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Honey Adulteration and Its Toxic Effects

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Honey is defined by the Codex Alimentarius as a natural sweet substance derived from plant nectar or secretions of living plant parts that is kept and dehydrated by honey bees to improve nutritional characteristics and make it palatable for humans. Honey has long been used for anti-aging, immune system enhancement, germ killing, bronchial phlegm therapy, and relief from a sore throat, cough, and cold. Honey also has anti-inflammatory, antioxidant, and anti-cancer effects that have been linked to breast and cervical cancer, prostate cancer, and osteosarcoma, according to the studies. Although honey is regarded as a high-quality food, it is more susceptible to adulteration, mislabelling, and unethical mixing with lower-grade honey, sugars, and other ingredients.

Composition of Pure Honey:

Fructose	38.2
Glucose	**31**
Water	**17.1**
Maltose	**7.2**
High carbohydrates	**4.2**
Sucrose	**1.5**
Minerals, vitamins, enzymes etc.	**0.5**

Type of Honey- based on its origin as follows:

1) **Blossom honey:** It is made from the nectar of flowers like linden, clover, citrus, cotton, thyme, and acacia.
2) **Honeydew honey:** Honeydew (Rhynchota genus insects puncture plant cells, drink plant sap, and then secrete it again) gathered by bees is the source of this honey. Pine, oak, fir, and leaf honey are examples of honeydew honey.
3) **Monofloral honey:** The plant on which the honey-producing bees primarily forage has given the honey its name.
4) **Multifloral honey:** This honey comes from a variety of botanical blooms, none of which are particularly prominent. This is where you'll find honey from meadow blossoms and forests.

Standardization of Honey

At International level

- Codex Alimentarius Commission (framed in 1981, revised in 1987 and 2001)

- EU council directive (2001/110/EC and amended in 2014 as 2014/63/EU)

At National level

- FSSAI [Food Safety and Standards (Food Product Standards and Food Additive) Amendment Regulations, 2019]

According to FSSAI: the following conditions, parameters, and limits must be met by honey-

S. No	Parameters	Limits
1.	Specific gravity at 27°C, Min	1.35
2.	Moisture per cent by mass, Min	20
3.	Total reducing sugars, Per cent by mass, Min.	
	(a) For the Honey not listed below	65
	(b) Carviacalosa and Honeydew honey	60
	(c) Blends of Honeydew honey with blossom honey	45
4.	Sucrose, per cent, by mass, Max	
	(a) For the Honey not listed below	5.0
	(b) Carviacalosa and Honeydew honey, Max	10
5.	Fructose to Glucose ratio (F/G)	0.95-1.50
6.	Total Ash, per cent by mass, Max	0.50
7.	(a) Acidity expressed as formic acid, per cent by mass, Max	0.20
	(b) Free Acidity miliequivalents acid/ 1000 g. Max	50.0
8.	Hydroxymethylfurfural (HMF) mg/kg, Max	80.0
9.	Diastase activity, Schade units per gram, Min	3
10.	Water insoluble matters, per cent by mass, Max	
	(a) For the Honey not listed below	0.10
	(b) For Pressed honey	0.5
11.	C4 Sugar, per cent by mass, Max	7.0
12.	Pollen count and plant element/g Min.	5000
13.	2-Acetylfuran-3-Glucopyranoside (2-AFGP) as Marker for Rice Syrup	Absent**
14.	Foreign oligosaccharides (Max. Per cent Peak)	0.7
15.	Proline mg/kg, Min.	180
16.	Electrical Conductivity	
	(a) Honeys not listed under Honeydew, Max.	0.8 mS/cm
	(b) Honeys listed under Honeydew, Min.	0.8 mS/cm
17.	(a) $\Delta\delta^{13}C$ max* (Maximum difference between all measured values $\delta^{13}C$) per mil	± 2.1
	(b) $\Delta\delta^{13}C$ Fru -Glu (The differences in $^{13}C/^{12}C$ ratio between fructose and glucose), per mil	± 1.0
	(c) $\Delta\delta^{13}C$ Protein-Honey (The difference in $^{13}C/^{12}C$ between honey and its associated protein extract); per mil	≥ - 1.0

*$\Delta\delta^{13}C$ Max. is the maximum difference observed between all possible isotopic ratios measured ($\Delta\delta^{13}C$ fructose-disaccharides/ $\Delta\delta^{13}C$ fructose-trisaccharides/ $\Delta\delta^{13}C$ fructose-protein/ $\Delta\delta^{13}C$ glucose disaccharides/ $\Delta\delta^{13}C$ glucose-trisaccharides/ $\Delta\delta^{13}C$ glucose-protein/ $\Delta\delta^{13}C$ disaccharides-trisaccharides/ $\Delta\delta^{13}C$ disaccharides-proteins $\Delta\delta^{13}C$ trisaccharides-protein)

**Minimum Required Performance Level-1mg/kg

Honey Adulterants

Cane Sugar: Cane sugar is typically made by extracting juice from the sugar cane, a perennial C4 grass, followed by chemical and physical purification, evaporation to remove water, and sugar crystal separation.

1) **Corn Syrup:** Corn syrup, or high fructose corn syrup (HFCS), is a viscous, odorless, and colorless liquid that is much denser than water. Corn syrup is a liquid sweetener derived by corn starch hydrolysis, which is used as a sweetener in foods
2) **Palm Sugar:** Palm sugar is made by extracting the flower buds of the palm tree. It's a chemical-free natural sweetener that goes through only a few stages.
3) **Invert Sugar:** By catalysing sucrose into its monosaccharide building blocks, fructose and dextrose, invert sugar (IS) is created. IS gets its sugar from beet and cane plants, so it has a sugar profile similar to that of pure honey.
4) **Rice Syrup:** One of the most common honey adulterants is rice syrup (RS), a result of rice polysaccharide hydrolysis that comes from a C3 plant (similar to beet syrup).
5) **Inulin Syrup:** Inulin is a naturally occurring polysaccharide that belongs to the fructans family. These dietary fibres are made up of a chain of fructose residues with glucose at the end.

Methods of Adulteration

1. **Direct Adulteration:** accomplished by combining a specific amount of sucrose syrup to the honey directly. Sugar beet, HFCS, maltose syrup, or industrial sugar syrups (glucose and fructose) generated through heat, enzyme, or acid treatment of starch might all be sources of sucrose syrup.
2. **Indirect Adulteration:** The introduction of sugars into honey via bee-feeding is known as indirect adulteration. Low-quality honey, chemicals, and synthetic sugars were integrated into the honey through a natural process in the bee's digestive system in this way. During the major nectar flow time, a large volume of sugar syrup was supplied to the bee colonies during indirect honey adulteration.
3. **Blending:** In this procedure, high-quality (pure and uncommon) honey is combined with lower-quality, lower-nutrition honey. In recent years, there has been a significant increase in the use of synthetic honey to replace pure honey.

Detection Method of Honey Adulteration

1) **HMF determination:** Honey adulteration frequently involves the addition of sugar. Sugar addition has traditionally been accompanied by thermal treatment in order to produce a homogeneous mixture that can be sold to consumers as pure honey. HMF can be formed as an intermediate chemical during the Maillard's reaction, which occurs when heat is applied to honey. As a result, the presence of HMF is a sign that honey has been manipulated. HMF production is possible at low temperatures, and it can be increased by increasing the applied temperature or storing the product.
2) **Diastase Enzymatic Activity:** Enzymatic activity (diastase and invertase) is one of the most basic and widely used analytical methods, although it is not always conclusive and must be used in conjunction with other methods to provide a trustworthy result. Invertase is a better marker for honey quality control than amylase since it degrades significantly faster during the heating up process.
3) **Differential Scanning Calorimeter (DSC)**- can be used to test how the direct addition of sugar syrup adulterants affects the thermal characteristics of honey.
4) **Conventional polymerase chain reaction (PCR)-** Rice molasses, which has been used in the direct adulteration of honey, can be detected using a typical polymerase chain

reaction (PCR). Furthermore, the real-time PCR standard curve may be used to measure the amount of DNA in rice molasses and determine the exact level of adulterants.

Adulteration in Honey has Several Following Health Consequences

1. **Obesity** - Honey is popular for its weight-loss qualities. The most common weight-loss cure is honey and warm water. However, by inadvertently consuming adulterated honey, they end up fighting obesity and its related problems.
2. **Increased insulin secretion**- it may be increased by consuming glucose from sugar-adulterated honey. Insulin activates the NADPH-oxidase-like plasma membrane enzyme system, resulting in the formation of H2O2 and fructose as well as an increase in uric acid in humans and rodents.
3. **Increased blood sugar level-** because pure honey has a low glycemic index, it is preferred by diabetics all over the world. Adulterated honey, on the other hand, is dangerous for diabetics since it can cause hyperglycemia (high blood sugar) and even type 2 diabetes in those who do not have it.
4. **Increased inflammation-** Inflammation is the root cause for many health problems such as heart disease, digestive problems, cancer, joint pain, skin problems and more. Adulterated honey that has high levels of HFSC can lead to an increase in inflammation in the body, leading to a multitude of health concerns. Pure honey can fight inflammation.