ltd. •Dutch Gold Honey Inc. •Rowse Honey Ltd. •Beeyond the Hive, Steens Ltd. •YS Eco Bee Farms. •NZ Honey Co. •Natures Way Products LLc. •Manuka Health NZ Ltd. •Honey NZ (Int) Ltd. •Bee Maid Honey Ltd. •Wedderspoon Organic Inc. •Little Bee Impex •The Honey Co., Apis Flora Indl. Coml. Ltda. •Capilano Honey Ltd. •Melita Honey Farm Pvt Ltd. •Barkman Honey LLC •Nature Nate's Honey Co •Savannah Bee Co.

Manuka honey (from *Leptospermum scoparium* in New Zealand and *L. polygalifolium* in Australia) is relatively rare in methylglyoxal content and contains various glycosides, polysaccharides, peptides, and proteins. The composition gives these honeys a broad range of antibacterial activity, including against antibiotic-resistant bacterial strains.

Research development on apiculture and honey therapy from ancient to modern medicine

Humans have relied on the honey and wax bees provide for tens of thousands of years, whether to make food, candles, or aid in medical and cosmetic applications. There are a few key movements (and fun facts throughout ancient honey's history and its importance to kind, e.g., the earliest record of 'honey hunting' (13,000-8000 BCE), first recorded rock painting of someone gathering honey (6000 BCE), and first use of honey for food, medicine, and religious rites in Egypt (3100-300 BCE).²⁶⁸

Al-Lawh al-Mahfuz (the Preserved Tablet) is a celestial, unalterable record in Islam containing the divine decree, destiny, and history of the entire universe. Written by the Pen (al-Qalam) before the creation of the heavens and earth, safeguards all past, present, and future events from any alteration or corruption. The Qur'an is the eternal, uncreated word of Allah. It was recorded in its entirety in the al-Lawh al-Mahfuz- a celestial ledger near the Divine Throne- long before the creation of the universe.²⁶⁹ This connection is explicitly mentioned in the Qur'an: "Nay, this is a glorious Qur'an, [inscribed] in a Preserved Tablet [al-Lawh al-Mahfuz]" (Surah Al-Burij 85:21-22). Allah, the Almighty, has placed so much importance and shifa (remedy) in honey that he revealed an entire Surah by the name of bee- Surah Al Nahl (The Bee) in which he says, "Thy Allah has inspired the Bees, to build their hives in mountains, on trees, and in man's habitations; then suck from every kind of flowers and travel the path of your Allah, within their bodies comes a drink of varying colors, wherein is healing for mankind; verily, in this is a sign for those who give thought (Surah Al Nahl 16: 68-69). Allah subhanahu wa ta'la ordered the bees to make honey, which will be healing for mankind and a subject for people to think on (do research). The Qur'an was revealed over 23 years, beginning in 610 CE and concluding in 632 CE with divine revelations to the Prophet Muhammad (SAW). However, the prescription for a standard wound salve discovered in the Smith papyrus (an Egyptian text dating from between 2600 and 2200 BC) calls for a mixture of mrst (grease), byt (honey), and fit (lint/fiber) as transliterated from hieroglyphic symbols.²⁷⁰⁻²⁷² But honey as a subject for people to think (research) about began after the establishment of the Qur'an. Honey research has evolved from ancient, empirical uses (such as the 632 AD Qur'anic revelations praising it) to a robust, evidence-based science. Key milestones in honey research (632 to 2026) are given below:

Honey research has evolved from ancient Islamic and folk observations to rigorous 21st-century clinical and biochemical analyses. The sweet superfood has shifted from traditional dietary and medicinal prescriptions to a standardized, scientifically supported biological therapeutic and cosmetic agent.²⁷³ Modern research continues to validate ancient claims that honey is a complex bioactive matrix that provides lasting antimicrobial, antioxidant, and tissue-regenerating properties,^{274,275} heavily on advanced botanical authentication, clinical wound healing mechanisms, and the isolation of honey's specific therapeutic enzymes,²⁷⁶ while advancing into advanced materials such as honey-incorporated hydrogels for tissue regeneration.²⁷⁷

Honey is an ancient therapy that has recently been reintroduced into modern medicine. The timeline below highlights the chronological evolution of these discoveries, tracing key milestones in its medical validation, chemical profiling, and biological applications from the Islamic era up to 2026.²⁷⁵

① 632-1650 CE (Early Islamic and Ancient Medicine)

- 632-661 AD (The Golden Age of Islamic Medicine): Islamic medical texts and the Qur'an formally endorse honey as an excellent natural medicine and wholesome food. The Hadith and the Qur'an documented honey's therapeutic properties extensively. It was routinely prescribed for gastrointestinal ailments, diarrhea, wound healing, and as a general tonic.^{274,278,279}
- 865-925: Muhammad Ibn Zakariya Al-Razi (Rhazes) wrote more than 224 books, including the medical encyclopedia Al-Hawi fi al-Tibb (The Comprehensive Book on Medicine), which documented honey's specific therapeutic benefits. His books on medicine, philosophy, and alchemy greatly influenced human civilization, especially in Europe.²⁸⁰ He championed honey as a core medicine and advised using it as a simple drug or an essential vehicle in compound medicines.²⁸¹
- 11th century (around 1025 AD): Islamic scholar Ibn Sina (Avicenna) advanced honey's medical standing. In his encyclopedia, The Canon of Medicine, he documented honey as a potent medical agent, prescribing it for digestive issues, wound healing, memory enhancement, cold symptoms, and as a natural mood booster.^{282,283}

- 1609: English naturalist Charles Butler published his groundbreaking treatise on apiculture, ‘The Feminine Monarchie, or the History of Bees.’ He identified the queen and helped raise public awareness that the bee colony is ruled by a Queen rather than a king.²⁸⁴
- 1682: English travel writer Sir George Wheeler published *A Journey into Greece*. While traveling in Greece, he documented the traditional wicker top-bar hives used by monks on Mount Hymettus. These were among the first detailed European records of hives with movable frames, serving as early precursors to modern beekeeping.^{268,285}

② 1700-1899: The dawn of apiculture and biochemical analysis

- 1789: Swiss naturalist Francois Huber invented the ‘leaf hive’ (or book hive). Featuring hinged frames that opened like pages, it allowed scientists to observe comb construction, study bee biology, document the queen’s nuptial flight, and observe antennal communication for the first time.^{286,287}
- 1852: American apiarist Lorenzo Langstroth received US Patent No. 9,300 for his movable-frame beehive in October 1852. His design utilized a precise ‘bee space’ that prevented bees from attaching combs to the hive walls, allowing for easy inspection and honeycomb removal without destroying the colony. The invention revolutionized beekeeping by allowing beekeepers to manage hives more easily, monitor for pests, and boost honey production.^{268,288} Today, the standard Langstroth hive remains the most commonly used beehive design worldwide.
- 1882: The German chemist Edmund Oskar von Lippmann determined that honey’s primary sugars are glucose and fructose.²⁸⁹ This discovery laid the foundation for modern honey chemistry, identifying these two monosaccharides as the main constituents responsible for honey’s sweetness and tendency to crystallize.²⁹⁰
- 1892: The first scientific documentation and discovery of the antibacterial activity of honey was reported in 1892 by the Dutch scientist Bernardus Adrianus van Ketel.^{276,291} This was later followed by significant research, such as Sackett in 1919 identifying honey’s antibacterial potency, and Dold and Witzenhausen coining the term ‘inhibitor’ in 1955 to describe the active antibacterial substance, later identified as hydrogen peroxide.²⁹²
- 1892: The antimicrobial and preservative osmotic effect of honey was first scientifically described by German researcher Dr. G. Th. Sack in 1892. He published the first major experiments showing that high sugar concentrations draw water out of microorganisms, causing them to die of dehydration.²⁹³

③ 1900-1999: The proof of antimicrobial and medicinal properties

- 1927-1973: Austrian ethologist Karl von Frisch first described the waggle dance in 1927. However, it took decades of dedicated research for him to fully decode the complex spatial information- such as direction and distance- conveyed by the dance, culminating in his receipt of the Nobel Prize in Physiology or Medicine in 1973.²⁹⁴
- 1950s: Dr. Jonathan W. White pioneered the modern scientific understanding of honey’s chemical composition. Through his work at the USDA, he identified the precise sugar, acid, and moisture levels.²⁹⁰
- 1963: Scientists Jonathan W. White, M. H. Subers, and A. I. Schepartz were the first to identify and report the presence of the enzyme glucose oxidase in honey in 1963.²⁹⁵ They published their findings in a pioneering study demonstrating that the antibacterial factor in honey- originally referred to by researchers as ‘inhibine’-was actually hydrogen peroxide, which is produced by the natural glucose oxidase enzyme in honey.²⁹⁵ Research has established that, as honey is diluted (e.g., by wound exudate), this enzyme produces hydrogen peroxide (H₂O₂), thereby providing broad-spectrum bactericidal activity. H₂O₂ production in honey requires glucose oxidase (Gox), which oxidizes glucose to gluconolactone and reduces molecular oxygen to hydrogen peroxide.²⁹⁶

- 1970s: Carbohydrate chemist Jonathan W. White Jr. identified honey's complex chemical profile. He outlined the primary sugars and organic acids, and standardized international limits for moisture and sugars.²⁹⁷
- 1990s: Honey has spoiled since ancient times, but food scientists and biologists first explained its specific chemical properties (notably Peter Molan in the 1990s) after archaeologists discovered perfectly edible, 3000-year-old honey in Egyptian tombs.^{298,299} The four overlapping chemical properties that aggressively resist bacterial spoilage of honey are: (a) High acidity (honey has a naturally low pH of 3.2-4.5, which is highly hostile to most microorganisms that prefer a neutral environment); (b) Low moisture (honey typically contains only 17-18% water. Bacteria require at least 20% moisture to thrive and survive, (c) Osmotic effect (the supersaturated, high-sugar concentration acts like a sponge, drawing water out of bacterial cells and effectively dehydrating them to death, and (d) Hydrogen peroxide (bees add an enzyme (glucose oxidase) to the nectar, which naturally breaks down sugars, producing hydrogen peroxide, a mild antiseptic).³⁰⁰⁻³⁰³
- 1990: Professor Peter Molan at Waikato University in New Zealand discovered that certain Manuka honeys (derived from the *Leptospermum scoparium* bush) have additional stable antibacterial properties that do not exist in other honey. He was not, though, able to determine what exact component gives Manuka honey its unique property; therefore, he coined the term UMF (unique manuka factor).^{304,305}
- 1992: Professor Peter Molan, in his landmark 1992 review article published in Bee World and the Journal of Applied Bacteriology, detailed that honey inhibits around 60 species of bacteria (including both aerobic and anaerobic, Gram-positive, and Gram-negative species) and emphasized the crucial roles of polyphenols, flavonoids, and antioxidants.^{276,306} The extensive list of inhibited bacteria includes common human pathogens such as *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*.³⁰⁷

④ 2000-2015: Advanced molecular biology and clinical validations

- 2006: A research team led by Professor Thomas Henle, head of the Institute of Food Chemistry at the Technical University of Dresden, Germany, tested more than 80 honeys from around the world and found Methylglyoxal (MGO) levels as high as 700 mg/kg in some New Zealand manuka honeys, more than 70 times higher than ordinary honey, which is responsible for its unique, reliable antibacterial activity.^{305,308}
- 2006: George Weinstock and Gen E. Robinson, who initiated and organized the honeybee genome sequencing consortium, mapped the genome of *Apis mellifera*. The consortium used a single drone (male honeybee) from the Rebecca L. Simons honey bee line to complete the draft, allowing them to work with a single set of chromosomes.³⁰⁹⁻³¹¹
- 2007: The US FDA cleared the first honey-based wound and burn dressings. Marketed under the brand name Medihoney®, these products are primarily formulated with medical-grade, sterile Manuka honey (derived from the *Leptospermum scoparium* bush).³¹² These sterile, medical-grade honey products are uniquely designed for clinical and at-home management of: (a) Wounds (minor abrasions, traumatic and surgical wounds), (b) Ulcers (diabetic foot ulcers, leg ulcers, and pressure sores, and (c) Burns (1st- and 2nd-degree partial-thickness burns).³¹³
- 2007: Warren and co-workers reported the first definitive trial and scientific report on using honey to treat acute nocturnal coughs in children. It was published in the journal Archives of Pediatrics and Adolescent Medicine (now JAMA Pediatrics).³¹⁴
- 2007: Dr. Ian M. Paul first reported that honey is a safe and effective cough suppressant, and superior to over-the-counter dextromethorphan (DM) in easing childhood coughs.³¹⁵
- 2009: Jenkins and Cooper compared the antibacterial potency and microbial flora of 18 supermarket table honeys to a representative sample of *Leptospermum* honey (MGH) and showed that the table honey

contained a wide range of potentially pathogenic bacterial species, whereas MGH was sterile. Therefore, using non-sterile honey samples in wound management cannot be justified.³¹⁶

- 1970-2023: Several foundational studies in the late 20th century established the systematic identification and characterization of phenolic acids and flavonoids acting as antioxidants in honey.³¹⁷ These include: early flavonoid isolation in 1970, pinocembrin as a bioactive in 1984, broad flavonoid profiling in 1989,³¹⁸ and antioxidant quantification in 1996-2002.³¹⁹
- 2021: HPLC recognizes that honey's antioxidant prowess comes from dozens of these compounds, which vary depending on the floral source. The most common ones include: (a) Flavonols and Flavones (quercetin, luteolin, kaempferol, apigenin, chrysin, and galangin), (b) Flavanones (pinocembrin, hesperetin), and (c) Phenolic acids (p-hydroxybenzoic, caffeic, vanillic, syringic, p-coumaric, ferulic, benzoic, gallic, and cinnamic acid).^{276,320,321}
- 2011 & 2013: Dr. Rowena Jenkins and Dr. Rose Cooper confirmed that medical-grade honey, with its low pH, osmotic effect (high sugar content), and hydrogen peroxide, can effectively eradicate bacterial biofilms (including MRSA) while stimulating immune and tissue responses.^{278,291,300}
- 2014: Cooper described that honey is not a uniform product, and its chemical composition can be influenced by multiple factors. Gamma irradiation of honey has been shown not to affect antibacterial activity, although it may increase antioxidant activity.³²²

⑤ **2016-2026: Modern therapeutics, technology, and hive health**

Modern research integrates advanced biotechnology, IoT, and apitherapy to improve hive health and human therapeutics. Key scientists have led breakthroughs using artificial intelligence to monitor colony collapse, microparticle sponges to detoxify pesticides, and mass spectrometry for non-invasive health analysis in apiaries.³²³⁻³²⁵

a. Modern honey therapeutic research

- 2018: Abel and others reported that honey and its sugar and phenolic components can lower the metastatic properties of prostate cancer cells, and may do this by preventing effective cell adhesion to the extracellular matrix. The sugars and phenolic compounds of honey are much more effective in combination than individually.³²⁶
- 2019: Martin Farkas developed portable biosensors that can quickly detect honey bee diseases, dramatically reducing diagnostic times of colony pathogens.³²⁷
- 2021: Naik and co-workers investigated the efficacy of medical-grade honey (L-Mesitran soft) for treating HSV-induced cold sores, finding a promising alternative treatment for cold sores, likely by combining increased antiviral and wound healing activities while alleviating pain and itching.³²⁸
- 2021 (Paleoproteomic Archaeology): Biomolecular techniques extracted non-collagenous proteins from medieval manuscripts, empirically providing evidence of the historical use of honey in midwifery and maternal care in England.³²⁹
- 2022: Apitherapy research: Scientists have validated honey's antibacterial, antioxidant, and anti-inflammatory roles. Modern biomedical reviews by researchers (e.g., ARMS Al-Waili) highlight honey as a nutraceutical agent that suppresses tumor growth, promotes burn healing, and modulates the human immune system.³³⁰
- 2022: Nolan and co-scientists reviewed the efficacy of honey against a variety of multidrug-resistant (MDR) bacterial species, with 18 different types of honey against 32 different bacterial species, including numerous MDR strains. Surgihoney was found to be the most effective honey, displaying minimum inhibitory concentrations as low as 0.1% (w/v), however, all honeys showed a high efficacy against most bacterial species analyzed. The MDR bacterial strains were often more susceptible to honey treatment.

Honey therapy should be considered for MDR-caused bacterial infections.³³¹

- 2023: Holubova and co-scientists found that the application of MGH-containing dressing led to the activation of the healing process, debridement stimulation, and faster wound bed cleaning phase. MGH reduced odor and exudate secretion and maintained an optimal moist environment in the wound bed, thus aiding the cleansing phase of the healing process. All wounds were completely healed, and MGH exhibited antibacterial, anti-inflammatory, and antioxidant effects in diabetic foot syndrome wounds; glycated hemoglobin did not increase or glycemia levels, and thus constitutes an effective alternative to antibiotics in the treatment of locally infected wounds.³³²
- 2024: Demonstrated that MGH can be used in each type of wound commonly encountered in elderly patients.³³³
- 2025: El-Seedi and co-workers studied bee Venom (Apitoxin): Researchers are synthesizing bee venom components (like melittin) into targeted nanomedicines and modulating the human immune system.³³⁴
- 2025: MGH cannot cure or prevent cancer on its own, but it serves as a highly effective supportive therapy to manage conventional cancer treatment side effects. However, recent studies demonstrate that specific monofloral honeys (such as Gelam) reduce inflammation and cytokine levels (e.g., TNF- α , IL-6) by inhibiting NF- κ B translocation. This has revolutionized honey-infused medical hydrogels used for advanced wound debridement and tissue repair.²⁷⁷
- 2025: Kiryowa and co-scientists reviewed that manuka honey (*Leptospermum scoparium*) contains active elements such as methylglyoxal, methylsyringate, and leptosin that have been identified to possess anti-cancer properties. These molecules eradicate cancer cells by inhibiting the AKT/mTOR pathway, dampening oxidative stress, and inducing apoptosis. Studies in animals have shown that these substances can inhibit tumor growth in breast, colorectal, and liver cancers, both *in vitro* and *in vivo*. This honey offers a valuable opportunity for incorporation into cancer treatment protocols. Manuka honey not only protects the body from the side effects of chemotherapeutic agents but also enhances their efficacy.³³⁵
- 2025-2026: Medical-grade honey (MGH) has been incorporated into modern hydrogels and advanced dressings. Research confirms it promotes autolytic debridement (cleaning dead tissue) and prevents biofilm formation.^{277,336}
- 2026: Oncology and Apitherapy: Pre-clinical studies from 2024 to 2026 have explored honey's mechanisms in inhibiting cancer cell proliferation. Compounds such as bee venom and melittin have been engineered into nano-formulations to target breast and bladder cancers while remaining non-cytotoxic to healthy cells.³³⁷
- 2026: A research team of analytical chemists and food scientists, led by Nikolaos S Thomaidis and colleagues, was the first to employ Liquid Chromatography-Trapped Ion Mobility Spectrometry coupled with High-Resolution Mass Spectrometry (LC-TIMS-HRMS) to fingerprint and classify honey varieties, effectively verifying its botanical and geographical origin to combat global food fraud.^{277,338}
- 2026: A reviewer team reviewed clinical and postoperative applications of Manuka honey in wound healing and found that Manuka honey exhibits antibacterial, anti-inflammatory, antioxidant, and tissue-regenerative properties through methylglyoxal, phenolic compounds, high sugar content, and low pH. Manuka honey demonstrates broad-spectrum antimicrobial and antibiofilm effects, supports non-traumatic debridement, and modulates inflammation to promote granulation and re-epithelialization.³³⁹

b. Hive health and modern beekeeping technologies

- 2021: Dr. Minglin Ma (Cornell University) developed a pollen-sized microparticle sponge fed to honey bees that acts as a targeted enzyme detoxifier. Published in 2021, this technology protects bees from lethal pesticides such as organophosphates.³⁴⁰

- 2021: Dr. Y-L Wu discovered that plant-derived compounds like sodium butyrate boost honey bees' expression of immunity and memory-related genes, helping virus-infected bees find their way home.³⁴¹
- 2022: Dr. E. Katsamakas & A. Fleming's team developed 'direct-shotgun metagenomics,' a technique to test honey for DNA traces to map botanical diversity and identify deadly disease variants in the hive.³⁴²
- 2022: Dr. Asya Ilgun created self-healing, activity-evolving architecture for beehives using mycelia. These 'living beehives' mimic natural tree cavities and can be embedded with medical fungi to help bees fight pathogens.²⁴³
- 2023: A recent study documented the use of immune-boosting therapies to reduce viral activity in honey bee cells. Additionally, synthetic biology approaches, such as the specific genetic treatment Noroa, have been utilized to shut off protein production in Varroa mites without harming bees.³⁴⁴
- 2024: Giovanni Formato coordinated European projects evaluating sustainable, organic treatments (e.g., oxalic acid) and breeding Varroa-resistant bee strains to create self-sufficient colonies.³⁴⁵
- 2024: Ilic and co-scientists developed a portable membrane inlet mass spectrometer (MIMS) for noninvasive hive analysis, demonstrating its ability to detect various compounds (internal air of a hive) indicative of hive conditions and environmental stressors to rapidly detect diseases and chemical pollutants without disturbing the bees. The MIMS detection method provides rapid, accurate, and real-time results, making it suitable for preventive measures against bee diseases and integral to environmental biomonitoring.³²³
- 2024: Shelley and Co-scientists developed the ProtectaBEE® system, an innovative beehive-entrance technology that guides bees through a compartment inoculated with an inseminating dry powder-formulated biocontrol agent to manage Varroa destructor. Inspensing paves new paths for optimizing bee health and pest control strategies, streamlining disease management, simplifying hive maintenance, and minimizing beekeeping intervention, all contributing to sustainable apiculture.³⁴⁶
- 2025: Ramesh Sagili leads research tracking Varroa mite population dynamics, testing novel miticides, and developing a pollen-substitute diet to combat malnutrition in managed hives.
- 2024-2426: Intelligent Monitoring & Machine Learning: Researchers such as T Kavin³⁴⁷ and teams at the University of Malaysia Terengganu evaluated the integration of Internet of Things (IoT) sensors, computer vision, and Artificial Intelligence (AI) to remotely monitor weight, hive temperature, humidity, honey quality, and acoustic changes in hives for early disease detection.³⁴⁸ Others utilized Membrane Inlet Mass Spectrometry (MIMS) for real-time analysis of environmental stressors.³²³
- 2026: Dr. C. Duplais & P. Hafker (Cornell University) investigating a novel dietary supplement to enhance honey bee overwintering immunity and offset miticide-induced pressures.³⁴⁹
- 2026: Mass spectrometry imaging of the honeybee brain revealed distinct functional chemical signatures linked to brain functions and longevity, significantly advancing agricultural and ecological research into honeybee health.³⁵⁰
- 2026: USDA researcher Vincent Ricigliano³²⁵ has led research on RNA interference (RNAi) tools to combat mites and the manipulation of the honey bee microbiome to shield colonies from viruses
- 2020: Studies highlight the critical role of honeybees in global agriculture, raising research interest in colony health and floral diversity preservation.³⁵¹

Clinical application of honey in human health

Medical-grade honey (MGH) and honey-based formulations are widely recognized in modern medicine globally for their potent antimicrobial, anti-inflammatory, and wound healing properties. These

pharmacological-grade products treat specific conditions such as chronic wounds, diabetic ulcers, dry eyes, oral mucositis, and upper respiratory infections, leveraging honey’s antibacterial, anti-inflammatory, and osmotic properties.^{25,276,333} Medical professionals and pharmacies use standardized, sterile honeys (primarily Manuka, Kanuka, or Tualang) for specific conditions (Table 1).²⁴⁵

① Wound care and burn management

- Examples: Medihoney®, Activon®, Revamil® (Table 90)
- Honey creates a moist healing environment, maintains a low pH, and has high osmolality that draws fluid out of the wound bed to clear infection and produce hydrogen peroxide. These characteristics create an antibacterial environment that clears infections, including antibiotic-resistant strains like MRSA, reduces inflammation, and promotes tissue regeneration. It promotes rapid healing, reduces edema, and helps debride wounds. It is particularly effective for diabetic foot ulcers and skin grafts.³⁵²
- **Diabetic foot ulcers and leg ulcers:** Utilizes sterile medical-grade Manuka honey to create a moist environment that promotes autolytic debridement and reduces healing time.³⁵³
- Diabetic foot ulcers, pressure sores, 1st and 2nd-degree burns, and surgical or traumatic wounds. It provides a low-pH moist environment to prevent bacterial growth and reduce malodor.²⁴⁵
- **Diabetic foot ulcers:** Aids autolytic debridement (cleaning dead tissue) and significantly shortens healing time without synthetic antibiotics.³³³
- **Minor burns and abrasions:** Form a protective, moist barrier that reduces inflammation, naturally prevents bacterial growth without antibiotic resistance, and accelerates tissue regeneration.³⁵³
- **Pressure ulcers, surgical and traumatic wounds:** Decontaminates infected, sloughing, or necrotic wounds, effectively controls foul odors, and eliminates multidrug-resistant bacteria from deep wound beds like MRSA.^{333,353,354}
- **Safety warning:** Standard kitchen honey is not sterile and should never be applied directly to open wounds or burns, as it can introduce bacterial spores.²⁷⁶

② Dermatological conditions

- Examples: Various Manuka-infused creams and ointments.
- **Commercial Brands:** Medihoney wound gel and First honey wound ointment are widely available commercial formulations for these skin conditions.³⁵⁵
- Skin conditions: Acne, Rosacea, Cold sores, Herpes lesions, and minor skin infections
- Its antifungal and antibacterial effects are being studied; topical applications of honey have shown success in managing seborrheic dermatitis, dandruff, and certain fungal and viral skin infections.³⁵²
- Topical application directly to herpetic lesions can improve healing time.³⁵⁶
- **Safety warning:** Standard kitchen honey is not sterile and should never be applied directly to open wounds or burns, as it can introduce bacterial spores.²⁷⁶

③ Ophthalmology disorders

- Examples: Optimel Antibacterial Manuka eye gel/drops
- **Mild to moderate dry eye disease and blepharitis:** Honey drops help lower the bacterial load and improve the tear film’s lipid layers.²⁵⁶
- **Dry eye syndrome:** Specialized antibacterial eye drops and gels relieve dry eye symptoms and improve overall ocular surface health.²⁵⁶
- **Commercial Brands:** Optimel Manuka + Eye drops and Gel (commonly used in clinical practice for ocular surface disease).²⁵⁶

④ Gastrointestinal disorders

- Examples: Medihoney® Paste and clinical swallow protocols
- **Gastritis and Peptic ulcers:** Can inhibit the growth of *Helicobacter pylori* (the bacteria responsible for

most stomach ulcers), reduce inflammation of the gastric mucosa, and help repair damaged intestinal mucosa.²⁵

- Gut inflammation: Honey may help soothe gut inflammation and has been studied as an adjunctive treatment for conditions such as mild gastroenteritis (diarrhea) or colitis (Fig. 7).
- Gut microbiome: Certain oligosaccharides in honey can act as prebiotics, promoting the growth of beneficial gut bacteria.
- Prevents and treats mouth sores, ulcers, and radiation- or chemotherapy-induced oral mucositis.²⁴⁵
- Acts as a demulcent and antimicrobial agent to soothe and manage symptoms of bacterial diarrhea.³³³
- Gut health:** Utilized to regulate mild constipation (as a natural laxative agent) and to help soothe dyspepsia.³⁵⁷

⑤ Oral, throat and respiratory disorders

- Examples: Zarbee's Naturals®, Comvita®, Manuka honey syrups
- Oral mucositis and gingivitis:** Rinsing with and swallowing honey have been clinically shown to reduce the severity of mouth sores and ulcers, particularly those caused by the Herpesvirus, radiation therapy, or chemotherapy.³⁵⁶
- Clinical trials show that topical application of honey can help prevent or soothe oral mucositis (painful mouth ulcers and inflammation) caused by radiation and chemotherapy.
- Sore throat: Coats and soothes the pharynx, reducing irritation and minor local infections.³⁵⁸
- Cough and Sore throat:** Honey's high viscosity and demulcent effect line the throat, helping soothe irritated throat mucosa and relieve nocturnal coughs, pharyngitis, and upper respiratory tract infections.^{345,356,358}
- Honey is often recommended as an effective, natural alternative to over-the-counter suppressants for managing coughs due to upper respiratory tract infections in children over 12 months old. It acts as a demulcent, coating and soothing irritated throat mucous membranes.^{359,360}
- Safety warning:** Honey must never be given to infants under one year of age due to the risk of infant botulism, as raw honey contains bacterial spores that cause infant botulism-a rare but severe digestive illness.³⁶⁰

⑥ Metabolic and cardiovascular support

Because honey is rich in bioactive compounds, including polyphenols and flavonoids, it offers protective metabolic benefits when consumed in moderation as part of a balanced diet.³⁶¹

- Blood sugar management: Although honey is largely sugar, its rich antioxidant profile and trace elements may help improve fasting blood sugar levels and increase adiponectin (a hormone that reduces inflammation) more than refined table sugar.³⁵⁹
- Heart health: Regular, moderate consumption is associated with lower blood pressure and improved cholesterol and triglyceride levels, thereby reducing cardiovascular risk factors.³⁵⁹ It helps neutralize harmful free radicals associated with chronic diseases.

Mode of action of honey in the management of wounds

Honey is a viscous, sugary, hyper-saturated solution composed mainly of simple sugars (~80%), water (~17%), and other constituents derived from floral nectar, honeydew, or the honeybees themselves, such as enzymes, vitamins, minerals, and phenolic compounds.^{242,362} However, honey composition varies greatly across regions of the world due to floral diversity.²⁴² Today, honey is still used in modern medicine to promote wound healing. Commercially available honey-based pharmaceutical products that comply with European Commission and Food and Drug Administration (FDA) medical device legislation are made with medical-grade honey (MGH).^{242,245,354} MGH must come from organic sources, be free of contaminants or toxic substances such as pollution-derived toxics, and be gamma-sterilized to eliminate dangerous spores of *Clostridium botulinum*.²⁴² Manuka honey is the most commonly used MGH; a mono-

floral honey from *Leptospermum scoparium*, originating in New Zealand and Australia. Medical-grade manuka honey (MGMH) has been recognized in most 510(k)- FDA-cleared or Conformité Européenne (CE)- marked products. These honey-based pharmaceutical products are indicated for various types of wounds, including diabetic foot ulcers, 1st- and 2nd-degree burns, pressure ulcers, donor site wounds, traumatic wounds, and surgical wounds.²⁶³ Many published reports describe the effectiveness of honey products in all phases of wound healing, with no adverse effects on the healing process. Clinical trials showed that the therapeutic benefit of honey depends on wound type and honey composition.³⁶⁴

The mode of action of medical honey in wound management is based on its antimicrobial properties and its ability to influence wound healing.³⁶⁵ This is achieved in a number of ways:

① Antibacterial action

Effective therapeutic and preventive agents for wound infections are an important goal in wound treatment, especially with the increasing prevalence of multidrug-resistant (MDR) bacteria, including *Staphylococcus aureus* and *Pseudomonas aeruginosa*.³⁶⁶ MGH is known for its antibacterial activity, which relies on various mechanisms, including low pH, high osmolarity, hydrogen peroxide production from the oxidation of glucose by glucose-oxidase, after dilution by wound exudate, and the presence of antimicrobial compounds (Table 24).

SN Honey properties	Compounds in action	Mechanism of action	Antibacterial action (Ref. No.)
① Low pH (~pH 4)	Glucose Gluconic acid Glucose-oxidase*	Glucose is converted into gluconic acid by glucose-oxidase	Low extracellular pH lowers bacterial intracellular pH. ³³ ³⁶⁷
② High osmolarity (Water activity = 0.6)	Disaccharides (sucrose, maltose) Monosaccharides (glucose, fructose) Diastase* Amylase*	Polysaccharides are converted into monosaccharides by different enzymes in honey. High concentrations of monosaccharides and low-water content lead to high osmolarity.	Cytoplasmic volume of bacteria shrinks when in contact with honey. ³⁶⁸ Bacterial ribosomal proteins translation is impaired. ³⁶⁹
③ Hydrogen peroxide production	Glucose Glucose-oxidase* Hydrogen peroxide	Generation of H ₂ O ₂ during enzymatic glucose conversion into gluconic acid upon dilution (wound exudate absorption)	Chemical oxidation of bacterial cell lipids, proteins, and DNA. ³⁷⁰
④ Presence of methylglyoxal (MGO)	Dihydroxyacetone MGO	Dihydroxyacetone is converted into MGO during storage in honeycombs.	Disturbs bacterial membrane integrity. ³⁷¹ Blocks bacterial fimbriae and flagella formation. ^{371,372} Disrupts bacterial biofilms. ³⁷³
⑤ Presence of antimicrobial peptide	Bee defensin-1*	Defensin-1 directly comes from honeybees' hypopharyngeal glands.	Prevents the secretion of Polymeric substances that form (poly)microbial biofilms ³⁷⁴

*Exogenous substances produced by the honeybees' hypopharyngeal glands during storage in honeycombs

Manuka honey has been reported to have an antibacterial action against a broad spectrum of bacteria and fungi, including: (a) *Staphylococcus aureus*,^{375,376} (b) *Pseudomonas aeruginosa*,³⁷⁷ and (c) MRSA, vancomycin-sensitive and vancomycin-resistant enterococcus.^{375,378} Manuka honey has a distinctive, heat-stable antibacterial component, known as methylglyoxal (MGO).³⁷⁹ This allows it to maintain its antibacterial activity even when diluted, such as when it comes into contact with wound fluid.³⁸⁰

MGMH has demonstrated great antibacterial properties against both non-MDR and MDR bacteria.³⁸¹⁻³⁸⁴ MGMH could both prevent bacterial resistance and work with antibiotics by restoring bacterial susceptibility.³⁸²⁻³⁸⁶ It appears that MGMH could prevent the need for antibiotic therapy or shorten its duration, thereby reducing the risk of antibacterial resistance in chronic infected wounds. MGMH has also been reported to be effective against biofilm formation found in up to 80% of chronic wounds, 48 accentuating its relevance as an antimicrobial component.^{387,388}

② Removal of biofilms and MRSA

- Biofilms are now recognized to impede wound healing by trapping bacteria in a protective matrix, and their development needs to be inhibited.^{389,390}
- Honey supplemented with MGO (i.e., equal to manuka honey) has been reported to inhibit *S. aureus* biofilms.³⁹¹
- Inhibition of *P. aeruginosa* biofilms depended on the contact time and the concentration of manuka honey.³⁹²
- Eradication of MRSA from colonized wounds following topical application of manuka honey has been reported in patients with leg ulcers,^{393,394} pediatric oncology patients,³⁹⁵ and in patients with maxillofacial wounds.³⁹⁶
- Removing MRSA from wounds reduces the risk of systemic infection and cross-infection to other individuals.

③ Reduction in malodor

Patients with exuding and/or infected wounds may experience malodor. Honey's ability to eliminate unpleasant odors from wounds may be due to its rapid deodorizing effect in patients with malodorous fungating wounds³⁹⁷ and in leg ulcers.³⁹⁸

④ Debriding effect

Wounds that are not progressing require repeated debridement to remove necrotic and sloughy tissue to establish a healthy wound bed. Honey provides an autolytic debriding effect, where the osmotic action of honey encourages lymph fluid to rehydrate devitalized tissue, helping remove sloughy and necrotic tissue.³⁹⁹ Hydrogen peroxide produced in honey by the enzyme glucose oxidase is thought to contribute to the debridement process.⁴⁰⁰

⑤ Anti-inflammatory effects

Chronic wounds exhibit increased inflammation, leading to elevated protease levels that delay healing. Manuka honey has a low pH, which may help control protease activity in the wound and may be associated with reduced wound size.³⁹⁹ The antioxidants in honey likely also exert anti-inflammatory effects by scavenging free radicals that increase in both acute and chronic wounds.⁴⁰¹

⑥ Immune-modifying effect

- Acute wounds like surgical incisional wounds, lacerations, and abrasions exhibit acute inflammation and pain, whereas chronic wounds like diabetic foot ulcers, venous ulcers, pressure ulcers, and burn wounds are characterized by chronic inflammation, micro- and macrovascular damage, ischemia, high exudate production, pain, and, in some cases, diabetic neuropathy.⁴⁰²⁻⁴⁰⁴
- Acute wounds heal through four phases: hemostasis, inflammation, proliferation, and remodeling, whereas chronic wounds generally stall in a dysregulated chronic inflammation phase.⁴⁰²⁻⁴⁰⁶
- Honey exhibits both pro-inflammatory and anti-inflammatory properties. The contribution of each component likely depends on the wound context (etiology, comorbidities such as diabetes, chronicity) and is not currently well understood. Honey may attenuate excessive inflammation and jump-start the acute inflammatory response.³⁶⁴
- Manuka honey stimulates the immune system to produce inflammatory cytokines, which are important for wound healing. This stimulation likely helps promote progression toward healing.⁴⁰⁷

Medical honey pharmaceuticals

Medical-grade honey (MGH) is pharmaceutical-grade honey (PGH), most notably Manuka and Kanuka, ensuring safety for advanced wound care, dermatology, anti-inflammatory treatment, and gastrointestinal health. MGH is rigorously tested, filtered, and gamma-irradiated to guarantee zero contamination while preserving its antibacterial properties. Table 25 lists the major pharmaceutical and specialized medical-device companies that manufacture and supply MGH products globally.

Table 25. Key honey pharmaceutical companies by region in the world	
SN. Region & Companies	Key Honey Pharmaceuticals
A. United States	
① Integra Life Sciences	Medihoney line of medical-grade Manuka honey (MHMH) for wound care products (dressings, gels and paste), which are FDA-cleared and widely used for chronic wounds, diabetic foot ulcers, and burns. ⁴⁰⁸
② Gentell	Specializes in advanced wound care, manufacturing Manuka honey-based fiber and gel dressings for chronic wounds. ⁴⁰⁹
③ First Honey (USA/NZ)	Manufactures sterile, medical-grade Manuka honey (MGMH) creams, Ointments, and bandages primarily for at-home wound, cut, and burn care. ⁴¹⁰
④ ManukaGuard	Focuses on MGMH for both topical wound care and daily gastro-intestinal (GI) health. ⁴¹¹
B. Europe	
① Advancis Medical (UK)	Advanced wound care products, manufacturing the Activon and Algivon (alginate) ranges of MGMH, used in topical treatment, gels, and alginate dressings, utilized by hospitals for aggressive skin infections and antibiotic-resistant bacteria. ⁴¹²
② Sanomed (Netherlands) Mediq Healthcare/	Produces the L-Mesitran line, a widely used range of MGH ointments and wound gels with added vitamins and antioxidants for clinical chronic and acute wounds management. ⁴¹²
③ Revamil® (Bfactory Health Products, The Netherlands)	Revamil honey is produced in the Netherlands using a highly controlled greenhouse method by Wageningen University. ⁴¹³
④ Honey Green+ (Spain)	Supplies bulk MGH extract B2B honey for global pharmaceutical and food supplement formulas [https://honeygreen.com]
C. Oceania (New Zealand & Australia)	
① Manuka Health (New Zealand)	A premier producer of MGO-rated MGMH by grading methylglyoxal (MGO) levels, used topically in wound care and orally in healthcare products. ²⁴⁵
② ManukaMed (USA/ New Zealand)	Specializes extensively in harvesting and manufacturing sterile, high-Potency Manuka honey specifically designed for clinical and hospital Wound management. ²⁴⁵
③ Nature’s Gold (Australia)	Manufactures therapeutic topicals and creams using Australian Manuka Honey, famously recognized by the Australian Therapeutic Goods Administration (TGA) ⁴¹⁴
D. Bulk MGH Suppliers	
① Clinihoney (UK/New Zealand)	A primary B2B manufacturer that supplies certified MGH in industrial formats (pails and drums) to global cosmetic and pharmaceutical companies. ⁴¹⁵

Differences between food-grade honey and Medical-grade honey

Food-grade Manuka honey is a raw agricultural product with variable potency. MGH levels fluctuate with the season and weather conditions during nectar flow, and with hive location relative to *Leptospermum scoparium* forests. Two jars from the same producer can have dramatically different antibacterial activities. Table 8 compares FGH and MGH. Table 26 shows the standard differences between Food-grade honey and Medical-grade honey.

Table 26. Standards comparison between Food-grade honey and Medical-grade honey ⁴¹⁶			
SN	Requirement	Food-grade honey	Medical-grade honey
①	FDA classification	Food product	Class II medical device
②	Sterility	Unsterile (May contain spores)	Gamma irradiated (sterile)
③	MGO testing	Voluntary /Unverified	Mandatory Batch verification
④	Manufacturing standards	Good agricultural practices	ISO 13485 / GMP compliance
⑤	Filtration	Coarse strain (Retains debris)	Medical-grade micro-filtration
⑥	Potency consistency	Variable by Batch	Standardized and Blended
⑦	Clinical use authorization	Not approved for wound care	FDA Cleared / CE Mark

FDA-recognized medical-grade honey-based products

FDA 510(k)-cleared honey-based wound products are medical-grade devices regulated as Class II dressings, such as Medihoney®, ManukaMed®, and Thymed/Manuka HoneyGels. These sterile items utilize medical-grade *Leptospermum* (Manuka) honey to manage moisture and provide antibacterial properties. ⁴¹⁶

FDA Recognized Medical-grade Honey Brands

As of 2026, several manufacturers produce FDA-cleared or CE-marked medical-grade Manuka honey products. These brands have completed the regulatory process and maintain the manufacturing standards required for clinical use.

- ① **Medihoney:** First FDA-cleared honey wound dressing (2007). Available in gel, paste, and impregnated dressing formats. MGO concentration ranges from 400+ to 800+ depending on product line.
- ② **Activon:** CE-marked medical honey from the UK. Produces tube honey, impregnated gauze, and Manuka honey-based wound gels. Primarily distributed in European and Commonwealth markets.
- ③ **SurghoneyRO:** Medicated-grade honey enhanced with reactive oxygen species. CE marked for wound care. Developed specifically for biofilm penetration in chronic wounds.

Commercial honey-based formulations

A. United States

① Integra Life Sciences (USA)



a. Medihoney® Gel Wound & Burn Dressing ⁴¹⁷

- A medical-grade, honey-based topical treatment containing 80% active manuka honey and 20% natural gelling agents.
- It maintains an optimal moist healing environment, lowers wound pH, and supports autolytic debridement.
- Used for diabetic foot ulcers, leg ulcers, pressure ulcers, 1st & 2nd degree burns, surgical wounds, and donor sites.
- High osmolarity draws fluid to the surface to help clean the wound and remove dead tissue.

FDA Warning and Recall Alert

Integra Life Sciences and the FDA issued a significant medical device recall for specific Medihoney Wound and Burn products. Packaging failures were identified that could breach the sterile barrier, potentially leading to patient infections. ⁴¹⁸

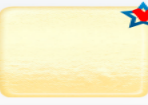


b. Medihoney® Paste Dressings (Integra Life Sciences, USA) ⁴¹⁹

- Medihoney paste dressings are sterile, 100% active Manuka honey-based treatments.
- They promote a moisture-balanced healing environment, support autolytic debridement, and easily reach deep or irregular areas.
- Indicated for partial-to full-thickness wounds, diabetic foot ulcers, leg ulcers, pressure injuries, 1st- and 2nd-degree burns, and surgical or traumatic wounds with light to moderate exudate.



Hydrogel Sheet
(Non-Adhesive)



Hydrogel Sheet
(Adhesive)



HCS (Adhesive)



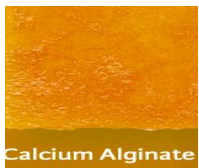
HCS (Non-Adhesive)

c. Medihoney® Hydrogel Sheet dressings (Integra Life Sciences, USA) ⁴²⁰

- These are advanced medical wound covers containing sterile 80% active manuka honey and 20% gelling agents (hydrogel sheet)
- Maintains a low pH level (3.5-4.5), which helps lower wound pH and draws fluid to the surface via osmotic action.
- Forms a therapeutic gel as it absorbs fluid, helping the body naturally lift away dead or non-viable tissue.
- Indicated for non-draining to moderately exuding acute and chronic wounds, including diabetic foot ulcers, leg ulcers, pressure ulcers, 1st & 2nd degree burns, surgical or traumatic wounds.
- Available in adhesive border formats and non-adhesive sheet configurations (which require a secondary wrap like gauze or film).

d. Medihoney® Hydrogel Colloidal Sheet (HCS) (Integra Life Sciences, USA) ⁴²¹

- HCS is a sterile wound dressing containing 63% active manuka honey combined with super absorbent polymers. Available in the following four different forms:
- Surgical dressings- Postoperative incisions and deep, draining wounds to absorb fluid, cushion the site, and protect the suture from external bacteria.
- Fenestrated dressings (Non-adhesive)- Commonly used around tracheostomy tubes, chest tubes, and intravenous catheters, allowing the dressing to lay flat against the skin without obstructing or shifting the tube.
- Non-adhesive dressings - Dressings without sticky borders that do not stick to the moist wound bed. Best uses are fragile, easily damaged skin, minor burns, and highly sensitive or painful areas.
- Adhesive dressings- Dressings that feature a sticky, self-adhering border or backing. Best uses are minor cuts, surgical incisions with very little drainage, and wounds on intact surrounding skin.



Calcium Alginate

e. Medihoney® Calcium Alginate Dressing (Integra Life Sciences) ⁴²²

- It is an absorbent primary wound dressing containing 95% active manuka honey impregnated into a 5% calcium alginate pad. It is designed for moderately to heavily exuding wounds, forming a gel as it absorbs fluid to support a moist healing environment.
- Indicated for diabetic foot ulcers, leg ulcers, pressure ulcers, 1st -and- 2nd -degree partial-thickness burns, traumatic wounds, surgical wounds, and skin graft donor sites.

② Gentell (USA)



a. Manuka Honey Fiber Dressing (Gentell, USA) ⁴²³

- It is an MGH-impregnated, super-absorbent gelling fiber wound dressing.
- It is designed to manage moderate to heavy wound drainage, lower wound pH to speed up healing, and reduce bad odors.

b. Honey Hydrogel Sheet Dressing (Gentell, USA) ⁴²⁴

- It is a sterile, semipermeable wound care product featuring 30% MGH, water, and an acrylic polymer gel with a polyurethane film backing. It rehydrates dry tissue, absorbs low levels of fluid, and helps reduce pain.

c. Manuka Honey Skin Protectant Cream (Gentell, USA) ⁴²⁵

- It is a topical barrier ointment containing 30% MGH, shea butter, kukui nut oil, vitamin E, vitamin B5, and allantoin designed to relieve dry, chapped, cracked, or irritated skin and minor burns.
- It is a primarily medical dressing made of MGH impregnated into an acetate gauze. It is designed for moist wound management, gelling with wound fluid to remain non-adherent and easy to remove.



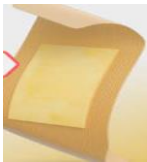
③ First Honey (USA/NZ) Ltd

First Honey is a family-owned wellness and medical-grade skincare brand. The company specializes in producing sterile, natural wound care and skin therapy items powered by pure Manuka honey harvested from their own forests and bee farms in New Zealand.



a. Manuka Wound Ointment (First Honey (USA/NZ) Ltd) ⁴²⁶

- It is a sterile, medical-grade topical treatment made with pure NZ 100% active Manuka honey harvested in New Zealand.
- It is designed to provide natural infection protection, promote rapid skin recovery, and minimize scarring for minor cuts, burns, and abrasions.



b. Manuka Honey Bandages (First Honey (USA/NZ) Ltd) ⁴²⁷

- First Honey makes medical-grade Manuka honey bandages using 100% pure mono-floral Manuka honey harvested from family-owned bee farms in New Zealand.
- These sterile, latex-free adhesive bandages are designed to promote faster healing and protect against infection as a natural alternative to synthetic antibiotic ointment.



c. Skin Therapy / Eczema Cream (First Honey (USA/NZ) Ltd) ⁴²⁸

- Skin Therapy Cream is a dermatologist-recommended, nourishing moisturizer made with MGMH from NZ, designed to soothe dry, irritated, and eczema-prone skin.
- It provides natural relief for conditions like eczema, rosacea, and psoriasis without harsh chemicals or steroids.



d. Foot Rescue Cream (First Honey (USA/NZ) Ltd) ⁴²⁹

- It is an all-natural, ultra-hydrating treatment made with MGMH, shea butter, and patented Drieline™ technology.
- It is specifically designed to heal dry, cracked skin, lock in deep moisture, and soothe irritated feet.

④ ManukaGuard Ltd. (USA)

ManukaGuard is a wellness brand specializing in medical-grade Manuka honey products sourced from New Zealand and bottled/distributed in the USA.



a. Deep Nasal Cleanse (Manuka Guard Ltd., USA) ⁴³⁰

- Deep Nasal Cleanse is a drug-free nasal spray made with MGMH, saline, and plant extracts to clear airborne irritants, hydrate dry passages, and soothe nasal tissues

b. Deep Allercleanse Nasal Spray ((Manuka Guard Ltd., USA) ⁴³¹

- Deep Allercleanse Nasal Spray is a drug-free, steroid-free sinus rinse made with Medical-grade manuka honey (MGO $\geq$ 400).
- It clears dust, pollen, and pet dander, moistens dry nasal passages, and provides natural allergy relief.



c. Extra strength Allercleanse Nasal spray (Manuka Guard Ltd., USA) ⁴³²

Extra strength Allercleanse Nasal spray is a drug-free, medical-grade nasal wash designed to clear pollen, dust, and pet dander from the nose. It features MGMH 600, saline solution, vegetable glycerin, fruit/plant extracts with vitamin C, and purified water.

d. Kids Nasal Spray (Manuka Guard Ltd., USA) ⁴³³

Kids Nasal Spray is a drug-free, alcohol-free saline mist made with MGMH 600, designed to gently cleanse and moisturize children's nasal passages. It is safe for children ages two and up (some labels note 1+) to help clear out dust, pollen, and congestion.



e. Throat soother (Manuka Guard Ltd., USA) ⁴³⁴

Throat soother is an MGMH dietary supplement bottled in the USA using New Zealand honey, featuring methylglyoxal (MGO) 200 mg/kg to relieve dry throats, hoarseness, and everyday irritation.

f. Cough & Throat syrup (Manuka Guard Ltd., USA) ⁴³⁵

Manuka Guard Cough & Throat Syrup is a natural dietary supplement made with high-potency MGMH 600+, designed to soothe sore throats and calm coughs.

B. Europe

① Advancis Medical (UK)

Advancis Medical specializes in 100% medical-grade Manuka honey used for advanced wound care and skin management. Key products include:



a. Activon Tube[®] ointment (Advancis Medical, UK) ⁴³⁶

- It contains 100% pure, MGMH used as a natural wound filler, which creates a moist healing environment, debrides necrotic or sloughy tissue, and eliminates foul wound odors.
- Best uses: sloughy wounds, pressure ulcers, surgical wounds, burns, graft sites, and malodorous wounds.

b. Activon Tulle (Advancis Medical, UK) ⁴³⁷

- It contains 100% pure MGMH used as a knitted viscose mesh dressing impregnated with Manuka honey, ideal for low-to-moderately exuding wounds (Wound 2026c)
- Dressing can be used in any wound, such as sloughy, necrotic, and malodorous wounds, dry wounds, leg ulcers, diabetic ulcers, pressure injuries, and infected wounds.



c. Aligivon /Aligivon Plus (Advancis Medical, UK) ⁴³⁸

- Aligivon is a soft alginate wound dressing impregnated with 100% MGMH and alginate fibers, enabling a slower, sustained release of honey, providing sustained antibacterial action, eliminating wound odor, and creating a moist healing environment.
- Aligivon: The standard dressing suitable for a wide range of wounds, aiding in de-sloughing and maintaining a moist healing environment.
- Aligivon Plus: Features reinforced alginate fibers, making the dressing softer and highly comfortable. It is primarily designed for wetter, heavier-exuding wounds because it holds its structure better and stops the honey from washing away as quickly.



d. Actilite (Advancis Medical, UK) ⁴³⁹

- It is a non-adherent, light viscose net that allows fluid to pass through, and a dressing coated with 99% antibacterial Manuka honey and 1% Manuka oil.
- It protects wounds, reduces inflammation, promotes healing, allows the passage of exudate, and helps manage odor.



e. Activon Manuka Honey Barrier Cream (AMHBC) (Advancis Medical UK) ⁴⁴⁰

- It is a 99% natural protective cream designed to prevent moisture-associated skin damage (MASD), caused by body fluids, incontinence, or sweat.
- It combines MGMH to soothe irritation with cocoa butter for moisture retention (Advancis 2026)
- It offers up to 24-hour protection against bodily fluids, reduces soreness, and moisturizes vulnerable or mildly irritated skin.

② SanoMed Manufacturing BV (The Netherlands)



a. SanoSkin Melladerm[®] Plus (SanoMed Manufacturing BV, The Netherlands) ⁴⁴¹

- Melladerm Plus is an antibacterial hydrogel with 45% medical-grade blossom honey (Bulgarian multi-flower plus glycerine and propylene glycol) used for acute and chronic wounds.
- It is designed to be gentle, painless upon application, and leverages the natural antibacterial strengths (osmosis & hydrogen peroxide).
- It does not stick to the skin and helps clean dirty or dead tissue.



b. Melladerm Plus Tulle (SanoMed Manufacturing BV, The Netherlands) ⁴⁴²

- It contains 45% multi-flower mountain honey from Bulgaria mixed with gelling agents (propylene glycol, PEG 4000, and glycerine).
- It features an MGH formulation applied to a carrier dressing designed for superficial, acute, or chronic wounds.

c. Melloxy ointment (SanoMed Manufacturing BV, The Netherlands) ⁴⁴³

- It is a patented wound care product combining 40% MGH, 11% ozonated vegetable olive oil, glycerine, propylene glycol, and PEG 4000.
- It creates an acidic (pH 4), high-osmolality, and oxidative environment that kill bacteria and draws fluid to cleanse the acute and chronic wounds.

③. Mediq Healthcare

Medeco BV (part of the Mediq group) distributes the L-Mesitran range of medical-grade honey wound care and pharmaceutical-grade topical products.



a. L-Mesitran ointment (Medeco BV, The Netherlands) ⁴⁴⁴

- It contains 48% MGH, combined with hypoallergenic lanolin, vitamins C and E, and other antioxidants, to treat infected and complex wounds.
- It manages acute and chronic wounds by providing antibacterial action and supporting tissue

b. L-Mesitran Soft Gel (Medeco BV, The Netherlands) ⁴⁴⁵

- It is a hydroactive, antibacterial wound gel containing 40% MGH, hypoallergenic lanolin, propylene glycol, PEG 4000, and vitamins C and E.
- It creates a moist healing environment via osmosis, helping to clean wounds and promote tissue



c. L-Mesitran Hydro Dressings (Medeco BV, The Netherlands / Mediq UK) ⁴⁴⁶

- A sterile, hydroactive, low-adherent sheet dressing containing MGH for moist wound healing.

d. L-Mesitran Border Dressings (Medeco BV, The Netherlands/ Mediq UK) ⁴⁴⁷

- A hydroactive sheet dressing featuring an adhesive film border and integrated MGH.

④ Revamil® Wound Gel (Bfactory Health Products BV, The Netherlands)

- Revamil wound gel is exclusively developed and manufactured by Bfactory Health Products BV, based in the Netherlands, while other regional entities like Oswell Penda Pharmaceuticals Ltd and Focusmed-Beyer KG act as regional distributors or license holders. Its production procedure is available. ^{448,449}
- Revamil is a 100% MGH wound gel that provides a hydrophilic effect, creating a moist wound environment, promoting optimal wound healing, and inhibiting bacterial growth. This wound gel contains antimicrobial properties and is best suited for the treatment of acute, chronic, and infected wounds. Revamil gel accelerates autolytic debridement of necrotic tissue whilst eliminating wound odor, encouraging wound healing. ⁴⁵⁰



a. Revamil® Wound Gel-Single dose (Bfactory Health Products BV, The Netherlands) ⁴⁵¹

- Revamil single-dose gel consists of 100% pure MGH with a single enzyme content and a low pH, which is used in chronic wounds. Infected wounds, acute wounds, surgical oncological wounds, radiation-induced oncological wounds, minor (1st- and 2nd-degree) burns.
- It is a pure MGH gel for direct application into deep or shallow cavities, providing a hydrophilic moist environment.

b. Revamil Wound Dressing (Bfactory Health Products BV, The Netherlands)

- Impregnated non-adherent gauze with 100% pure MGH, with high enzyme content and low pH, that delivers a slow release of honey without sticking to the fragile underlying tissue during removal. ⁴⁴⁹
- It is used for chronic wounds, infected wounds, acute wounds, surgical oncological wounds, radiation-induced oncological wounds, and minor (1st- and 2nd-degree) burns. ⁴⁵²



c. Revamil Melginate (Bfactory Health Products BV, The Netherlands) ⁴⁵³

- Revamil Melginate is an advanced MGH and 100% natural calcium alginate fibers impregnated with enzyme-rich medical-grade Revamil honey (7g of honey per 100 cm²) wound dressing, featuring high fluid absorption, fast gelling, and antibacterial properties.
- Calcium alginate combination designed to absorb moderate to high levels of exudate, rapidly absorbs wound exudate to form a non-sticky gel, maintaining a moist healing environment while protecting peri-wound skin from maceration.

d. Revamil Balm (Bfactory Health Products BV, The Netherlands) ⁴⁵⁴

- Revamil Balm is a medical-grade honey ointment that soothes damaged skin, fights bacteria, and helps heal minor wounds.
- It contains 25% pure MGH combined with a gentle, moisturizing oil-and-beeswax base.
- A soothing ointment blend for skin irritations, superficial abrasions, and daily at-home first aid.

C. Oceania (New Zealand & Australia)

① Manuka Health (New Zealand)

Manuka Health (New Zealand) offers targeted therapeutic and functional health items, anchored by medical-grade wound care and natural relief drops.



a. Manuka Wound Honey (Manuka Health, New Zealand) ⁴⁵⁵

- Manuka Wound Honey: 30g tube of 100% sterile, medical-grade Manuka honey priced around \$25.00, designed for cuts, minor burns, grazes, and skin ulcers.
- It fights bacteria, keeps the injury moist to help skin recovery, and spreads smoothly from its tube. ⁴⁵⁶

b. Manuka Rescue Balm ((Manuka Health, New Zealand) ⁴⁵⁷

- Manuka Rescue Balm works intensively to nourish and restore the skin's natural barriers. Containing 30% high-grade Manuka honey plus Beewax, calendula, and tamanu oil, this rich protective balm provides quick-acting and long-lasting care for damaged skin.
- Targeted topical ointment formulated for cough, cracked, or stressed skin.

② ManukaMed (USA/New Zealand)

ManukaMed produces medical-grade, honey-based advanced wound care products using 100% active Manuka honey harvested from New Zealand.



a. ManukaHD (ManukaMed, USA/New Zealand) ⁴⁵⁸

- Manuka HD Super-absorbent fiber dressings are sterile wound care products featuring 100% pure, impregnated medical-grade manuka honey, polyacrylate polymer, and polyester fibers for moderate-to-heavy exuding chronic wounds, pressure ulcers, and venous ulcers.
- ManukaHD is a medical-grade, honey-impregnated wound dressing designed to manage exudate, lower wound pH, and promote healing.
- It swells and forms a soft gel upon contact with wound fluid, absorbing necrotic tissue and debris.



b. ManukaHD Lite (ManukaMed, USA/New Zealand) ⁴⁵⁹

- ManukaHD Lite is a sterile, honey-impregnated wound dressing that uses 100% pure medical-grade NZ Manuka honey, combined with a super-absorbent gelling fiber pad to lock in fluid and debris.
- Standard absorbent honey-impregnated fiber pads designed to lower wound bed pH and manage tissue debris.
- It is designed to manage moderate to heavily draining wounds while promoting a moist healing environment.



c. Manuka Pli sterile pure honey tube (ManukaMed, USA/New Zealand) ⁴⁶⁰

- Manuka Pli is a 100% pure, sterile active NZ Manuka honey gel tube intended for surgical wounds, severe burns, and deep ulcers.
- It lowers wound bed pH, supports healing in a moist environment, and promotes autolytic debridement.

d. ManukaDerm Healing Skin creams (ManukaMed, USA/New Zealand) ⁴⁶¹

- It is a natural, medical-grade topical ointment containing 30% bioactive Manuka honey (MGO 560+) as a barrier cream and skin protectant, formulated to soothe and repair skin, eczema, minor burns, dermatitis, and minor irritations.

③ Nature's Gold (Australia)

Nature's Gold (Australia) produces therapeutic and medicinal honey items registered or listed with Australia's Therapeutic Goods Administration (TGA), including Therapeutic Skin Cream with Manuka honey, Manuka Power Concentrated ointments (MGO 1000 & <MGO 514), and Naturally Active Oral Spray. These items use Australian Manuka honey with high methylglyoxal (MGO) levels for healing and skin relief.⁴⁶²



a. Therapeutic Skin Cream with Manuka honey (Nature's Gold, Australia) ⁴⁶³

- Flagship medicinal cream consisting of active Australian manuka honey designated to relieve skin irritations, mild eczema, dermatitis, dry skin, minor burns, and psoriasis.

b. Manuka Power Concentrated Ointment (MGO 1000) (Nature's Gold, Australia) ⁴⁶⁴

c. Manuka Power Concentrated Ointment (MGO 514) (Nature's Gold, Australia)

- Both skin ointments are made with 30% raw active manuka honey, one with methylglyoxal (MGO 514), offering strong everyday antibacterial and soothing action, whereas the other contains ultra-potent honey with MGO 1000 for higher antibacterial and anti-inflammatory strength for severe skin fix and deep healing.
- MGO 514 formulation is recommended for daily maintenance, minor cuts, chafing, mild dry skin, lips, and general soothing of minor bug bites or small abrasions.
- MGO 1000 formulation is targeted as an upgraded first-aid solution for more stubborn or intense skin issues like severe dry patches, hard calluses, acute burns, stings, and persistent eczema flare-ups.

d. Naturally Active Oral Spray (Nature's Gold, Australia) ⁴⁶⁵

- A natural throat and mouth care product featuring Australian Manuka honey and native bee propolis, designed to soothe discomfort and support oral health.
- Ingredients: Manuka honey, Sage extract, Echinacea extract, Propolis extract, Olive leaf extract, and Eucalyptus oil.
- Throat and oral spray combining Australian Manuka honey with native bee propolis.

e. Skin Fix Packs (Nature's Gold, Australia) ^{466,467}

- Skin Fix Packs contain three complementary therapeutic items designed to help heal problem skin such as eczema, dermatitis, rashes, and minor wounds.
- Available options include the Regular, High Strength, and High Strength Super packs, featuring therapeutic skin cream, Manuka Power Ointment, and raw Manuka honey.
- Therapeutic skin cream: Use all over the skin to reduce redness, itchiness, and inflammation from rashes, eczema, or dermatitis as often as needed.
- Manuka power ointment: Apply to smaller, broken, or infected areas of skin for targeted relief.



D. Bulk suppliers of Medical-grade honey

Bulk suppliers of medical-grade and high-MGO Manuka honey operating across New Zealand and the UK include Clinihoney, BulkHoney Co., and USP Healthcare Limited. These entities provide industrial formats like pails and drums backed by strict laboratory testing and batch traceability.⁴⁶⁸

① Clinihoney (UK/New Zealand)

Specializes in industrial MGH formats (10kg, 25 kg pails, and 280 kg drums) for wound care, cosmetic, and veterinary sectors with full UK and New Zealand lab verification.⁴⁶⁹

② Bulk Honey Co.

Provides high-MGO and MG active Manuka honey in bulk drums, IBCs, and pails, supported by independent laboratory certificates of analysis (CoA).⁴⁶⁸

③ USP Healthcare Limited

Operates globally out of the UK and New Zealand, supplying wholesale bulk quantities, white-label options, and traceable active Manuka honey.⁴⁷⁰

④ Midlands Apiaries

A major New Zealand processor supplying high-grade bulk Manuka honey and other raw varieties globally for manufacturing and pharmaceutical ingredients.⁴⁷¹

Clinical efficacy of Medical-grade honey in human diseases

Medical-grade honey (MGH) demonstrates proven clinical efficacy primarily in wound management and superficial infections, showing significant benefits in accelerating healing times, clearing bacteria, and reducing inflammation, with core clinical results in diabetic foot ulcers, burn care, and chemoradiotherapy-induced mucositis.⁴⁷² MGH differs from table honey because it is strictly sterilized (typically via gamma irradiation) to remove bacterial spores while preserving its therapeutic bioactivity.³³⁹

Medical-grade Manuka honey (MGMH) demonstrates antibacterial, antibiofilm, anti-inflammatory, and tissue-regenerative properties in wound healing (Table 27), improving healing outcomes in diabetic foot ulcers, venous leg ulcers, pressure injuries, and post-operative wounds, and enhancing surgical wound care through integration with advanced therapies such as hydrogels, nanofibers, and negative pressure wound therapy.³³⁹

SN	Healing phase	Key effect	Specific mechanism	Ref. No.
①	Inflammation	IL-6, TNF- α , IL-10, keep the wound acidic (pH 3.2-4.5)	Immunomodulation of macrophages/ neutrophils; low pH limits protease activity.	473-475
②	Debridement	Promotes gentle autolytic debridement.	Strong osmotic gradient draws lymph/ exudate while maintaining a moist bed.	476
③	Proliferation	Granulation tissue formation.	Rise in fibroblast proliferation vs. untreated controls; VEGF up-regulation.	477-479
④	Epithelialization	Speeds re-epithelialization, faster scratch-wound closure.	Keratinocyte migration driven by MMP-9 and Ca ²⁺ signaling pathways.	480-482
⑤	Antimicrobial	Disrupts biofilms and inhibits pathogens.	MGO cross-links proteins; H ₂ O ₂ generation; synergy with β -lactams vs. MRSA and with rifampicin vs. <i>Pseudomonas aeruginosa</i> .	483,484

Medical-grade honey (MGH) is sterilized, rigorously tested honey used in clinical settings primarily for treating acute and chronic wounds, burns, and localized skin inflammation (Table 28).⁴⁸⁵

Table 28. Summary of clinical studies using medical-grade honey in humans			
SN	Clinical studies	No. of patients	Ref. No.
1.	Open-label RCT catheter exit sites	Honey (n = 51) vs. Mupirocin (n = 50)	486
2.	Open-label RCT venous leg ulcers	Honey (n=187) vs. Usual care (n = 181)	487
3.	Open-label, multicenter RCT lower leg ulcers	Honey (Apinate) dressings (n = 20)	488
4.	Open-label RCT wounds	Medical honey (n=52) vs. Conventional treatment (n=53)	489
5.	Prospective, single-blind RCT Malignant wounds in advanced stage cancer patients:	Honey dressings (n = 34) vs. Silver dressings (n = 33)	490
6.	Randomized feasibility study Microvascular free tissue transfer reconstruction for cancer of head and neck.	Honey wound gel (n = 25) vs. Conventional therapy (n = 24)	491

FDA 510(k)- cleared honey-based products (Major cleared product lines)

The US FDA regulates surgical and wound care dressings under the Medical Device Regulation Act and classifies them as Class I and Class II (Table 29).

Table 29. List of dressings and associated level of risk ⁴⁹²				
Type	Examples	Level of risks	FDA Classification	Regulatory requirement
Fabric dressings	Hydrophilic wound dressings, occlusive wound dressings, and Hydrogel wound dressings	Low	Class I	Approval not required; the FDA only needs to be informed before marketing. It is the responsibility of the manufacturer to maintain the safety and quality of the product.
Advanced wound care dressings	Medihoney, Prisma, and Oasis wound matrix	Intermediate	Class II	510 (k) approval is required.

Various honey-based products are available on the market, and the FDA has approved each of these examples for medical use with different indications (Tables 30 and 31).

Table 30. FDA-approved commercially available honey-based wound dressings			
SN	Wound dressing	Composition	Ref. No.
①.	Activon®	Manuka honey or a mixture of Manuka honey and additives.	436
②	L-Mesitran™	Mixture of different percentages of honey, polyethylene, acrylic polymer gel, water, polyurethane film backing, and an adhesive border.	493
③	Medihoney®	Contains 100% active Leptospermum Honey in a hydrocolloid suspension.	245,418
④	Revamil®	Poly-acetate sheet dressing impregnated with pure honey.	449

Contd. Table 30. FDA-approved commercially available honey-based wound dressings				
SN	Wound dressing	Composition	Application	Ref. No.
⑤	Principelle IF®	Made up of an inert acetate substrate mixed with trace elements and a medical-grade honey ointment.	Used to treat acute and chronic wounds (particularly those that are contaminated or infected), wounds that are moderately exuding, or dry; it can also be utilized on wounds that are heavily exuding when a secondary dressing is used.	494

Table 31. FDA 510(k)-cleared honey-based products for wound healing with mostly randomized controlled trials							
SN	Pharmaceutical honey products	Formulations	510 (k) Nos.	Honey type (%)	Other components	Clinical studies	Ref. No.
01.	Activon™, Advancis Medical	Gel Tulle	K101114 K101118	Manuka (100) Manuka (%)	- Viscose	Case study for penile denudation.	495
02.	Apis™, Sweet Bio	Dressing	K182725 K222143	Manuka (%)	Gelatin Hydroxyapatite	Preliminary evaluation in DFUs Small case series for surgical wounds Wound closure significantly faster than control	496 497 498
03.	Elasto-gel™, Southwest Technologies	Dressing Gel	K083334 K102478	Manuka (%)	Dressing: Glycerin, Polyacrylamide Gel: Glycerin Polyacrylic acid	Glycerin-based dressing gel offers bacteriostatic action which is absent in other hydrogel dressings.	499 500
04.	L-Mesitran™ Theo Manufacturing BV	Dressing Gel Tulle	K053613 K150676 -	MGH MGH (30%) MGH (40%)	Dressing: Polyacrylic acid Gel/Tulle: Lanolin PEG 4000 Polyethylene (Tulle) Propylene glycol Vitamins C & E	MGH has been reported as an alternative or complementary therapy in wound healing of various etiologies, ⁵⁰¹ infected DFUs, ⁵⁰² neonatal patients, ⁵⁰³ pediatric wounds, ⁵⁰⁴ and heel pressure ulcers in high-risk patients. ⁵⁰⁵	501- 506
05.	Manuka Fill™ Links Medical Products	Gel	K121227 K131796	Manuka honey (100%)	-	Manuka fill provides a moist wound environment conducive to healing. Ideal for debriding necrotic tissue.	507
06.	Manuka Foam™ HC, Links Medical Products	Dressing	K133934	Manuka honey (100%)	Foam-fiber hybrid material	A moist wound environment allows autolytic debridement of necrotic tissue.	508
07.	Manuka IG Links Medical Products	Dressing	K120976	Manuka honey (100%)	Acetate CMC	Provide antimicrobial action, maintain a moist environment, and promote autolytic debridement.	509
08.	Manukahd™ Manuka Medical	Dressing Rope Border	K102659 K102659 K102659	Manuka honey (%) -	CMC -	It manages exuding wounds, reduces local wound pH, controls malodor & stimulates autolytic debridement of necrotic tissue.	510
09.	Manuka Apli™ Manuka Medical	Gel	K092689	Manuka honey (100%)	-	Wound care relies on high MGO potency, antimicrobial, autolytic debridement.	511
10.	Manuka tex™ Manuka Medical	Dressing	K110042	Manuka honey (100%)	Acetate CMC	Antimicrobial action, low pH (3.0-4.5) to optimize healing & autolytic debridement.	512
11.	Manuka Wound™ Dressing, Manuka Health, NZ	Dressing	K133729	Manuka honey (%)	-	Proved to promote the growth of tissues for wound repair, suppress inflammation, & autolytic debridement.	513
12.	Medihoney™ (Integra Life Sciences)	Dressing	K053095	Manuka honey	Wound dressing	Highly effective in wound care by promoting autolytic debridement, low wound pH, and maintaining a moist environment.	514
13.	Medihoney™ (Integra Life Sciences)	Wound gel	K072956	Manuka honey (100%)	Alginate	Autolytic debridement, blocks bacteria, and feeds new tissue (faster regrowth). Suboptimal effectiveness of MAWG in preventing driveline infection due to biofilm development.	515 516

Contd. Table 31. FDA 510(k)-cleared honey-based products for wound healing with mostly randomized controlled trials							
SN	Pharmaceutical honey products	Formulations	510 (k) Nos.	Honey type (%)	Other components	Clinical studies	Ref. No.
14.	Medihoney™ (Integra Life Sciences)	Wound gel	K080315	Manuka honey (100%)	Natural gelling vegetable source esters/alginate)	Reduced risk in peritoneal dialysis patients catheter-associated infections, and reduce perineal laceration pain during the post-partum period.	517-518
15.	Medihoney™ (Integra Life Sciences)	Wound gel	K081584	Manuka honey (80%)	20% natural gelling agents/waxes	Passing in the presence of a manuka honey wound gel to changes in antimicrobial sensitivity and virulence that varied between test bacteria.	519
16.	Medihoney™ (Integra Life Sciences)	Wound and burn gel	K101793	Manuka honey (80%)	Natural gelling agents, emulsifiers, and surfactants	FDA has issued a safety alert regarding the potential for serious injury with the use of Medihoney wound and burn products and certain lots of CVS wound gel products.	520
17.	Medihoney™ (Integra Life Sciences)	Hydrogel sheet dressings	K110546	Manuka honey (80%)	20% natural gelling agents	Wound size and pain decreased significantly in a short time period, and noticeably less slough/necrosis. Bacterial clearance and 90% healing rate reported in chronic pressure ulcer patients with spinal cord injury.	521 522
18.	Medihoney™ (Integra Life Sciences)	Topical gel dressing	K133279	Manuka honey (80%)	20% natural plant-derived gelling agents	MGH dressing reported effective for treating hard-to-heal venous leg ulcers with pain reduction and deodorization, with high patient acceptability and positive clinical outcomes in 12 weeks.	523
19.	Medihoney™ (Integra Life Sciences)	Topical wound gel	K150985	Manuka honey (80%)	20% natural gelling agents	Designed to manage acute and chronic wounds and minor burns that provides crucial wound-healing properties.	524

CMC = Carboxymethylcellulose

PEG = Polyethylene glycol

DFUs = Diabetic foot ulcers

Randomized controlled trials and recent narrative reviews indicate that Manuka honey accelerates healing, reduces bacterial loads, and manages inflammation across diverse acute and chronic wounds, burns, or surgical site management (Table 32).

Table 32. Summary of randomized controlled trials (RCTs) evaluating Manuka honey in wound healing across various indications						
SN	Country	Sample size	Wound type	Comparator	Primary outcome (s)	Ref. No.
01.	India (2021)	n = 99 2 M-17 yrs.	Pressure injuries in children	Standard care	Median healing time: 7 days (95% CL: 6-7) vs. 9 days (7-10) for intervention vs. control.	525
02.	India (2020)	n = 40 (M = 22, F = 18)	Post-operatively mastoid cavity	Antibiotic-soaked gel	MH group decreased infection rate from 75% to 35% at 3 months, with 65% having sterile cultures. MH showed activity against <i>Pseudomonas</i> , <i>Proteus</i> , <i>Klebsiella</i> , <i>E. coli</i> and <i>S. aureus</i> . No significant differences between test & control.	526
03.	Hong Kong (2017)	n = 32 (M = 18, F = 13)	Diabetic foot ulcers (DFUs)	Nanocrystalline silver, conventional dressings	Cumulative ulcer healing incidence after 12 weeks: Proportional healed: nAg 81.8%, MH 50%, and conventional 40%. Ulcer size reduction rate: Highest in nAg (97.45%) followed by MH (86.24%) and conventional (76.91%).	527
04.	UK (2017)	n = 55 (M = 17, F = 29)	Post-operatively eyelid wounds.	Standard dressing (Vaseline)	MH resulted in less skin distortion (1.6 vs. 1.8), less palpable scar (1.8 vs. 2.0), & less stiffness (1.3 vs. 1.6). No difference in grading at 1 or 4 months.	528
05.	Greece (2014)	n = 63	Neuropathic diabetic foot ulcers (DFUs)	Conventional dressings	MHID vs. CD: faster healing (31±4 vs. 43±3 days). Higher sterilization at week 1 (78.1% vs. 35.5%), but % ulcers healed similarly (97% vs. 90%).	529

Contd. Table 32. Summary of randomized controlled trials (RCTs) evaluating Manuka honey in wound healing across various indications						
SN	Country	Sample size	Wound type	Comparator	Primary outcome (s)	Ref. No.
06.	Saudia Arabia (2013)	n = 57 (M = 31, F = 26)	Diabetic foot ulcers (DFUs)	Conventional treatment	The honey group showed faster infection clearance and shorter hospital stays ($p < 0.05$); higher complete healing rate at 6 weeks and 6 months ($p < 0.05$)	530
07.	Ireland (2008)	n = 108 (M = 35, F = 73)	Sloughy venous leg ulcers (VLUs)	Hydrogel	MRSA eradicated in 70% of MH-treated wounds vs. 16% with hydrogel after 4 weeks. <i>P. aeruginosa</i> cleared in 33% (MH) vs. 50% hydrogel.	531
08.	New Zealand (2008)	n = 368	Venous leg ulcers (VLUs)	Usual care*	Proportion of participants with a completely healed reference ulcer at 12 weeks: 55.6% (honey) vs. 49.7% (usual care).	
09.	UK (2006)	n = 100	Post-operatively toenail surgery wounds	Paraffin tulle gras	Mean time healing: Honey 40, .3 d vs. Paraffin 39.98d. Partial avulsions healed faster with paraffin (19.62 d vs. 31.76 d, $p = 0.01$) but no significant difference.	532.

*Usual care (alginate, hydrofiber, hydrocolloid, foam, hydrogel, non-adherent, iodine or silver dressings)

Medical-grade honey (MGH) is highly effective in treating a diverse range of dermatological conditions and wounds due to its unique broad-spectrum antimicrobial, osmotic, and anti-inflammatory properties (Table 33). It works via several synchronized mechanisms: (a) high osmolarity dehydrates pathogenic bacteria, (b) Low pH (3.2-4.5) inhibits microbial growth and promotes tissue oxygenation, (c) Hydrogen peroxide production provides sustainable, non-toxic activity, and (d) Phytochemical factors (like Methylglyoxal in Manuka honey) provide robust antibiofilm effects.³³⁹ It drives rapid autolytic debridement, tissue degeneration, and symptom reduction.⁵³³

Table 33. Efficacy of honey in dermatologic conditions with the main clinical outcome of treatment					
SN	Dermatologic condition	Clinical studies	No. of patients	Main outcomes	Ref. No.
01.	Impetigo	Antibacterial activity of honey against bacteria implicated in impetigo.	<i>S. aureus</i> (n=10) <i>S. pyogenes</i> (n=10)	Honey inhibited <i>S. aureus</i> & <i>S. pyogenes</i> <i>in vitro</i> ; MIC50 for <i>S. aureus</i> 4-8% w/v; <i>S. pyogenes</i> 8-29% w/v.	534
02.	Herpes simplex labialis (HSL)	Kanuka honey versus acyclovir (5%)	Adults (n = 952)	Honey reduced healing time and pain compared to acyclovir in children with HSV gingivostomatitis	535
03.	Herpes simplex gingivostomatitis (HSGS)	Kanuka honey + oral acyclovir, and oral acyclovir alone.	Children (n = 100) Honey + Acyclovir: Control= Acyclovir	The combined use of honey with oral acyclovir produced a more favorable outcome than acyclovir alone in children with primary herpetic gingivostomatitis.	536
04.	Herpes Simplex (Cold sores)	Supplemented Medical-grade honey (MGH) (M-Mesitran Soft)	Patients (n = 29)	Reduced absolute healing time to 5.8 days (out-performing conventional acyclovir cream at 10 days) and relieved pain/itching in >17% of patients.	537
05.	Vulvovaginal candidiasis (VVC)	Medical-grade honey L-Mesitran Soft and fluconazole	-	MGH as an alternative treatment option for VVC and resistant VVC with fluconazole. L-Mesitran has stronger antimicrobial activity against Candida.	538
06.	Necrotizing fasciitis wounds	Compared of topical MGH with EUSOL dressing	MGH (n = 90) EUSOL (n = 85)	Compared to control, honey significantly reduced slough clearance time (2.48 vs. 2.83 days, wound healing time (20.2 vs. 28.4 days) & hospital stay (4.96 vs. 9.33 days)	539
07.	Eczema, Seborrheic dermatitis, Psoriasis	Raw natural honey daily for seven consecutive days	Atopic dermatitis (AD) (n=12 patients) Psoriatic (n=6 patients)	Three Item Severity (TIS) score had a significant decreased (improved) 6 to 1 in the honey-treated in one week; PASI scores improved in psoriasis with sustained benefits at 1 month.	540
08.	Atopic dermatitis (Eczema)	Pure Manuka honey (topical, overnight occlusion	Patients (n=14)	Significant reduction in erythema, scaling, and itching; Three Item Severity (TIS) scores dropped from 6 to 1 within 7 days. Downregulates CCL26 release.	541

Contd. Table 33. Efficacy of honey in dermatologic conditions with the main clinical outcome of treatment					
SN	Dermatologic	Clinical studies	No. of patients	Main outcomes	Ref. No.
09.	Atopic dermatitis (Eczema)	Medical-grade Manuka honey	Review article	Significantly reduced clinical lesion scores, alleviated itching, and suppressed inflammatory markers; well-tolerated with zero adverse events.	542
10.	Rosacea	Medical-grade Kanuka (90%) + Glycerine (10%) (Honevo)	Adult patients ≥ 16 years aged (n = 138 in RCT	Patients in the Honevo (Kanuka honey + glycerine) showed 34.3% (24/68) compared to 17.4% in control had a 2-point improvement in IGA-RSS.	543
11.	Intertrigo	Medihoney Barrier Cream (with medical-Grade Manuka honey)	Moisture-related skin damage, including IAD	Reduced pain, inflammation, and erythema across age groups (infants to elderly), and shown to lower pruritus complaints associated with intertrigo, and promotes comfort.	544
12.	Folliculitis decalvans	MGH: Manuka honey + oral cephalixin: CoNS, S. aureus, S. capitis	A 20-year-old man with boggy scalp with pustules	Complete clearance of inflammation and pustules in 6 months with topical Manuka honey and oral cephalixin; allowed discontinuation of antibiotics.	545
13.	Oral lichen Planus (OLP)	Honey + Photo-bio-modulation in the treatment of OLP	46 patients n=23(HT/PBM) (n=23 (Placebo)	Post-treatment resulted VAS (p<0.0001), oral function scores (p<0.0001) & OLP clinical signs (p<0.05) significantly better compared to placebo.	546
14.	Radiation Induced Mucositis	Natural and Manuka honey	Meta-analysis of 10 RCT (n = 599) in patients	Honey significantly reduced the occurrence of grade 3-4 mucositis, pain relief, and had a positive effective on reducing weight loss during radiotherapy.	547
15.	Diabetic foot ulcers (DFUs)	L-Mesitran® or Medihoney® (ointment/foam/dressings)	Patients (n=1030) 1 week therapy	Promotes higher bacterial clearance at 1 week, shortens necrotic tissue debridement time, and significantly lowers amputation risks.	548

EUSOL = Edinburgh University's Solution of lime
IAD = Incontinence-associated dermatitis

IGA-RSS = Investigator Global Assessment of Rosacea Severity Score
VAS = Visual analog scale

Adulterated and fake honey-associated diseases in humans and One Health perspective

Consuming adulterated and fake honey, often mixed with high-fructose corn syrup, cane sugar, rice syrup, or tainted with heavy metals, pesticides, chemical additives, and veterinary antibiotics, poses significant metabolic syndrome, organ damage, systemic health risks, and potential carcinogenic effects and allergic reactions due to excess sugar loads and hidden contaminants (Table 34).^{549,550}

Table 34. Major health risks and associated diseases caused by consumption of adulterated and fake honey ^{18, 551,552}			
SN	Adulterants	Major health risk & associated diseases	Affected biological system & organs
①	High-fructose corn syrup (HFCS) and cheap sugars	Type II diabetes, hyperglycemia, insulin resistance	Endocrine and metabolic system
②	Excess fructose / Sucrose blends	Obesity, abdominal fat gain, hyperlipidemia (high blood lipids)	Adipose tissue and cardiovascular system
③	Sugar-induced reactive oxygen species (ROS)	Atherosclerosis, hypertension, coronary heart disease, heart failure.	Cardiovascular system
④	Industrial syrups and chemical additives	Non-alcoholic fatty liver disease (NAFLD), hepatic toxicity.	Liver
⑤	Altered sugar profiles and toxins	Acute and chronic kidney injury, glomerular filtration failure.	Kidneys
⑥	Rice syrup adulterants (Arsenic traces)	Arsenic poisoning, chronic gastrointestinal distress, potential oncogenesis.	Digestive system and systemic tissues
⑦	Veterinary antibiotics residues (e.g., sulfonamides)	Antimicrobial resistance, severe allergic hypersensitivity (anaphylaxis, hives, rashes)	Immune and gastrointestinal systems
⑦	Heavy metals and pesticide contaminants.	Cellular degeneration, genetic mutations, potential carcinogenic risks.	Nervous system and cellular DNA

Contamination of honey and One Health perspective

Honey contains dormant or trace microbial communities originating from flower nectar, the environment, and the honeybee digestive tract. While honey's high sugar content and low pH inhibit most active growth, Honey contains a low number of dormant microorganisms originating from bees, plants, and environmental dust. While honey's high sugar content and acidity prevent microbes from multiplying, spores and osmotolerant strains- such as *Bacillus*, *Lactobacillus*, and various yeasts- frequently survive and can be isolated and identified.⁵⁵³ Pure honey, honeycomb, and bees rarely transmit direct microbial infections to humans because honey's high sugar content and acidity create a hostile environment for most pathogens. However, raw honey and hives can occasionally harbor bacterial spores or environmental contaminants posing specific health risks, particularly to infants and people with weak immune systems.⁵⁵⁴

Adulterated and fake honey lacks pure honey's natural antimicrobial properties and often becomes a vehicle for microbial and zoonotic pathogens introduced via unhygienic water, handlers, or contaminated sugar syrups. Fake or adulterated honey, diluted with water or cheap syrups, has higher moisture and loses its germ-fighting power. Studies on compromised or diluted honey commonly isolate spore-forming and environmental bacteria like *Bacillus* species, alongside opportunistic or enteric contaminants like *Staphylococcus aureus*, *Escherichia coli*, and *Klebsiella pneumoniae*.⁵⁵⁴

The primary sources of microbial contamination in honey likely include pollen and the digestive tracts of honeybees, dirt, dust, air, and flowers. Microorganisms identified in honey include bacteria, yeasts, and molds, as follows:

Microorganisms isolated and identified in honeys

a. Bacteria

- Lactic acid bacteria: *Lactobacillus* spp., *Bifidobacterium* spp., *Fructilactobacillus*, *Apilactobacillus kunkeei*, and *Leuconostoc*.⁵⁵⁵
- *Bacillus* species: *Bacillus subtilis*, *B. cereus*, *B. pumilus*, *B. licheniformis*, *B. megaterium*, and *B. thuringiensis*.⁵⁵⁶
- Bee-gut symbionts: *Gilliamella*, *Snodgrassella*, *Bombella*, and *Orbaceae*.⁵⁵⁷
- Environmental bacteria: *E. coli*, *S. aureus*, *Micrococcus luteus*, *Klebsiella pneumoniae*, *Pseudomonas*, *Proteus*, and *Clostridium* (including dormant *C. botulinum* spores).⁵⁵⁸

b. Yeasts (Osmotolerant)⁵⁵⁴

- | | | | | | |
|------------------------|----------------------------|------------------------------|----------------------|----------------------|----------------------|
| • <i>Saccharomyces</i> | • <i>Zygosaccharomyces</i> | • <i>Schizosaccharomyces</i> | • <i>Candida</i> | • <i>Lipomyces</i> | • <i>Debaromyces</i> |
| • <i>Rhodotorula</i> | • <i>Ascosphaera</i> | • <i>Hansenula</i> | • <i>Nematospora</i> | • <i>Oosporidium</i> | • <i>Pichia</i> |
| • <i>Trichosporium</i> | • <i>Torula</i> | • <i>Torulopsis</i> | | | |

c. Molds and fungi^{554,558}

- | | | | | | |
|---------------------------|-----------------------|---------------------------|--------------------------|---------------------|----------------------------|
| • <i>Aspergillus</i> spp. | • <i>Alihia</i> | • <i>Betisia alvei</i> | • <i>Cephalosporium</i> | • <i>Chaetomium</i> | • <i>Cladosporium</i> spp. |
| • <i>Coniothecium</i> | • <i>Hormiscium</i> | • <i>Penicillium</i> spp. | • <i>Peronosporaceae</i> | • <i>Peyronelia</i> | • <i>Talaromyces</i> |
| • <i>Triposporium</i> | • <i>Uredianaceae</i> | • <i>Ustilaginaceae</i> | | | |

- Bacteria isolated from bee gut samples include *Bacillus*, *Enterococcus*, *Escherichia*, *Micrococcus*, *Morganella*, *Ochrobacterum*, *Pseudomonas*, *Salmonella*, *Shigella*, *Sphingomonas*, and *Staphylococcus*. Two pathogenic bacteria, *Salmonella enterica* and *Shigella sonnei*, which cause diseases in humans and other animals, were confidently characterized. The work suggested that the forager *Apis mellifera* acts as a reservoir and potential vector of bacterial pathogens.⁵⁵⁹
- Frequently isolated zoonotic and enteric pathogens include *Salmonella enterica*, *Escherichia coli*, *Staphylococcus aureus*, and *Shigella* species.⁵⁵⁹
- Microbes of concern in post-harvesting honey include yeast and spore-forming bacteria, those that indicate the sanitary or commercial quality of honey (coliforms and yeasts), and those that, under certain conditions, could cause human illness.
- Primary sources of microbial contamination are likely to include pollen, the digestive tract of honey bees, dust, air, earth, and nectar, sources which are very difficult to control. The same secondary (after-harvest)

sources that influence any food product also contaminate honey, including air, food handlers, cross-contamination, equipment, and buildings. The microbes of concern in honey are primary yeasts and spore-forming bacteria.⁵⁶⁰

- Adulterated and fake honey pose distinct health risks to humans. Instead of providing the natural therapeutic and nutritional benefits of pure honey, fake honey acts as a source of empty calories laden with cheap sugar syrups, potential residues, and toxins that can negatively impact metabolism and cause organ damage over time.⁵⁶¹

Common bacteria found in compromised honey

Pure honey naturally prevents bacterial growth because of its high sugar content, low pH, low moisture, and hydrogen peroxide production. When honey becomes contaminated, spore-forming and environmental bacteria such as *Clostridium botulinum*, *Bacillus cereus*, and secondary indicators like *Escherichia coli* or *Staphylococcus aureus* can be introduced through dust, pollen, or poor handling.^{560,562}

- ***Clostridium botulinum***: Spores can survive in honey and pose a severe infant botulism risk if ingested by babies under one year, whose digestive systems cannot stop germination. Honey contamination with spores of *C. botulinum* has been documented in many countries, including Finland (spores in 7% of inland and 16% of imported honey samples) and China (15% of clinically reported cases of infant botulism).⁵⁶³
- ***Bacillus* species**: Bacteria like *B. cereus* or *B. subtilis* enter via dust, pollen, or bees and can multiply if moisture levels rise.⁵⁶⁴ Spores from this soil-dwelling group survive in sweet environments and multiply if moisture levels rise due to dilution. Spore-forming environmental bacteria, *Bacillus cereus*, are linked to food spoilage and toxins.
- **Coliforms (*Escherichia coli*)**: Indicate secondary contamination from poor processing, unclean equipment, or unhygienic food handlers.⁵⁶⁰ Signifies fecal or environmental water contamination during processing.⁵⁶²
- ***Staphylococcus aureus***: Opportunistic pathogen that can be introduced through human handling or environmental cross-contamination.⁵⁶⁵ Often introduced via human handling or unhygienic bottling environments. Indicates secondary post-harvest human or equipment contamination.
- ***Klebsiella pneumoniae***: Found in lower-quality or improperly handled liquid sweeteners that fail to inhibit microbial growth.⁵⁶⁰
- ***Pseudomonas* species**: Environmental bacteria sometimes found when honey has been heavily diluted or improperly sealed.⁵⁶⁶
- **Osmophilic yeasts (*Zygosaccharomyces* spp.)** that grow in compromised honey with high water content, causing fermentation and spoilage.⁵⁵⁴

Major diseases and health risks caused by consumption of adulterated and fake honey

Fake or adulterated honey diluted with unhygienic water or cheap sugar syrups can harbor pathogenic microbial spores and pathogens.⁵⁶⁶

- **Infant botulism**: Caused by *Clostridium botulinum* spores growing in an infant's immature digestive tract, leading to constipation, lethargy, weak crying, and descending flaccid paralysis.⁵⁶⁷
- **Gastroenteritis (Food poisoning)**: Caused by spore-forming bacteria like *Bacillus cereus* or *C. perfringens* surviving in poorly handled or adulterated sugar matrices, causing vomiting and diarrhea.⁵⁶⁸
- ***E. coli* infection**: Consuming honey contaminated with *E. coli* can cause severe food poisoning. Symptoms usually start within one to eight days and include severe stomach cramps, bloody diarrhea, vomiting, and low fever. In rare cases, it leads to a dangerous kidney failure condition called hemolytic uremic syndrome.
- **Fungal infections / Mycotoxicosis**: Fungal overgrowth (molds and yeasts) or illegal antibiotic residues (tetracycline, chloramphenicol) in fake/unregulated honey can trigger allergic skin eruptions,

gastrointestinal distress, or antimicrobial resistance.⁵⁶⁶

- Pure, high-quality raw honey has natural antimicrobial properties that resist microbial growth. When honey is fake or adulterated with unhygienic water, cheap sugar syrups, or poorly processed, these protective properties are lost, introducing harmful microorganisms that can lead to foodborne illnesses and infections in humans.^{19,137}
- Consuming fake or adulterated honey introduces microbial hazards when high moisture or poor hygiene dilutes honey’s natural antimicrobial properties. This permits opportunistic pathogens, spore-formers, and osmophilic fungi to survive or proliferate, leading to specific clinical manifestations in humans (Table 35).^{567,569}
- Consuming adulterated or fake honey introduces microbial, chemical, and metabolic risks that can significantly impact human health, leading to adverse clinical effects (Table 35).

Table 35. Microbial risks and clinical effects in adulterated and fake honey consumers ^{18,19,549,551,566,570}			
SN Pathogen / Agent	Source / Condition in adulterated honey	Associated disease/ condition	Common symptoms in humans
① <i>Clostridium botulinum</i> (spores)	Environmental dust/soil or unhygienic processing; survives in high-water/diluted syrup blends.	Infant botulism (in infant <1 year)	Constipation, lethargy, weak cry, poor feeding, symmetrical descending flaccid paralysis.
② <i>Escherichia coli</i> / Coliforms	Contaminated water used to dilute sugar syrups or poor handling or bottling process.	Bacterial gastro-enteritis / Urinary tract infections	Watery or bloody diarrhea, severe abdominal cramps, nausea, vomiting, and low-grade fever.
③ <i>Staphylococcus aureus</i>	Poor hygiene by handlers during manual bottling or preparation of fake blends	Food intoxication / Acute gastroenteritis	Sudden severe nausea, vomiting, stomach cramps, mild diarrhea.
④ Salmonella species	Environmental contamination or unclean processing facilities.	Salmonellosis (Enteric infection)	Diarrhea, fever, abdominal cramps, headache, chills
⑤ Antibiotic-resistant bacteria (various)	Misuse of unapproved veterinary antibiotics mixed into fake honey to mask poor hygiene.	Resistant opportunistic infections	Failure of standard antibiotic treatments during secondary
⑥ Osmophilic yeasts (<i>Zygosaccharomyces</i> spp.)	High moisture content (>20%) from unripened or improperly boiled sugar syrups.	Honey fermentation/ Mycotoxicosis	Gastrointestinal irritation, abdominal discomfort, nausea, bloating.
⑦ Molds (<i>Aspergillus</i> / <i>Penicillium</i>)	Storing adulterated honey with high water activity in damp conditions.	Mycotoxin exposure (Aflatoxins) mycotoxicosis	Acute or chronic toxicity, nausea, respiratory distress, digestive upset, mutagenic risks.

Wound Healing and ‘One Health’

Wound healing is a biological repair process divided into four key stages: hemostasis (clotting), inflammation (clearing bacteria), proliferation (building tissue), and remodeling (strengthening). When paired with a One Health approach, it connects human, animal, and environmental health. The intersection of wound healing and the One Health framework centers on how skin injuries in humans and animals act as critical contact points for antimicrobial resistance (AMR), zoonotic transmission, and shared environmental pathogens. Managing infected wounds requires coordinated oversight across human medicine, veterinary care, and environmental hygiene to prevent multidrug-resistant strains from passing between species.⁵⁷¹⁻⁵⁷³

Medical-grade honey (MGH) acts as an effective, natural wound-healing treatment by providing antimicrobial, anti-inflammatory, moist-barrier properties, and tissue-regenerating actions. From a ‘One Health’ perspective, honey links environmental floral diversity and bee health to human and veterinary

clinical outcomes, reducing reliance on conventional antibiotics and mitigating antimicrobial resistance. Utilizing natural non-antibiotic treatments like honey helps combat global antimicrobial resistance across human, animal, and environmental ecosystems.²¹ By evaluating bee ecosystems, safe pathogen management, and sustainable therapeutics.^{21,574,575} Under a One Health framework, honey bridges human, animal, and environmental health by offering a sustainable, cost-effective antimicrobial alternative that mitigates global antibiotic resistance.²⁰

Medical-grade honey accelerates wound healing through multiple synergistic biochemical mechanisms while supporting One Health goals by reducing reliance on conventional antibiotics (Table 36).

Table 36. Honey-based wound healing mechanism and ‘One Health’ impacts			
SN	Wound healing aspect	Honey-based mechanism	One Health implication (Human-animal-environmental link)
①	Antimicrobial action	High osmolarity, low pH, and generates slow-release H ₂ O ₂ to clear pathogens including resistance bacteria (MRSA)	Reduce antibiotic resistance: Decreases reliance on traditional clinical antibiotics, lowering selection pressure for drug-resistant pathogens in humans and animals, and lowering risks in shared environmental microbial pools.
②	Anti-inflammatory and debridement	Suppresses reactive oxygen species (ROS), and pro-inflammatory cytokines, reducing swelling, pain, edema, and clears necrotic tissue.	Cross-species utility: Applicable to companion animals, livestock, and humans with identical physiological modulation of inflammation. Provide an affordable, locally sourced therapeutic agent accessible in resource-limited veterinary and human settings.
③	Tissue regeneration	Promotes fibroblast proliferation, angiogenesis, and collagen organization for rapid re-epithelialization.	Sustainable therapies: Safe and effective wound management across diverse mammalian species (companion animals, livestock, and humans), supporting broad-spectrum translation utility.
④	Sourcing and safety	Requires sterile, medical-grade honey (e.g., Manuka) rather than raw grocery variants to prevent spore contamination.	Environmental and pollinator health: Connects human medical outcomes directly to bee conservation, pesticide management, and healthy floral biodiversity required to produce quality therapeutic honey.

The ‘One Health’ framework links human, animal, and environmental health. Using natural agents like honey supports sustainable, cost-effective therapeutics that reduce reliance on conventional synthetic antibiotics. Overuse of standard antibiotics drives antimicrobial resistance (AMR) in both human and veterinary medicine. Honey’s multi-targeted physical and chemical properties, such as osmolarity and acidity, make it difficult for bacteria to develop resistance, offering a sustainable alternative in clinical and veterinary settings. Promoting beekeeping and healthy pollinator ecosystems supports biodiversity and plant health, which in turn sustains the availability of medicinal floral sources like Manuka honey. (Table 37).

One Health implications in wound care

- **Shared pathogens:** Companion animals and humans often harbor or cross-contaminate similar resistant bacteria (such as *Staphylococcus* or *Pseudomonas* species) through surgical or bite wounds.⁵⁷³
- **Antimicrobial resistance:** Overprescribing and using topical or systemic antibiotics for minor or non-infected animal and human wounds accelerates resistant wound pathogens (such as MRSA) globally.⁵⁷⁶ Resistant bacteria in human and animal wounds can share genes and spread via the environment, rendering standard treatment ineffective.⁵⁷⁷
- **Zoonotic risks:** Licking, scratching, or sharing living spaces with pets with open or healing lesions increases the risk of cross-species pathogen transfer.⁵⁷⁸ Animal bites or scratches introduce dangerous pathogens (like *Pasteurella* or Rabies) into human wounds.

Table 37. Honey-treated wound healing and One Health integration			
SN	Dimension	Honey-treated wound healing	One Health integration
①	Core mechanism	High sugar content dehydrates bacteria; acidifies, releases oxygen and reduces protease activity.	Broad-spectrum pathogen helps reduce systemic antibiotic reliance across species, mitigating antimicrobial resistance (AMR)
②	Clinical application	Used topically on human and animal wounds, burns, and chronic ulcers to accelerate tissue regeneration.	Bridges veterinary and human medicine using standardized, sterile biological products for cross-species wound care.
③	Ecosystem & environment	Relies on floral sources (e.g., Leptospermum /Manuka) and bee health for bioactive properties	Connects pollinator health, biodiversity, and environmental pesticide exposure directly to the potency of medical resources.
④	Safety and regulation	Requires gamma-irradiation sterilization to eliminate bacterial spores (like Clostridium) without losing efficacy.	Ensures quality control from hive to patient, tracking safety, environmental contaminants, and zoonotic/pathogen transfer risks.

•**Environmental factors:** Climate, soil contaminants, and water quality influence the prevalence of environmental wound pathogens (like *Pseudomonas* or *Vibrio* species in aquatic settings).

•**Alternative therapies:** Research increasingly emphasizes non-antibiotic management such as advanced barrier dressings, strict hygiene, and debridement to protect both human and animal health.⁵⁷⁹

The interaction of wound healing and a ‘One Health’ framework centers on managing chronic or infected wounds by recognizing the deep links between human medicine, veterinary care, and environmental factors. This collaborative approach is vital to stop the spread of dangerous pathogens and combat drug resistance.⁵⁸⁰ Controlling microbial diseases transmitted through consumption of adulterated and fake honey requires greater interdisciplinary collaboration among human medicine, veterinary medicine, environmental scientists, apiculturists, toxicologists, food safety experts, and policymakers to build integrated risk assessment models and formulate globally applicable safety guidelines. This strategy targets the shared ecosystem where apiculturists, veterinary care, honey production and management technicians, and the environment interact to stop the spread of zoonotic microbes and antimicrobial resistance.

Comparison of the current status of sects in Islam and honey fraud

- Based on a Sahih hadith (authentic), ‘the Jews split into 71 sects, Christians into 72, and Muslims into 73; one of each group will be in Paradise, and the rest of all groups in Hell. The Prophet Muhammad (SAW) identified the saved sect as ‘the main body’ and ‘that which my companions (Sahabah) and I are upon.’ - (Al-Jema’ah, Majah 3992, Jami’ Al-Tirmidhi, Hadith No. 2641).
- The Prophet Muhammad (SAW) established Islamic governance based on the legislation of the Quran (Ohio mutual) and Hadith (gore mutual) with the help of his companions. Later, during the four-caliphate period (632-661 CE), Islamic governance was continued in the same way. That is, the religion is Islam, and people who practice Islam are called Muslims, and they all belong to the party of Allah. ‘They are the party of Allah. Indeed, Allah’s party is bound to succeed.’ - Surah Al-Mujadila (58:22)
- ‘Muslims to hold firmly to Allah’s rope (the Quran/Islam) together, forbidding division.’ - Surah Al-Imran (3:103).
- ‘If Allah willed, He could have made all humanity a single community of believers, but instead, He granted free will, resulting in continued differences and diversity in beliefs among people.’ - Surah Hud (11:118).
- ‘Those who have divided their religion and become sects as factionalized groups that take pride in their own specific doctrines’ - Surah Al-Rum (30:32).

The Islamic religion must have only one group (party) of Allah, and they never created any new groups (parties). A single group of Muslims holds firmly to Allah’s rope (the Quran/Correct Hadith), never separated from ‘the main body.’ (Fig. 15)

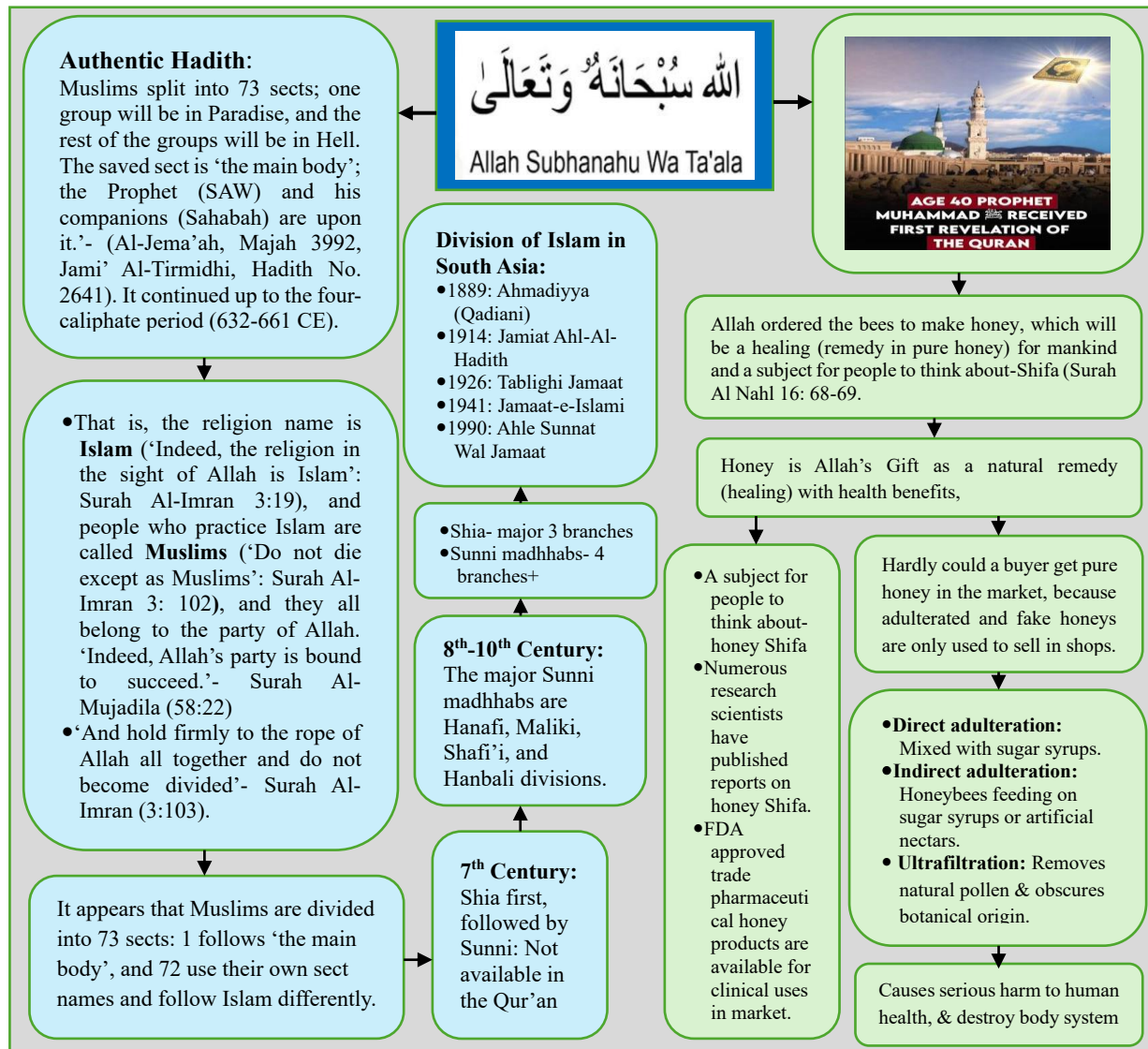


Fig. 15. Hadith and Qur'anic assessment of division of Muslims with honey fraud

Some observations on Hadith and Qur'anic assessments of divisions among Muslims and food frauds

- Surah Ar-Rum 30:32: "Those who have split up their religion and have become divided into sects, each sect rejoicing in what they have."
- Surah Al-Qalam (68:7): "Indeed, your Allah knows well who strays from His way, and who are rightly guided." And Ayat (68:8): "Then do not obey the deniers."
- Hadith: Prophet Muhammad (SAW) stated, "Whoever deceives (cheats), he is not one of us." -Sahih Muslim (102), Jami at-Tirmidhi (1315), and Sunan Ibn Majah (2224). 'He is not one of us' indicates that cheating is a major sin (Kabirah), which expels the perpetrator from practicing Islam. Furthermore, the financial earnings from selling adulterated and fake honey are considered entirely unlawful (Mal-e-Haram).
- At least 37 times cited in the Qur'an, for example, Surah Al Baqarah 2:82: "And those who believe (Iman) and do good (honest way) will be the residents of Paradise. They will be there forever."

CONCLUSIONS

That bottle of honey in a Facebook advertisement or on a supermarket shelf that looks like honey, tastes like honey, and pretends to be honey is most likely not pure bee work. Most of it is likely adulterated or fake honey, closer to golden syrup than the alluring wonders bees produce. The flavoring and texture are manufactured, the color imbued by shrewd engineering; smoke and mirrors deflect us with the avaricious design of a Machiavelli. There is no guarantee of getting pure honey from local or imported sources on the global market, except from some reported sources, such as locally produced honey in the UK, Canada, and parts of Australia. The Apimondia (World Beekeeping Congress) officially discontinued the honey category in the World Beekeeping Award after detecting adulterated honey in 45% of entries submitted in Montreal in 2019; similar disqualifications happened in Istanbul in 2022, and organizers cited the impossibility of adequately screening all samples for global adulteration. Modern testing uses light scanning and chemical fingerprints to detect fake honey; combining multiple methods is essential to prove authenticity, and portable smart sensors enable real-time food composition screening, but these methods are not available for routine use. The only way to guarantee real, bona fide honey from a local producer is to see it coming out of the hive, or to produce our own honey ourselves. These indicate that Allah’s gift of pure honey has skin-wound-healing properties, and original Islam is viewed as the complete and final guidance sent by Allah for humanity, but both have lost their originality or been modified to an unacceptable status. Bangladesh has various ministries and agencies involved in food safety and quality control, but lacks a unified food safety administration system. The Bangladesh Standards and Testing Institution (BSTI) and the Bangladesh Food Safety Authority (BFSA) are the primary authorities regulating food and honey. Honey producers and importers must obtain mandatory product quality certification from BSTI and may also need to register with BFSA for food safety, storage, and import-export control. The Ministry of Health and Family Welfare has primary responsibility for enforcing food safety. Multiple ministries also play roles in food safety related to agriculture, livestock, the environment, and industry. While a single institution like the US FDA has struggled to eradicate economically motivated adulteration in honey because of regulatory gaps, outdated testing methods, and resource constraints, how could multiple institutions in Bangladesh, amid a national political crisis, successfully control honey fraud? It is surprising that in a country like Bangladesh, where much of the food is fake, adulterated, or contaminated by the cynical grimness of a criminal mindset, even much of our ‘honey’ is the work of people for whom the term ‘fraudster’ would not seem inappropriate. These 72 sects of Muslim believers have made friendship with nonbelievers kafir and musrick, without considering believing Muslims for their national security and business, without dependence on Allah, resulting in divine punishment on this earth as well as in the better world after death. A ‘One Health’ approach to honey fraud control integrates human and economic health (consumer safety & regulation), animal health (bee colony management), and environmental health (ecosystems & forage) to secure the food chain against sophisticated adulteration. Therefore, greater interdisciplinary collaboration between environmental scientists, apiculturists, toxicologists, food safety experts, and policymakers is essential to building integrated risk assessment models and formulating globally applicable safety guidelines.

ETHICAL APPROVAL

Ethical approval was not required, as the review relied solely on publicly available data.

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