APIMONDIA STATEMENT ON HONEY FRAUD

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1. PURPOSE

APIMONDIA Statement on Honey Fraud is the official position of APIMONDIA regarding honey purity, authenticity and the best available recommended methods to detect fraud.

This Statement 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 developments of testing methodologies regarding honey purity and authenticity.

2. RESPONSIBILITY

The APIMONDIA Working Group on Adulteration of Bee Products will be the responsible body for the preparation and reviewing of this Statement at yearly intervals or whenever significant new information becomes available that the group becomes aware of.

The Working Group will ensure through consultation with the leading honey scientists, technical experts, specialist honey laboratories or others with sufficient market knowledge, that the Statement is reflective of the most up-to-date information and collective thinking on the topic.

Due to the dynamic nature of honey fraud, this Statement is intended to be reviewed and updated periodically, and every time significant scientific advances occur in any of the fields covered by the document. Updates will be published on the APIMONDIA website and other appropriate publications.

3. THE TRANSFORMATION OF NECTAR INTO HONEY

Honey is a one-of-a-kind product, the result of a unique interaction of the plant and animal kingdoms.

Honey maturation starts with the uptake of nectar and/or honeydew in the bee honey stomach while the foraging bees complete their load of nectar in the field and in their return flight (Nicolson and Human, 2008). It is inseparable from the drying process and involves the addition of enzymes and other bee-own substances, the lowering of pH through the production of acids in the bee stomach and the transformation of nectar/honeydew-own substances (Crane, 1980). Furthermore, a considerable microbial population exists at the initial stages of the maturation process that could be involved in some of these transformations, such as the biosynthesis of carbohydrates (Ruiz-Argueso and Rodriguez-Navarro, 1975).

The transformation of nectar into honey is the result of thousands of years of evolution by bees to achieve a long-term provision of food for their own use when there is no nectar flow from the surroundings of the colony. The reduced water content, the elevated concentration of sugars, the low pH and the presence of different antimicrobial substances make honey a non-fermentable and long lasting food for bees. An eventual fermentation of food reserves is an undesirable process for bees since it produces ethanol, which is toxic to them and affects their behaviour in a similar way than to other vertebrates (Abramson *et al*., 2000). During the ripening process, bees also add enzymes like invertase, which helps to invert sucrose into more stable simple sugars as glucose and fructose, and glucose oxidase, essential for the production of gluconic acid and hydrogen peroxide, which in turn prevent fermentation (Traynor, 2015).

The transformation of nectar continues inside the hive when non-foraging bees ripen nectar both, by manipulating it many times with their mouthparts and by reallocation. Actually, the allocation and relocation of the content of many cells before final storage is an important part of the ripening process and needs sufficient space in the beehive for its normal occurrence.

Eyer *et al.* (2016) provide evidence for the occurrence of both passive and active mechanisms of nectar dehydration inside the hive. Active dehydration occurs during ‘tongue lashing’ behaviour, when worker bees concentrate droplets of regurgitated nectar with movements of their mouthparts. By contrast, passive concentration of nectar occurs through direct evaporation of nectar stored in cells and depends on the conditions inside the beehive, being faster for smaller sugar solution volumes, displaying a larger surface area (Park, 1928).

As the nectar is dehydrated, the absolute sugar concentration rises, rendering the ripening product increasingly hygroscopic. Bees protect the mature product by sealing off cells filled with honey with a lid of wax. Therefore, the ripening process finishes when capping has already started, suggesting the possibility of a race against honey dilution (and unwanted fermentation) due to the high hygroscopic nature of mature honey (Eyer *et al*., 2016).

A colony possesses a division of labour between foraging and food-storing bees, and can

adapt its nectar collecting rate by stimulating non-foragers to become foragers (Seeley, 1995). If honey is harvested when still unripe by the beekeeper, non-foraging bees would become foragers earlier, thus increasing the harvesting capacity of the colony. This mode of production violates the principles of honey production, alters the composition of the final product which does not meet the expectations of consumers.

4. THE EXPECTATION OF CONSUMERS

Stone paintings from prehistoric times (Paleolithic period, 15,000 to 13,500 B.C.) show us that humans were indeed hunters of this natural and sweet food entirely prepared by bees that needs no manipulations by humans to be ready to eat. Honey was the only sweetener for thousands of years, as the use of sugar cane is reported since approximately the 4th century B.C. and restricted to those parts of the world where it was endemic (Warner, 1962). Sugar beet was the result of breeding in the 18th century (Biancardi, 2005).

The product that was accessible to early honey hunters must be assumed to be honey in sealed combs instead of immature products, which would be simply too difficult to handle (lower viscosity, storage) and would not have the desired microbial stability for long-term storage. Consequently, early humans were exposed to ripe honey when consuming this precious food, giving rise to certain expectations regarding organoleptic properties of honey.

As honey was the only available sweetener at those times, it was soon attempted to practice beekeeping in a way to provide access to capped combs as a source of both ripe honey and beeswax. That attempt has also been documented by the interest of ancient scientists in the mechanisms of the bee-colony. One of the earliest descriptions of the division of tasks within the colony is attributed to Aristotle. Furthermore, the fact that honey is a unique and highly estimated product by man, may also be concluded from its important role in essentially all world religions, either as an offering food, a product with healing properties, as part of food for deities, or simply as allegories (Crane, 1999).

In summary, the expectation by human beings about honey has been transmitted from generation to generation up to the modern honey consumer, who appreciates the properties and nature of honey as never before in history. And, as opposed to other foods, whose manufacturing practices and consumer tastes may change, honey perception by humans has not changed as it is nowadays consumed in practically the same way as it was in ancient times.

5. ABOUT THE DEFINITION OF HONEY

Codex Alimentarius (1981; CA), the internationally accepted standard for foods issued by the FAO, contemplates the aforementioned biological aspects of honey production and defines:

“Honey is the natural sweet substance produced by honey bees from the nectar of plants or from secretions of living parts of plants or excretions of plant sucking insects on the

living parts of plants, which the bees collect, transform by combining with specific substances of their own, deposit, dehydrate, store and leave in the honey comb to ripen and mature".

APIMONDIA adheres to the CA definition of honey and to its description of essential composition and quality factors (CA, Section 3):

"3.1 Honey sold as such shall not have added to it any food ingredient, including food additives, nor shall any other additions be made other than honey. Honey shall not have any objectionable matter, flavour, aroma, or taint absorbed from foreign matter during its processing and storage. The honey shall not have begun to ferment or effervesce. No pollen or constituent particular to honey may be removed except where this is unavoidable in the removal of foreign inorganic or organic matter.

3.2 Honey shall not be heated or processed to such an extent that its essential composition is changed and/or its quality is impaired.

3.3 Chemical or biochemical treatments shall not be used to influence honey crystallization."

APIMONDIA understands that the use of "shall" or "shall not" in Section 3 of CA makes it not optional but mandatory.

As described in Section 3.1 to 3.3, the transformation of nectar into honey must be completely made by bees. No human intervention in the process of maturation and dehydration, neither any removal of constituents particular to honey are permitted. A constituent particular to honey is any substance naturally occurring in honey like sugars, pollen, proteins, organic acids, other minor substances and, of course, water.

The definition of CA further rules out any additions to honey (including those substances that are contained naturally in honey such as water, pollen, enzymes, etc.), nor any treatment intended to change honey's essential composition or impair its quality. Such non-permitted treatments include (but are not limited to) the use of ion-exchange resins to remove residues and lighten the colour of honey, and the active removal of water from honey with vacuum chambers or other devices.

It is known that under certain climatic conditions, e.g. tropical climates, even honey in capped combs may have a moisture content over the requirement of CA in Section 3.4. According to APIMONDIA's opinion it is acceptable to store frames with a little extra excess humidity in a dry room in order to both prevent further uptake of moisture from the environment and to adjust honey moisture in the frames to the required limits before extraction. This practice resembles the passive evaporation normally occurring inside the beehive.

In summary, according to APIMONDIA's understanding, honey is the result of a complex process of transformation of nectar/honeydew that occurs exclusively inside the beehive. Honey is unique because of its production process and its composition. Water, as well as glucose, fructose, other sugars, proteins, organic substances and other natural components are definitely considered constituents particular to honey that cannot be removed.

6. OVERVIEW

It is historically well documented that honey has long been subject to fraud (Crane, 1999), however the conditions for honey fraud have never before been so well aligned:

1. honey is becoming a scarce and expensive-to-produce product;
2. there is an opportunity for strong profits through fraud;
3. the modes of honey adulteration rapidly change;
4. official method, EA-IRMS (AOAC 998.12), cannot detect most current modes of honey adulteration.

Honey fraud is a criminal and intentional act committed to obtain an economic gain by selling a product that is not up to standards.

Different types of honey fraud can be achieved through:

1. dilution with different syrups produced, e.g. from corn, cane sugar, beet sugar, rice, wheat, etc.;
2. harvesting of immature honey, which is further actively dehydrated by the use of technical equipment, including but not limited to vacuum dryers;
3. using ion-exchange resins to remove residues and lighten honey colour;
4. masking and/or mislabelling the geographical and/or botanical origin of honey;
5. artificial feeding of bees during a nectar flow.

The product which results from any of the above described fraudulent methods shall not be called “honey” neither the blends containing it, as the standard only allows blends of pure honeys.

7. MODES OF HONEY PRODUCTION

APIMONDIA has a role in guiding a sustainable development of apiculture globally and always supporting the production of high quality authentic natural honey containing all the complex properties given by nature.

APIMONDIA supports those production methods that allow bees to fully do their job in order to maintain the integrity and quality of honey for the satisfaction of consumers who seek all the natural goodness of this product.

APIMONDIA rejects the developing of methods intended to artificially speed up the natural process of honey production through an undue intervention of man and technology that may lead to a violation of the honey standard (Table 1).

8. THE IMPACT OF HONEY ADULTERATION

Information coming from global honey trade statistics, official surveys and private

laboratories on the prevalence of honey fraud, allow us to conclude that fraud mechanisms are responsible for the injection of a very important volume of diluted and/or non-conforming honeys into the market.

The current honey fraud problem has an extensive global magnitude, and impacts on both the price of honey and the viability of many beekeeping operations.

The Executive Council of APIMONDIA has recently defined honey fraud as one of the two major challenges to the viability of beekeeping globally. APIMONDIA aims to play an increasingly important role in driving solutions to honey fraud in the future as the voice that represents world beekeepers.

According to the U.S. Pharmacopeia's Food Fraud Database, honey ranks as the third "favourite" food target for adulteration, only behind milk and olive oil (United States Pharmacopeia, 2018). Similarly, the European Union has identified honey to be at high risk to be fraudulent (European Parliament, 2013).

The European Commission (2018) considers that four essential elements must be present in a case of food fraud:

i) intentionality;
ii) violation of law (in this case, the CA definition of honey);
iii) purpose of economic gain and
iv) consumer's disappointment.

Table 1: Modes of honey production that violate the Codex Alimentarius Standard

MODE OF PRODUCTION	WHAT IS VIOLATED?
One-box Langstroth-type beehive during honey crop.	- No adequate space/surface for the complete natural dehumidification and transformation of nectar into honey. - Higher levels of chemical residues, substances untypical to honey, or substances in uncommon concentrations in honey.
Harvesting of immature honey by the beekeeper.	- Bees have insufficient time to dehydrate and add specific substances of their own by multiple manipulations. - The transformation of nectar into honey is only partially made by bees, and human intervention completes the process in an illicit manner.
Honey dehydration with technical devices, such as vacuum dryers, etc.	- Water is a constituent particular to honey, which cannot be removed by some technical devices replacing the natural work of bees.

Use of Ion-Exchange Resins to remove residues and lighten the colour of honey.	- Honey shall not be processed to such an extent that its essential composition is changed and/or its quality is impaired. No pollen or constituents particular to honey may be removed.
Feeding bees during a nectar flow.	- Honey can only be produced by honey bees from the nectar of plants or from secretions of living parts of plants or excretions of plant-sucking insects on the living parts of plants.

Honey fraud in its five different modes has resulted in at least three visible consequences in the international market: i) a downward pressure on pure honey prices due to an oversupply of the product, ii) a disincentive to produce and export pure honeys by several traditional countries, which have shown significant decreases in their export volumes during the past years, and iii) the appearance of new exporting countries, that re-export cheap imports, straightly or in blends, as locally produced.

As long as honey fraud, customs fraud and the violation of national and international trade laws persist, the wellbeing and stability of world beekeepers remain in jeopardy. With only some exceptions, current honey prices paid to the beekeeper are not sustainable. If the current situation of low prices persists, many beekeepers will abandon the activity, and those who decide to continue will not be incentivized to keep their current number of beehives.

Honey fraud goes against defending honey's image as a natural product and against efforts to protect honest beekeeping. It also happens at the expense of consumers who often do not receive the product they expect and pay for. The overall result is a threat to food safety, food security and ecological sustainability.

In order to better understand the magnitude of the problem, we must remember that honey is the best-known product of bees but surely not the most important one. Bees, through their pollination work, are essential for the maintenance of the planet's biodiversity and absolutely necessary for the pollination of many crops that represent 35% of all our food.

9. THE SOLUTION

The strategy to combat honey fraud must include:

- awareness of the beekeeping community through presentations and publications;
- awareness of consumers through the media;
- awareness of retailers and packers on the need to improve testing in countries with legislation that does not fulfill the criteria of the CA and whose product could not be exported to countries where the CA standard applies;
- awareness and collaboration with national authorities who should periodically review their honey standards and use the best available methods for the detection of honey fraud;
- awareness and collaboration with multinational authorities and institutions.

10. RECOMMENDATIONS FOR ASCERTAINING AUTHENTICITY OF HONEY

APIMONDIA recommends the use of a multi-pronged approach strategy to combat honey fraud through:

a. Traceability

APIMONDIA recommends that honey should be able to be traced back to the beekeeper, to the botanical floral source from where the bees gathered the nectar and to the geographic location of the apiary. Beekeepers should keep records that document their production process as consumers demand transparency of the whole supply chain. APIMONDIA considers this an integral part of modern Good Beekeeping Practices.

b. Testing

Honey fraud, as other modes of food fraud, is a dynamic phenomenon. Effectiveness of methods to detect honey fraud normally decreases after some time due to the successful learning process on the fraudster's side. Ethical stakeholders of honey trade and processing should always go a step forward, and not a step behind, in their commitment to minimize the probability of occurrence of fraud by always using the best available method(s) to detect it.

Many different kinds of syrups (some of them specially designed to adulterate honey) are currently available. These syrups display varying patterns of minor components and trace compounds, which are often used as analytical markers. It is practically impossible to have a single and perdurable method able to detect all kinds of honey fraud. By contrast, as fraud involves criminal intentions, variations in fraud practices have to be expected.

According to standards in the food sector, such as BRC or IFS, a proper risk assessment has to be conducted and appropriate measures have to be applied. That may involve organisational as well as analytical measures. It has to be emphasized that, due to the dynamic nature of fraud, not only official and/or traditional methods are suitable for testing, but also the adequate application of novel technologies are indicated.

The importance of applying suitable testing regimes, not only covering methods required by authorities, has to be emphasized due to the limitations of official methods, e.g. the AOAC official method 998.12 "Internal Standard Stable Carbon Isotope Ratio". It is well known that the AOAC official method can detect reliably and sensitive additions of syrups derived from C4-plants, but fails to detect many other types of syrup. The sole use of the AOAC method under the argument that it is the only official method may deliberately be used to whitewash adulterated honey. APIMONDIA does not endorse such practice because it neglects other certain risks. According to standards of the food sector, such as BRC or IFS, the aforementioned behaviour by some stakeholders ignores the requirement of establishing a risk-assessment procedure with the corresponding preventive actions in their operations.

APIMONDIA highly recommends a choice of method(s) tailored to each specific situation. In most cases, a proper honey fraud detection strategy should include a

powerful screening method like Nuclear Magnetic Resonance (NMR). NMR is currently the best available method to detect the different modes of honey fraud. In case non-conformances are found by NMR, other targeted tests may be useful in complement to better clarify the origin of deviations.

In some cases, a combination of other targeted tests (e.g. AOAC 998.12, honey-foreign enzymes, small molecule or DNA-based syrup-specific markers, honey-foreign oligosaccharides, LC-IRMS, artificial food ingredients and acids indicative for invert sugar) may also be useful.

Pollen and organoleptic testing, along with other honey components, are considered good complementary parameters to determine the geographic and botanical authenticity of honey. Care should be taken, however, for some specific regions where some plants are known to secrete nectar but not pollen.

It is interesting to note that, due to the nature of honey fraud, it is not infrequent that the results of a method may need to be clarified by the use of other alternative tests.

The decision taken regarding the best testing method(s) to be used should be the result of a detailed risk-assessment that should consider the origin of the product, the history of honey adulteration cases from that origin, trade movement statistics and the most usual modes of production and adulteration used in that region or country of origin. It has to be strongly noted that the selection of method(s) has to be periodically checked in accordance with new scientific insights.

APIMONDIA supports the development of new techniques to detect honey fraud, available at reasonable costs for the majority of stakeholders, and supports the constitution of an international database of original honeys with a more open exchange of analytical information between the different laboratories specialized in honey analysis.

c. Auditing & Quality Assurance Programmes

APIMONDIA recommends that business stakeholders, who import or export honey, or who process or produce more than 20 tons/year, have in place a Food Safety and Quality Assurance programme.

Third-party audits of Food Safety and Quality Assurance programmes are an important verification method to detect potential honey fraud, which should be used as a valuable tool to complement laboratory honey testing.

Audits should check different parameters of honey traceability, country and companies' mass trade balances and the existence of a documented Vulnerability Assessment and Critical Control Points (VACCP) in place in order to prevent honey fraud.

Finally, audits should only be performed by professionals who have an adequate knowledge of beekeeping, good beekeeping practices and honey quality parameters in order to detect possible deviations in the modes of honey production and/or processing that may result in a non-genuine product.

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