9. DEFINITION AND USES OF HONEY

WHAT HONEY IS

Bees make honey from the nectar that they collect from flowers, other plant saps and honeydew are used to a minor extent. The colour, aroma and consistency of honey all depend upon which flowers the bees have been foraging. Forager honeybees are always female worker bees. The queen bee and drone bees never forage for food.

After visiting a flower, the foraging honeybee flies back to her nest that may be in a hollow tree or other natural cavity, or inside a man-made hive. The nectar that she collected from the flower is carried in her honey sac, a modified part of the gut. Once inside the nest, she regurgitates the fluid and passes it through her mouth to one or more 'house' bees, which in turn swallow it and regurgitate it. As each bee sucks the liquid up through her proboscis and into her honey sac, a small amount of protein becomes added and water is evaporated. The proteins added by the bees are enzymes, which convert sugars in the nectar into different types of sugars. The liquid travels through a chain of bees in this way before it is placed in a cell of honeycomb. After the liquid has been placed in the cell, bees continue to process it, and further water evaporates as they do so. The temperature of the nest near the honey storage area is usually around 35 °C. This temperature, and the ventilation produced by fanning bees, causes further evaporation of water from the honey. When the water content is less than 20 percent, the bees seal the cell with a wax capping: the honey is now considered 'ripe' and will not ferment. The bees have prepared for themselves a concentrated food store, packed in minimal space that can be stored until they need it during any future period with no flowers, or winter period ahead. The honey has been produced and stored in such a way that it will not significantly deteriorate in quality – it will not go mouldy, and there will be no problem of fermentation during storage.

BOX 10
Definitions of honey according to the Codex Alimentarius and the EU[13]

Definition of honey according to Codex Alimentarius
Honey is the natural sweet substance, produced by honeybees 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 honeycombs to ripen and mature.

Definition of honey according to the EU
Honey is the natural sweet substance, produced by *Apis mellifera* 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 honeycombs to ripen and mature.

The EU definition states that honey is only honey according to the definition when it is produced by *Apis mellifera* honeybees.

FORAGING BY BEES

Bees commonly forage on flowers within two kilometres of their nest, although they can travel much further – bees have been recorded foraging 14.4 kilometres from their home, and foraging distances of five kilometres are common (Ratnieks, 2002). Assuming a foraging range of just two kilometres, the honey produced in one hive may have therefore come from flowers in an area of 12.6 square kilometres. How bees detect flowering plants and make decisions about which plants the colony should use is very complex and interesting – but beyond the scope of this book. Foraging strategy involves honeybees communicating foraging information to one another, recruiting other bees to join in, changing from nectar-gathering to pollen – or water-gathering, making decisions to change to new foraging sources, and taking many other decisions about how to most efficiently exploit available forage resources so as to meet the colony's constantly changing requirements.

[13] Codex Alimentarius (2001) Draft revised standard for honey. Alinorm 01/25 19-26. and EU Council (2002) Council Directive 2001/11 O/EC of 20 December 2001 relating to honey. Official Journal of the European Communities L10, 47-52.

To produce one kilogram of surplus honey requires bees to visit several million flowers and to fly a total flight path equal in distance to six orbits around the earth!

THE USES OF HONEY

For bees

Bees produce honey to act as a food store for the colony for periods when there are no flowers, or the climate is adverse. For example, during the winters of northern, temperate countries, few plants are flowering between October and March, and bee colonies need honey stores to survive throughout this flowering dearth period, and when it may be too cold to leave the nest. In tropical countries, bees need to survive through seasons when there are no flowers, periods of drought, or when bees are not able to forage because of rain or other adverse weather.

As food for humans

Honey is a useful source of high-carbohydrate food, and usually contains a rich diversity of minor constituents (minerals, proteins, vitamins and others), adding nutritional variety to human diets.

TABLE 18
Energy value of honey

Energy value	3,040 kcal/kg
Sweetness	High
Sugar content	80%
Minerals, protein, enzymes	Very little, but valuable

As a medicine or tonic

In many countries, honey is regarded more as a medicine or special tonic, rather than as an every-day food. Honey does have medicinal properties that are acknowledged increasingly by modern medicine. Read more about this in Chapter 12.

Other uses

Honey is widely used as a source of sugars for making honey wines and beers, and in the manufacture of many secondary products: breakfast cereals, bakery goods, and a multitude of other value-added products. Read more in Chapter 13.

CHARACTERISTICS OF HONEY

Granulated honey

Glucose is one of the major constituents of honey and when this crystallises the honey becomes solid, known as granulated honey. Granulation is a natural process and there is no difference in nutritional value between solid and liquid honey. This process may be likened to ice and water – liquid honey and granulated honey is the same substance but in a different form.

Some honeys are much more prone to granulation than others are, and almost all honey will granulate if its temperature is reduced. As with the colour of honey, different people favour different qualities: some prefer granulated honey while others choose liquid honey. If honey is required in the granulated form, but it is slow to granulate, it is possible to start the granulation process by 'seeding' it by adding some finely granulated honey and stirring this in until it is evenly distributed. The honey will now granulate if kept at a low temperature.

If a jar of granulated honey is required in the liquid form, stand it up to its neck in a container of warm water (60 °C) – it should soon liquefy. However, heating honey always reduces its quality by destroying its enzymes, evaporating volatile compounds and therefore reducing the flavour.

The following factors are important for rapid granulation:

- temperature below 15 °C;
- high concentration of glucose; and
- availability of nuclei to act as seeds to start the process of crystallisation (e.g. pollen or existing crystals).

Honey quality

It does not matter where they are living – in their own nest built in the wild or in any type of hive – bees always store clean and perfect honey. The place where they live has no effect upon the quality of honey that bees make. It is only subsequent handling by humans that leads to reduction in quality; if the honey is harvested when the water content is still too high (honey is still 'unripe'), if it is contaminated, over-heated, over-filtered or spoiled in any other way.

Quality – according to the consumer

For the consumer of honey, the important features of honey are its aroma, flavour, colour and consistency, all of which depend upon the species of plants being visited by the bees. For example, bees foraging on sunflower will produce a golden honey that granulates (crystallises) quite quickly, while bees foraging on avocado produce a dark honey that remains liquid over a long period. The factors of aroma and flavour of honey are subjective, and honey is often judged according to its colour. Usually dark-coloured honeys have a strong flavour while pale honeys have a more delicate flavour. A great number of different substances (alcohols, aldehydes, organic acids, and esters) contribute to the flavour of honey. These are volatile compounds and evaporate easily at temperatures above 35 °C: this is one of the reasons why honey quality is reduced by heat.

It is impossible to give a comparable value to the subjective values of flavour and aroma: the relative popularity of dark and light coloured honey varies from country to country. Colour can sometimes be a useful indicator of quality because honey becomes darker during storage, and heating will darken honey. However, many perfectly fresh, unheated and uncontaminated honeys can be very dark.

Quality – according to trade criteria

Honey is not a simple commodity with a single, standard composition. It is a product that is harvested and marketed in nearly every country, and marketed globally, yet there is no single, international standard for honey quality. Nations and market regions set their own criteria for honey, defining what honey is, and what its composition should be (see Definitions of honey above, and Honey legislation below). This can make honey marketing very difficult for exporters. Honey is a natural product, produced by different bees in widely differing vegetation zones and climates worldwide. Honey content can vary greatly even within one nation, let alone between regions and continents. Inevitably, attempts to define honey have proved imperfect to characterise all honeys.

Currently a major issue of concern for the world honey market is contamination of honeys with the residues of medicines used to control bee diseases (see below). The best way forward for the honey trade may be, rather than to attempt to define exactly what honey should be, to focus on defining only the non-permitted constituents of honey. The EU has the most stringent honey quality requirements: honey is not permitted to contain any trace of antibiotic. In the US, some trace levels of antibiotics are permitted.

Colour

Colour of honey is measured using a "Pfund grader" (named after the inventor Dr Pfund). In this instrument, a sample of the honey is placed in a wedge-shaped glass container. (Only liquid honey can be graded for colour; granulated honey must first be liquefied). The sample is viewed through a narrow slit and the "wedge" of honey moved until the density of colour visible through the slit matches with a piece of standard amber-coloured glass. A scale on the instrument gives a numerical value for the colour of the honey, and using this, the colour category of the honey can be determined. Colour descriptions range from "water white" through shades of amber to dark.

Honey categories

Honey may be categorised according to its origin, the way it has been harvested and processed, and its intended use.

HONEY CATEGORIES CONCERNING ORIGIN

Blossom honey is obtained predominantly from the nectar of flowers (as opposed to honeydew honey).

Honeydew honey is produced by bees after they collect 'honeydew' – secretions of insects belonging to the genus *Rhynchota*, which pierce plant cells, ingest plant sap and then secrete it again. Honeydew honey colour varies from very light brown or greenish to almost black, and is an important type of honey for producers in coniferous forest areas of Central and Eastern Europe. Honeydew honey is very highly valued in these countries, and for example in Slovenia, beekeepers transport their bees to forests to forage for honeydew. Fir and spruce trees produce honeydew regularly each year, yet in each place differently. A well-organised, computer-based service for predicting the appearance of honeydew on forest trees provides migratory beekeepers with accurate information on the locations and intensities of the flow. Each year, several observation hives located in Slovene forests provide information on the quantities of honey collected by bees in certain periods. Based on such data, beekeepers decide where and when they will take their bees to forage. They use lorries, trailers and containers into which their hives are stacked like dominoes.

Monofloral honey is where the bees have been foraging predominantly on one type of plant, and is named according to that plant. Common monofloral honey types are clover, *Acacia*, lime (linden) and sunflower honey. Monofloral honey is priced more highly than polyfloral honey. Light, monofloral honeys like orange blossom or *Acacia* – because they look so attractive – always obtain higher prices then blends of honeys.

Multifloral honey (also known as polyfloral) has several botanical sources, none of which is predominant, for example, meadow blossom honey and forest honey.

HONEY CATEGORIES CONCERNING PROCESSING

Comb honey is pieces of honeycomb, as produced by the bees, where the beekeeper has done no processing to separate the honey from the beeswax. The beeswax comb, as well as the honey, is edible. Comb honey always fetches a very good price, as the consumer can be sure that the honey has not been contaminated in any way. Ironically, this can be one of the easiest forms of honey to harvest and prepare for sale (see below).

Strained honey is honey obtained by straining honeycombs, to separate the honey from the beeswax.

Chunk honey is a jar of liquid honey inside which is placed a piece of comb honey. This can look very attractive. It is important that the liquid honey is a type that is very light and clear, and will not granulate over a long period. Honeys from *Acacia* and *Robinia pseudoacacia* are often used for this. This type of product depends on the right type of honeys and excellent packaging, and can achieve a very good price.

Extracted honey is honey obtained by centrifuging honeycombs.

Pressed honey is extracted by pressing honeycombs with or without the application of moderate heat.

Crystallised or granulated honey is strained honey that has crystallised (see below).

Creamed honey is strained honey that has been seeded to start crystallisation and then stirred to produce a honey of uniform, soft consistency. On an industrial scale, honey is creamed by the 'Dyce method' (Dyce, 1975). About 20 percent of fine crystallised honey is mixed with liquid honey and the crystals are allowed to grow at 14 °C. This procedure stabilises the honey consistency, and does not affect the honey's authenticity, as no foreign matter has been added or removed.

HONEY CATEGORIES CONCERNING INTENDED USE (TRADE CATEGORIES)

Table honey means honey intended for consumers, to be eaten directly or as a natural sweetener for drinks or in cooking.

Industrial or bakers' honey is honey that does not meet fully all the criteria for table honey, for example, the hydroxymethylfurfural (HMF) content may be higher than 40 mg/kg, although the regulations allow some exceptions. This may be because it has been heated too much, or it naturally has a high HMF, and is therefore regarded, according to the EU criteria, to be of lower quality than table honey. In this case, it still qualifies for use in the food industry, for the manufacture of bakery goods, confectionery, breakfast cereals, sauces, tobacco, and products such as honey-roasted nuts and pharmaceutical products. About 20 percent of honey on the world market is classified as bakers' honey. Major substitutes for industrial honey are sugar, invert sugar, and corn syrup, but honey is valued because it conveys a message of 'natural value' to manufactured products.

CONSTITUENTS OF HONEY

Honey consists of a mixture of sugars, mostly glucose and fructose (White, 1975). In addition to water (usually 17-20 percent), honey also contains very small amounts of other substances, including minerals, vitamins, proteins and amino acids. A minor, but important component of most honey is pollen. Pollen is carried to the bees' nest (hive) and stored inside it quite separately from nectar, but a few pollen grains find their way into nectar, and eventually into honey. The pollen in honey can be identified using a microscope, and gives a guide to the plants from which bees have been collecting nectar and pollen.

Experts are able to determine the geographical origin of honey by the pollen it contains. This science of melissopalynology requires only an optical microscope for seeing the pollens in honey, and knowledge of the characteristic shapes of pollens that should be present in particular honeys. In many countries, pollen analysis of the locally produced honeys is regularly carried out and the pollen specialists have a precise knowledge of the pollen spectrum of the honeys of their region.

TABLE 19
Major constituents of honey

Major constituents (99%)		
	%	**Mean (%)**
Water	13.4-26.6	17.0
Fructose	21.7-53.9	39.3
Glucose	20.4-44.4	32.9
Sucrose	0.0-7.6	2.3
Other sugars	0.1-16.0	8.5
Minor constituents (1%)		
	% of 1%	
Acids (gluconic)	0.17-1.17	
Minerals		0.02-1.03
Nitrogen (protein)		0.00-0.13
Enzymes		>0.1%
Aroma		>0.1%
Others (HMF, etc.)		>0.1%

The 'ash' content of honey is mainly mineral trace elements. Minerals present are calcium, copper, iron, magnesium, manganese, potassium, sodium, and chlorides, phosphates, silicates and sulphates. Dark honeys are often very rich in minerals, but variation in the mineral content of different honeys is great. These trace amounts of minerals may be important for human nutrition.

Other constituents

Some honeys have a very high pollen content that makes them appear cloudy: for example, honey extracted from combs by squeezing often contains a relatively high level of pollen. In some countries this 'unfiltered' honey containing plenty of pollen is sold at a premium price, elsewhere such honey is sometimes thought (wrongly) to be of low quality. The presence of any other contaminants in honey (for example particles of wax, parts of dead bees, and splinters of wood or dust) make the honey of low quality and low value.

HMF

HMF is hydroxymethylfufural, a breakdown product of fructose (one of the main sugars in honey) that is formed slowly and naturally during the storage of honey, and much more quickly when honey is heated. The amount of HMF present in honey is the reference used as a guide to the amount of heating that has taken place: the higher the HMF value, the lower the quality of the honey is considered to be. Some countries set an HMF limit for imported honey (sometimes 40 miligrams per kilogram), and honey with an HMF value higher than this limit will not be accepted. However, some honeys have a naturally high HMF level. HMF is measured by laboratory tests.

Enzymes

The levels of enzymes present in honey are sometimes assayed and used as a guide to honey quality. The enzymes in honey (invertase, glucose oxidase, amylase, etc.) come from the bees, or from the plant where the bee foraged. They are present in very small quantities, but may still have a nutritional importance in the human diet. The enzymes are very sensitive to overheating (above 35 °C) or storage at too high a temperature. Because they are destroyed by heating, a low enzyme level may mean that honey has been heated, but many honeys of good quality are naturally low in enzyme content.

Water

The water content of honey can naturally be as low as 13 percent or as high as 23 percent depending on the source of the honey, climatic conditions and other factors. If the water content of honey is greater than 20 percent then the honey is likely to ferment. Low water content is therefore most important. Water content is measured using a honey refractometer, a small instrument that measures the refraction of light as it passes through a glass prism on which a few drops of honey have been smeared. In areas of high humidity, it can be difficult to produce honey of sufficiently low water content.

Different countries set different values for acceptable water content of honey. The Codex Alimentarius and EU regulations set a level of 20 percent, with exceptions for bakers' honey and heather honey. US regulations state 18.6 percent. International honey buyers often insist on lower water levels, typically 17 percent, in order to buy a reduced volume of water. The above information relates to honey from honeybees. Honey from stingless bees (see Chapter 5) usually has relatively high water content (23-24 percent), yet does not ferment.

OTHER FACTORS CONCERNING HONEY

Acidity

Honey is acidic, usually with a pH within the range 3.7-4.5.

Fermentation

Fermentation of honey is sometimes a problem. The main factors causing fermentation are:

- high moisture content (above 20 percent);
- high temperature; and
- a high yeast count (>10/gram).

Uneven granulation of honey within a container can lead to small pockets with high levels of water, and this may result on fermentation. Honey that has begun to ferment can be used for making into fermented products like beer, wine or vinegar.

Sweetness

Honey sweetness depends on high fructose content and acidity. A few plants give bitter honey: *Agave* sp. (sisal), *Datura* sp., *Euphorbia* sp., *Senecio* sp. – in some societies (for example, in East Africa), these honeys are very popular.

Hygroscopicity

Honey, especially when rich in fructose, is very hygroscopic i.e. it absorbs moisture from the air when the container is not closed. This may lead to an increase in water content and possible fermentation. For this reason is it important that honey is always stored in containers with tight fitting lids.

POST-HARVEST HANDLING

Once harvested, honey need not necessarily require further processing. On a small scale, simple equipment as used in other forms of food preparation is adequate: plastic buckets, bowls, sieves, straining cloths and containers. Honey is a stable commodity with a long shelf life: if harvested carefully and stored in containers with tight-fitting lids, it will remain wholesome for several years.

Honey is a food and it must therefore be handled hygienically, and all equipment must be perfectly clean and without any odour of cleaning materials. Honey processing is inevitably a sticky operation, however, because honey is hygroscopic and will absorb moisture; all honey processing equipment and containers must be completely dry. Any water being added to honey increases the chances of fermentation.

PROCESSING HONEYCOMBS FROM FIXED COMB HIVES OR MOVABLE COMB (TOP-BAR) HIVES

Cut-comb honey

Because the whole comb is harvested from these hives, it is possible to harvest pieces of cut-comb honey for sale this way. Select pieces of comb consisting only of sealed and undamaged honeycomb, cut them into neat portions and package them carefully for sale. Since the honey in the comb is untouched and is readily seen to be pure, honey presented in this way always fetches a good price, and honey that has not been open to the air has a finer flavour than honey that has been subjected to processing in any way. Beekeeping equipment suppliers sell cutters to cut uniform sizes of comb, and plastic boxes with transparent lids for selling cut comb honey. The sharp edge of a tin can can make a useful comb cutter.

Strained honey

Because combs from fixed comb hives or movable comb (top-bar) hives do not have the support of a wooden frame or wired foundation, they would break up in the type of extractor used for frame hives (see below), and the product would be a mixture of honey and fragments of wax.

The simplest way to prepare strained honey is to remove the wax cappings of the honeycomb with a knife, break the combs into pieces, and strain the honey from the wax. Make sure that you do not use unsealed combs containing unripe honey or pollen. Strained honey must not contain any trace of beeswax or other debris. It is best to first use a coarse strainer to remove large particles, and then to use successively finer strainers. Use a cotton cloth, basket, or sieve to strain the honey from the pieces of honeycomb. Collect the honey that strains through in a clean and dry container. Finally squeeze the combs inside a bag made from the cloth to remove as much honey as possible. Do not discard the empty wax comb – it is valuable! Form the wax into a block by melting it gently in a water bath or solar wax extractor (see Chapter 9).

With larger volumes of comb, it may be worthwhile to make or buy a press. This has a container for the pieces of comb and a mechanical device to squeeze them. Some equipment suppliers sell extractors for honeycombs. In these especially modified extractors, the combs are placed in wire mesh baskets that support them securely as they are spun.

PROCESSING HONEYCOMBS FROM FRAME HIVES

Cut-comb honey

To produce cut-comb honey from frame hives it is necessary to use beeswax foundation that does not contain strengthening wires. The wax foundation should also be thinner than that normally used in wired frames. Portions of cut-comb can then be prepared for sale as described for top-bar hives. After the combs are cut, the frames must be refilled with fresh foundation sheets before returning to the hive.

Strained honey

Remove the wax capping from the frames of honeycombs with a long, sharp knife. If the room is cold, then the knife may be one that is heated electrically (obtainable from equipment suppliers), or which has been standing in warm water. In the latter case, it is important to dry the knife before you use it. Hold one end of the top-bar of the frame and rest the other end of the top-bar on a piece of wood placed across a collecting tray, the frame is therefore held at right angles to the tray. Start cutting downwards across the frame, and with a zigzag movement of the knife, cut off the thin layer of wax capping and allow it to fall into the dish below the frame. Turn the frame around and cut off the capping from the other side, and then place the frame in the extractor. Practice makes perfect with this task – the trick is to cut all the wax cappings, but with as little of the honey as possible. Some honey will stick to the wax cappings; do not waste this, but strain it out of the collecting tray. Honey drains slowly from cappings and this process may take over 24 hours.

Honey extracting

A honey extractor is a machine to remove honey from combs in frames by rotating them at high speed so that honey is thrown out of the comb on to the wall of the extractor, and then runs down to the bottom of the drum. Honeycomb built inside a wooden frame is not damaged by this process and when empty, can be returned to the hive. The extractor consists of a metal drum containing holders in which the frames are placed. There is a tap at the base of the container so that the honey can be run out. There are two types of extractor: tangential and radial. The tangential extractor is the most common type, being relatively easily available and appropriate for small-scale beekeeping. The tangential extractor holds two, three or four combs in cages, held at right angles to the radius of the container, and is usually hand operated. Although it sounds complicated, a village blacksmith can make a radial extractor. Plastic bins can be modified to serve as the drum, and parts from bicycles can be used to provide the means for spinning. Radial extractors are larger than tangential ones and often hold up to 20 frames arranged radially inside the cylinder. Radial extractors are usually operated with electric motors.

Honey should always be strained as it runs out of the extractor so that any pieces of wax capping, dead bees or splinters of wood (from frames) are removed.

Storage

Honey is best stored in clean, dry buckets with tight fitting lids. As long as it is kept away from heat, it can be stored this way until it is packaged for consumption or sale. Chapter 14 gives information on the marketing of honey.