Apimondia Statement on Immature Honey Production

Norberto García

Abstract: This statement gives the scientific background and concepts on why this mode of production leads to a violation of the definition of honey. Different strategies for the detection of this mode of honey fraud are discussed.

Keywords: Immature honey; water content; honey fraud; traceability; auditing

1. Purpose

This Statement on Immature Honey Production constitutes the official position of Apimondia, which aims to be a trusted source for authorities, traders, supermarkets, retailers, manufacturers, consumers, and other stakeholders of the honey trade chain to ensure they stay updated with the current concepts regarding this mode of honey fraud. It is also a guide to promote best practices for the prevention of this illicit mode of production with insidious negative side effects on global honest beekeeping, crop pollination, and food security.

2. Biology of Honey Production

As opposed to nectar, honey's low water content, elevated concentration of sugars, low pH, and presence of various antimicrobial substances make it a long-lasting food for bees that does not easily ferment (García & Schwarzinger, 2020).

The transformation of nectar and/or honeydew into honey starts in the honey stomach of the forager bee (Nicolson & Human, 2008) and then continues through repeated manipulations and reallocations in the honeycomb by food-storing bees. That transformation requires the addition of enzymes and other substances by bees, lowering the pH through the addition of acids in the honey stomach of the bee, changing the chemical composition of the maturing product, and the evaporation of water (Crane, 1980).

Both passive and active mechanisms of nectar dehydration take place inside the hive during maturation (Eyer *et al.*, 2016). Active dehydration occurs when worker bees concentrate droplets of regurgitated nectar with movements of their mouthparts. Passive dehydration of nectar occurs through direct evaporation of water from nectar inside the beehive. In fact, honey bees can dehumidify honey by lowering the internal relative humidity of the beehive through the introduction of dryer air from outside, a process that continues throughout the night.

The allocation and relocation of the immature content of cells is essential for the ripening process and needs sufficient space in the beehive (Gary, 2015; Park, 1928). The beekeeper can assist in this process by adding extra supers to the hives. Hence, removing water from nectar is part of the maturation and ripening process that results in honey—it is solely achieved by the bees and is an all-natural process.

To protect the highly hygroscopic mature product and prevent the uptake of water from the air, the bees cap the cells with a lid of wax (Eyer *et al.*, 2016). Capped honey is mature and ready to be harvested.

The production chain of authentic honey involves beekeeper techniques of honey production and extraction that always respect its natural chemical-physical composition. Beekeepers and honey packers/traders must not remove or add any substance, including altering or accelerating the natural active and passive dehydration processes that bees carry out on nectar before storing and capping honey cells.

Frames with fresh nectar that can be shaken out of the cells like water should not be harvested by the beekeeper (Horn & Lüllmann, 2019; Matheson, 1993). Beekeepers should always check very carefully the level of maturation of honey both visually (capping and drip test) and instrumentally (measuring humidity using a hand refractometer) before collecting the supers.

The possibility of harvesting some partially capped honeycombs will depend on the ambient humidity conditions of the production year and/or the region. Under certain climatic conditions, e.g. tropical climates or areas facing unusual events due to climate change, bees may cap honey with a moisture content exceeding 18%. Under such circumstances, the beekeeper, although carrying the best beekeeping practices and techniques, has no choice but to store the harvested honey supers in rooms where humidity is controlled for a short period, both to prevent the honey from absorbing more moisture from the environment before honey extraction, and also to remove the little excess moisture. In fact, when storing honey with slightly excess moisture in dehumidified rooms, the honey in combs may lose a small fraction of its water. This practice before honey extraction has already been contemplated by Apimondia (2020) and should not be considered an invasive or fraudulent activity on the part of the beekeeper since it is not carried out for economic gain. It completely differs from the illegal, intentional, and systematic production of immature honey developed for economic gain, which involves the extraction of large amounts of excess moisture in a non-natural process with the help of technical equipment.

In conclusion, it is good beekeeping practice to ensure a suitable dry environment for the storage of honey frames

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Table 1. Fermentation liability of honey (from Traynor, 2015).

Moisture content	Tendency to ferment
< 17.1 %	Safe, regardless of yeast count
17.1 – 18.0%	Safe if yeast count is <1,000/g
18.1 – 19.0%	Safe if yeast count is <10/g
19.1 – 20.0%	Safe if yeast count is <1/g
>20.1%	Always in danger of fermentation

before extraction to minimize the uptake of moisture by the honey from the air and prevent fermentation, which also depends on the honey's yeast content (Table 1). Honey that has begun to ferment cannot be marketed for direct consumption and can only be used for cooking (European Directive, 2001; 2024).

3. Why a Moisture Limit for Honey Liability to Ferment?

xIn summary: honey over 17% moisture may ferment, and over 19% it will ferment.

4. Modes of Honey Adulteration

The European Commission (2018) states that four key criteria must be simultaneously present in a case of food fraud: i) violation of law; ii) intention; iii) economic gain and iv) deception of consumers.

Honey fraud occurs through:

1. Dilution with different sugar sirups (such as those produced from corn, sugar cane, sugar beet, rice, wheat, tapioca, etc.).
2. The intentional harvesting of immature honey to unfairly hasten the process for economic purposes. The immature product is subsequently actively dehydrated by the use of devices such as vacuum dryers.
3. The use of ion-exchange resins to remove residues and lighten the color of honey.
4. Masking and/or mislabeling the origin (geographical and/or botanical) and the mode of production (conventional/organic) of honey.
5. Artificial feeding of bees during the honey flow period to increase the harvest.
6. Intentional addition of elements (pollen, diastase, etc.) to mask the adulteration or degradation of honeys.
7. Intentional removal of pollen or addition of micro-filtered honey to render palynological analysis inoperative.

The product which results from any of the methods described above should not be called "honey", and the same is true for blends containing it (Codex Alimentarius, 1981).

This Statement will mainly focus on the second mode of honey adulteration: the systematic and purposeful production of immature honey.

5. The Production of Immature Honey and its Dehydration

Under normal conditions, nectar in the initial phase of the drying process is found in greater abundance in cells within the brood nest. Then bees start using cells in combs located in upper boxes (supers). As previously mentioned, the ripening is facilitated if there are sufficient empty combs in the supers for the bees to distribute the droplets across many cells (Gary, 2015).

In many Asian countries, honey is often harvested too early and unripe from one-box beehives. This mode of production is intended to speed up and simplify the process for evident economic reasons.

If honey is harvested by the beekeeper while it is still unripe, non-foraging bees become foragers earlier, thus increasing the harvesting capacity of the colony (Seeley, 1995). This unripe honey usually lacks the typical taste and odor associated with honey and has far too high water content (Dübecke *et al.*, 2018). The water content of that immature product must then be reduced before packing in so-called "honey factories" to prevent fermentation. In those factories, the product is also filtered and cleaned of residues (Phipps, 2016).

Vacuum dryers are frequently used to reduce the moisture of immature honeys. The speed of moisture reduction by evaporation using a vacuum dryer is around 15—20 times faster compared to dehumidification achieved using a room moisture control device (Lastriyanto *et al.*, 2020).

According to the definition of honey in the most widely accepted international honey standards (Codex Alimentarius, 1981; EU Directive, 2001; and the United States Pharmacopeia Honey Identity Standard, 2021), the transformation of nectar into honey must be exclusively made by bees. Neither human intervention in the process of maturation and dehydration, nor any removal of constituents particular to honey, is contemplated or permitted in the aforementioned standards. A constituent particular to honey is any substance naturally occurring in honey within its typical range of concentration, like sugars, pollen, proteins, organic acids, other minor substances, and, of course, also water. Hence, the removal of excess water in any non-natural way by, e.g. vacuum-drying etc. is not in accordance with the regulations (Lang & Schwarzinger, 2020).

The production of immature honey is also at odds with bee welfare practices referred to as maintaining optimal conditions for their health and survival, as described by Formato *et al.* (2024). This mode of production does not ensure that honey bees are housed under optimal conditions (no supers used in many cases), the naturally balanced division of labor between bees of various ages is disrupted, combs with brood from the brood box are centrifuged during honey extraction, the extracted frames with brood are mixed up between hives, etc.

Honey is unique because of its production process and composition. It is a microbiologically stable, long-term storable food that bees produce for their own use. Honey has been known that way to mankind for ages and has been a sweetener for thousands of years before cane sugar became widely available. Because of its composition, properties, and rarity, honey has earned a special appreciation in major religions and has often been a valued gift for kings. Today, it is regarded as synonymous with an all-natural food that is produced by bees and harvested in its final, ripe form by the beekeeper, who makes it available to consumers. Hence, Apimondia (2020) only supports production methods that allow the bees to fully do their job to maintain the integrity and quality of honey. Apimondia (2020) also rejects the development of methods intended to artificially speed up the natural process of honey production through the undue intervention of humans and technologies that may lead to

Table 2. Features of Immature Honey Production that lead to a violation of the definition of honey.

Feature	Consequence	Recommendation
Only one-box Langstroth-type beehive during honey crop.	• No adequate space/surface for the complete natural dehumidification and transformation of nectar into honey by bees.	• Add supers to use more than one box.
Harvesting immature honey by the beekeeper.	• Bees have insufficient time to dehydrate and add specific substances of their own through multiple manipulations of the maturing product. • The transformation of nectar into honey is only partially made by bees. Human intervention, in an illicit manner, partially completes the process by removing the excess water, but the final product is still short of being fully mature, real honey.	• Frames with honey should remain in the hive until bees complete the maturation process. • Human intervention in the maturation process of honey should be avoided.
Honey dehydration with technical devices, such as vacuum dryers, etc.	• The product does not comply with the recognized regulations and, therefore, may not be called 'honey'.	• The use of honey dryers has to be avoided.

a violation of standards (Table 2) and lower the intrinsic nutritional and compositional value of real honey. Mature honey has been shown to be of better quality than immature honey, not only because of its physicochemical properties and richer polyphenolic composition but also because of its stronger bacteriostatic effect and stronger free radical scavenging effect (Guo *et al.*, 2020).

6. The Detection of Immature Honey Production

Due to the complexity of honey fraud, there is no single tool or method that can detect all the multiple modes of adulteration. In fact, every honey packer or trader should have a documented multi-pronged fraud mitigation plan, which should include a vulnerability assessment, a mitigation strategy, and its implementation (United States Pharmacopeia, 2020).

Following basic considerations, certain indications may point toward presence of unripe honey. Specifically, unripe honey quickly undergoes spoilage (fermentation), leading to an altered melissopalynological picture, an increased count of yeasts, and a changed chemical composition with the appearance of fermentation products like alcohol. Consequently, a product exhibiting an increased yeast count and that smells fermented can be an indication of unripe honey. In order to remove those indicators, and due to the fact that unripe honey often exhibits a low viscosity, such products may be treated with resin technology (which is also not in line with regulations due to its potential of removing honey-specific substances), then ultrafiltrated, which also removes pollen, and finally technically dehydrated. Consequently, it must be stated that, when dealing with filtered honey that exhibits no pollen or a very low pollen count, there is an increased risk that the product has been derived from immature honey.

We also must keep in mind that multiple tools can be used to mitigate the vulnerability of honey to fraud besides lab testing. Those tools may include (but are not limited to) the traceability of honey, the auditing strategy, an assessment of the supply chain, an evaluation of the fraud history, and the eventual existence of economic anomalies in the production region of the honey (García & Schwarzinger, 2020).

Specifically, honey that has been harvested while still immature is currently difficult to detect by the sole use of laboratory testing, but some tools like traceability (Pietropaoli *et al.*, 2020), auditing, and the analysis of economic anomalies can be efficient complementary tools for its detection (García, 2018; García & Amadei Enghelmayer, 2025).

6.1. Traceability

The traceability of honey is critical in making the process transparent, especially in more complex supply chains where the product may be more vulnerable to fraud (Pietropaoli *et al.*, 2020). A falsified origin of a honey may constitute a "red light" to suspect fraud. Apimondia (2020) recommends that honey should be traceable back to the beekeeper and the geographic location of the apiary.

A modern online traceability system should include the formal registration of all beekeepers and their honey extraction facilities, geo-referenced apiaries and movement of colonies, all trading steps, blending, and packing. Honey containers should be easily identifiable by means of electronic codes. In such a way, the whole honey chain could be perfectly transparent and auditable.

The traceability system should also serve as a great source of information to quickly locate any problematic or unsafe honey, immobilize it, and withdraw it from the market, thus protecting customers in case of any fraud or safety issue.

6.2. Audit Schemes

Strong auditing programs can efficiently detect the production of immature honey and the use of illicit processing methods (e.g. the existence of honey dryers, ion-exchange resin technology, etc.).

In all cases, audits should be unannounced to randomly chosen beekeepers and processing facilities and performed by authorities or third parties with well-trained auditors (Table 3).

6.3. Economic Anomalies

As a general principle, honey should always be sourced from suppliers without a documented history of fraud activity. The closer the relationship between buyer and supplier, the lower the risk of having fraud problems (United States Pharmacopeia, 2020).

The use of statistical information has been shown to be a valuable tool for authorities and stakeholders to detect economic anomalies. Less-than-market pricing, honeys offered at different prices according to the test/s they pass, the ability to maintain surprisingly more stable pricing than competitors, the sharp increases of export volumes of countries without parallel increments of productive capacities, and the increase of importing and reexporting activities are good indicators of potential fraud problems (García, 2018; García & Schwarzinger, 2020).

Table 3. Activities that the auditor should perform at the different steps of production, extraction, and processing of honey.

At the operation	At the honey extraction room	At the exporter's processing plant
• Verify the identification and registration of the selected beekeeper. • Ask for a list of apiaries with locations belonging to the beekeeper. • Visit randomly selected apiaries. • Evaluate the number of boxes on the beehives during the harvest season. • Assess the percentage of capped cells of harvested honey frames. • Look for evidence of artificial feeding during the honey season (e.g. feeders in the beehives). • Assess the total production capacity and the individual hive yields of the beekeeper (in comparison with the average yields in the same region). • Verify documentation of honey sales.	• Verify the official registration of the extraction facility. • Re-evaluate the percentage of capped cells in honey frames to be extracted. • Confirm the use of an uncapper during the honey extraction process. • Detect the eventual use of syrups for diluting honey. • Take random samples of extracted honey for moisture and purity determinations.	• Verify the official registration of the plant and the existence of other plants belonging to the same company. • Perform mass and financial balances of the company. • Perform traceability exercises on random drums. • Look for the presence of honey-drying devices and/or ion-exchange resin technology. • Look for the existence of sugar syrups in the surroundings of the processing plants. • Interview the staff, searching for any suspicious activities. • Collect random samples of honeys arriving and exiting the plant for moisture and purity testing.

7. Conclusions

The production of immature honey violates the principles of honey production, does not meet the definition of honey of internationally accepted standards, is intentionally performed for economic purposes, and deceives consumers. In other words, the production of immature honey meets all four criteria established for the constitution of a food fraud, and the resulting product should not be labeled as "honey". Its detection requires the use of multiple tools since current laboratory methods cannot easily detect this illicit mode of production, which damages honest beekeepers, crop pollination, and the food security of many countries.

Contributors

Norberto García (APIMONDIA, Chair of the Scientific Commission on Beekeeping Economy. Universidad Nacional del Sur, Bahía Blanca, Argentina).

Etienne Bruneau (APIMONDIA, former Chair of the Scientific Commission on Technology & Quality, Brussels, Belgium).

Miguel Vilas Boas (APIMONDIA, Chair of the Scientific Commission on Technology & Quality. CIMO, LA SusTEC, Instituto Politécnico de Bragança, Bragança, Portugal).

Stephan Schwarzinger (APIMONDIA, Vice Chair of the Scientific Commission on Beekeeping Economy. North Bavarian NMR Centre (NBNC), Research Unit for Food Quality (ForN), and Center for German and European Food Law (FLMR), University of Bayreuth, Bayreuth, Germany.

Riccardo Jannoni-Sebastianini (APIMONDIA, General Secretary, Rome, Italy).

Fani Hatjina (APIMONDIA, Chair of the Scientific Commission on Bee Health. ELGO 'DIMITRA, Inst. of Animal Science- Department of Apiculture, Nea Moudania, Greece.

John Caldeira (APIMONDIA, Chair of the Regional Commission for Oceania, Fiji Farmer to Farmer, Fiji).

Jodie Goldsworthy (APIMONDIA Vice Chair of the Regional Commission for Oceania, BEECHWORTH HONEY, Beechworth, Australia).

Sebastian Spiewok (German Beekeeping Association—Wachtberg, Germany.

Cindy Adolphe (BeeLife, Brussels, Belgium).

María Alejandra Palacio (Universidad Nacional de Mar del Plata, Balcarce, Argentina.

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Norberto García
Argentina
Email: n.garcia@nexco-sa.com.ar
http://orcid.org/0009-0003-6766-2893