

Chapter 2

Honey: Processing Techniques and Treatments

Abstract The industry of honeys is not a simple sequential chain of processing operations, although the normal consumer may consider it in this way. Each processing step is the answer to peculiar problems concerning the physicochemical and biological features of different honeys. This chapter discusses the honey production by the technological and chemical viewpoints. The production flow involves six different steps—initial extraction, dehumidification, liquefaction and mixture, heating, pasteurisation, crystallisation, and final packaging—although different industries can alter related conditions depending on various factors, including economic reasons. All steps have to be carefully considered and performed; otherwise, the quality of produced honeys, including also honey for medical purposes, could be negatively affected. Physicochemical and microbiological features of the final product can be assured on condition that each process is well carried out; in addition, certain precautionary measures should be taken before the final commercialisation.

Keywords Crystallisation • Dehumidification • Extraction • Heating • Honey production • Liquefaction • Pasteurisation

2.1 The Industry of Honey. Description of Processing Steps

The industry of honeys is not a simple sequential chain of processing operations, although the normal consumer may consider it in this way, at first sight. It should be noted that each processing step, from the initial extraction to the packaging of the final food product, is the answer to peculiar problems concerning the physicochemical and biological features of different honeys.

This chapter is dedicated to the description of honey production. In general, the following integrated steps correspond to the flow-chart description of such a process (Fig. 2.1):

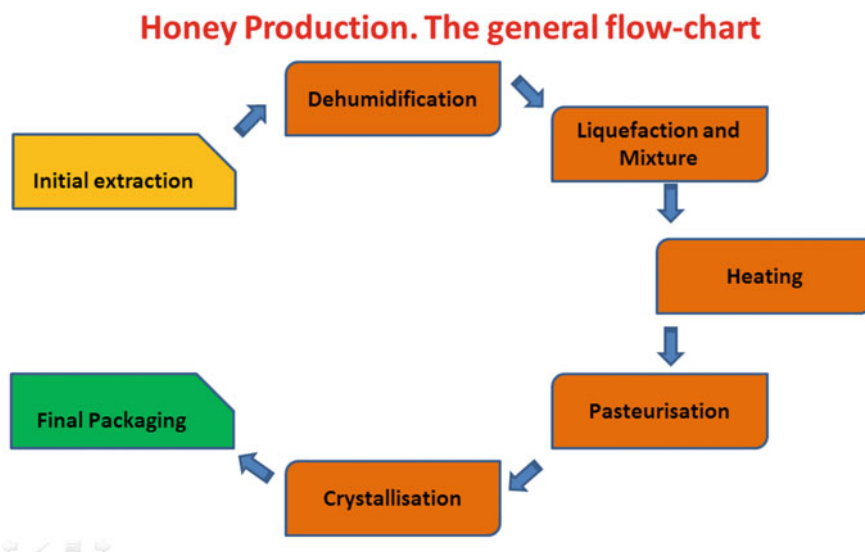


Fig. 2.1 The production flow of commercial honeys involves six different steps, from the initial extraction to the final packaging. It should be considered that different industries can perform their processes in a different way depending on various factors, including economic reasons

- (a) Initial extraction
- (b) Dehumidification
- (c) Liquefaction and mixture
- (d) Heating
- (e) Pasteurisation
- (f) Crystallisation
- (g) Final packaging.

The following sections correspond to the description of each step, with related procedures and correlated reasons.

2.2 Initial Extraction

After the initial harvest, the material (e.g. honeycombs, frames) is introduced into the so-called honey extractor: a container able to remove honey by means of the centrifugal force. The operation has to be carried out into special rooms, with possibility of heating. At the exit from the extractor, the honey is (a) collected by gravity in tanks placed often on the floor (wax is separated from honey) and (b) sent to the decanters with the aid of pumps from the same floor. The extraction must be performed by a desired degree of purification with the aim of eliminating wax

particles and air bubbles, which are possibly mixed with honey during extraction. The purification is carried out with two different techniques: decanting and filtration.

By the safety viewpoint, it should also be considered that extraction procedure (with the collection and other processing steps) may affect negatively the quality of produced honeys, with special reference to honey for medical purposes. Consequently, physicochemical and microbiological features of the final product can be assured on condition that a certain number of precautionary measures are taken before the final commercialisation.

2.3 Dehumidification

Certain honeys obtained with peculiar plant species (Rape, Calluna, Chestnut, etc.) may sometimes contain high water percentages, affecting its conservation; consequently, a dehumidification step is needed, and relative humidity values should be lower than 18.5–18.0% (Kuehl 1988; Oliveira 2007).

Should the number of honeycombs to be treated be very small, the procedure would easily be performed as follows: honeycombs may be piled up in a very dry and warm room, sucking air from the base with ordinary vacuum cleaner and funnelling it outside. On the other hand, the same operation is not possible when speaking of many batches. Should this be the situation, it would instead be necessary to introduce a current of hot air produced by a generator into the so-called hot rooms where honeycombs are left; also, rooms would be thermostatically maintained at a constant temperature. The temperature must be between 32 and 35 °C; anyway, it cannot exceed 38 °C; otherwise, honey may lose its basic features. The treatment should be prolonged for a period of 12–36 h depending on the contained humidity.

By the macroscopic viewpoint, the main difference is naturally the increase in dry content with augment of reducing sugars and apparent sucrose. On the other time, the increase in certain quality indicators such as hydroxymethylfurfural (produced as a result of Maillard reaction) and diastase activity (Chap. 3) may be observed because of two main reasons (Carvalho et al. 2009; da Silva et al. 2016):

- (a) The obvious augment of honey concentration, and
- (b) Possible thermally favoured reactions at temperatures such as 35.5 °C.

2.4 Liquefaction and Mixture

The physical state of extracted honey may often require a specific liquefaction step, depending on the solidification or stickiness of this intermediate. However, because of the low thermostability of certain honey components (enzymes, vitamins, etc.) and possible harmful and irreversible modifications after heating, liquefaction must

take place at temperatures that do not exceed 40 °C in the shortest possible time (Mousa 1999, 2001), although the use of different liquefaction or liquefaction/pasteurisation cycles (times and temperatures) is reported (Escriche et al. 2014). The main problem is correlated with the excessive thermal values used for liquefaction (and pasteurisation): generally, honey quality may be heavily affected. On the chemical level, one can affirm that a certain amount of volatile molecules can be lost in these conditions, with the concomitant reduction of enzymatic power (Bogdanov and Martin 2002). Normally, containers are placed in a water bath or in 'hot rooms'. The beekeepers (or companies) that have to manage different honey deliveries, need to proceed with a dedicated mixing step in order to obtain a uniform final product (parameters are colour, texture, and moisture). The mixing step is carried out in containers where the honey is put after being fluidised. A rotating axis is placed at the centre of the container: this axis drags helical blades placed at various heights allowing a uniform mixing of the mass.

2.5 Heating

It has to be noted that heating treatments can affect severely basic honey features from the organoleptic viewpoint. Honey heating entails a progressive browning and a more or less obvious loss of volatile substances that characterise the aroma. The following substantial modifications have been observed:

- Change in the crystal structure
- Increase in the amount complex sugars and concomitant reduction of the simple ones
- Augment of total acidity
- Partial activation of enzymes
- Increase in hydroxymethylfurfural (HMF) amount.

It should be also noted that the viscosity of honey takes on values ranging between 5000 and 40,000 cycles per second, and it decreases when temperature increases up to 40 °C; should this thermal value be exceeded, the viscosity would decrease slowly, with a final increase at elevated temperatures. This singular behaviour suggests that heating temperatures should not exceed 40 °C even for phase filtering. Moreover, it should be considered that the thermal conductivity of honey corresponds to 1/6 of the correspondent feature for water.

The most common heating and processing instruments for honey production are the so-called traditional bain marie (it has to be suitably thermostated) and hot rooms (with forced air circulation by means of adequate thermoconverters). Also, jacket-equipped tubs with continuous hot-water circulation and a central stirrer can be used. Finally, larger-size companies are accustomed to use size heat exchangers.

2.6 Pasteurisation

Pasteurisation is a heating process: honey particles, such as pollen grains, should aggregate themselves around microscopic air bubbles and small crystals acting as aggregation nuclei. This process could favour honey crystallisation (Sect. 2.7). Normally, thermal values should be rapidly raised up to 72 °C; this temperature is maintained for about 120 s. Subsequently, a rapid cooling of honey masses is required (Bogdanov and Martin 2002).

It has to be noted that the pasteurisation of honeys, unlike similar processes carried out on the majority of food products, is not performed for food safety purposes, including also prolonged shelf-life, but with the aim of meeting commercial needs. As an example, a honey should maintain its typical liquid state on the shelves as long as possible: a similar behaviour has to be reached by means of pasteurisation treatments. Anyway, all pasteurised honeys are subjected to be irreversibly modified during time, according to the first Parisi's Law of Food Degradation (Barbera and Gurnari 2017; Parisi 2002).

2.7 Crystallisation

Crystallisation is probably the most important physical features for the characterisation of honeys by the commercial viewpoint. The crystallisation process involves the formation of glucose monohydrate crystals in different quantity, shape, and arrangement depending on processing conditions.

In general, the longer the processing time, the more voluminous the obtained crystals. Different honeys have a different tendency to crystallise depending on the composition (the lower the water content and the higher amount in glucose, the greater the tendency to crystallise), but also depending on the storage temperature (maximum allowed value: 14 °C).

The crystallised honey is unfortunately still considered with suspicion by the average consumer; however, the crystallisation is a natural process and it is normally seen in natural honeys. In fact, the extracted honey tends to be a supersaturated solution of sugars in water; as a result, exceeding amounts of various sugars are naturally released from the liquid solution as crystals after some time. There are several factors influencing the complex crystallisation phenomenon:

- (a) The amount of glucose and fructose
- (b) Possible impurities.

With relation to the quantity of main sugars, glucose is the most interested sugar to undergo such a similar transformation because it is less soluble in water than fructose. As a consequence, honeys with high fructose percentage crystallise slowly or remain totally uncrystallised.

With concern to possible impurities, an important and necessary prerequisite of crystallisation is the presence of adequate condensation nuclei, including single glucose crystals, dust or pollen grains, air microbubbles.

Anyway, the speed and the type of crystallisation are influenced by the number of condensation nuclei: high numbers of aggregation centres will lead to a fast and fine crystallisation, and a sparse numbers of nuclei will lead to a slow and coarse crystallisation. This phenomenon takes place at temperatures between 5 and 25 °C; should thermal values be lower than 5 °C, honey viscosity would increase with unsatisfactory crystallisation (masses slow down during the crystal growth), while the formation of crystals is slowed down at temperatures >25 °C (formed crystals are destroyed). Should thermal values exceed 78 °C, the destruction of formed crystals would be complete: as a result, honey can no longer crystallise.

For these reasons, peculiar techniques have been developed to guide the natural tendency of honey to crystallise and obtain fully crystallised finished products: this result means stable, homogeneous, and creamy texture with good hedonistic performances by the customer viewpoint.

The most immediate method consists in the mixing of liquid honey with completely crystallised honey in varying proportions depending on the temperature and viscosity of the product (generally, ratios should be 9–1). Should some available honeys have a moisture content that would allow the growth of yeasts, crystallisation process would need to be performed after pasteurisation at 65 °C for 5–10 min. Moreover, in order to obtain an optimum crystallisation, operating temperatures should be recommended in the range 24–28 °C: the aim is to favour honey mixing without the incorporation of air bubbles, with the concomitant introduction of melt crystals.

After packaging (Sect. 2.8), honey must be stored at 14 °C in a few days, so that the crystallisation process can be completed until the final result: a fine granulation of the product. The drawback to this type of procedure is the formation of whitish outcrops at the surface, in correspondence of englobed air bubbles. The visual result is the consequence of water evaporation and drying of glucose crystals that appear white. This aesthetic defect may be avoided with the separation of honey crystals and the concomitant creamy consistency. For these reasons, honey is introduced in drums and placed in hot chambers at a temperature of 28–30 °C before wrapping step.

Subsequently, the honey is passed in a homogeniser with the aim of separating crystals; the resulting mass is introduced in jars. Should homogenisation be absent, the passage from hot rooms to the packing step would still give acceptable results, being sufficient handling of the honey to separate crystals. However, the crystallisation—a very delicate process—may present defects in terms of crystal structure, size, and crystal shape. One can obtain a coarse and non-homogeneous crystallisation due to prolonged processing times. In this situation, obtained crystals have angular, rough or sharp shapes. On the other hand, a compact crystallisation is the result of a very quickly process; it can occur spontaneously in honeys with high glucose/water ratio.

The honeys with very compact crystalline structure tend to present stains retraction, namely ‘white veins’ on the walls of the vessel, on the honey surface or in correspondence of air bubbles. This purely aesthetic defect may be avoided heating honey at 30 °C for 24–48 h. The separation into phases is the defect of more burden crystallisation: it occurs in honeys with high humidity degree, or in those kept at high temperatures for a too-long storage; in these conditions, crystals precipitate to the bottom while a solid surface is obtained instead of a liquid layer.

It should be remembered that crystallised honeys may be used to produce the so-called ‘creamed honey’ by means of the Dyce method (Bogdanov and Martins 2002). In detail, liquid honeys may be mixed with crystallised honeys with the aim of allowing the increase in crystal dimensions (suggested temperature: 14 °C).

2.8 Final Packaging

With reference to the final packing, small quantities of honey can be easily packaged placing the vat and decant honey at least 50 cm from the ground. The vat must be equipped with a large cutting tap or ball which will be placed under the vessel to be filled. The vessel must be placed under a calibrated balance (the weight of the empty vessel has to be considered ‘zero’) to control labelled net weight.

For medium or large amounts of honey, automatic dosing pumps, adjustable from 25 to 2500 g, can be used: the complete packaging step becomes easier and faster. Higher quantities would require further machines able to withdraw, fill and seal the jars automatically.

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Chemistry and Technology of Honey Production

Baglio, E.

2018, VI, 40 p. 13 illus., 6 illus. in color., Softcover

ISBN: 978-3-319-65749-3