LIQUEFACTION OF HONEY

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In practice, honey is liquefied from various reasons. Many consumers prefer liquid honey. On the high quality honey labels, there are mentioned instructions which recommend heating crystallized honey up to 40° C, in order to render it able to be spread on bread.

Retailers are, generally, heating honey, in order to facilitate its bottling into small capacity containers. Many beekeepers, and wholesalers are storing their honey in vessels of 25 to 50 litres, in view of its later liquefaction, according to necessities.

Liquefaction temperature of honey should not be too high, since, according to the Regulation Standards for Foodstuffs, the honey heated in excess cannot be any more sold to the public.

Honey crystallization

The problems related to honey liquefaction are directly depending on honey's phase of crystallization. This kind of problems was largely discussed in recent years: BOGDANOV, 1987; SCHLEY and SCHULTZ, 1987; HORN, 1992. As such, in this article, we will only approach the most important aspects of honey liquefaction.

It is well known that the high contents of glucose entails a speedy crystallization of honey. Honeys that contain more than 28% glucose are generally crystallizing fast, while the lesser content of glucose maintain honey in its liquid phase for a longer time. See Table 1, where the relationship between the glucose content, and the trend towards

Table 1

Crystallization of several monofloral honeys in Switzerland

	Rose Bay	Robinia	Chestnut Tree	Dandelion	Rape
Glucose, % (x)	25.5	24.7	27.3	34.5	34.5
Crystallization	+(+)	−	— to +	+++	+++

Beginning of crystallization: − more than a year; + from 4 to 6 months; ++ from 2 to 4 months; +++ from 1 to 2 months, since honey harvest

crystallization of several monofloral honeys in Switzerland, is shown.

In honeydew honeys, the melesitose contents is also acting upon crystallization. When those honeys contain more than 10% of melesitose, they do crystalize very fast; sometimes, their crystallization begins since they are still in combs. Other honeydew honeys, containing less melesitose, show a slower crystallization, which can last for more than 6 months, and even more than a whole year. Fast crystallizing honeys are noticeable enough through their fine structure, while those of slower crystallization show rough granulation.

Selecting the liquefaction procedures depends on honey's content in sugars (glucose and melesitose), as well as on the shown crystallization speed: liquefaction will be the more so slow as so fast were the crystallization; the more rough were the crystals, the bigger will be the energy consumption for liquefying that honey. The energy used shall be under the form of *heat,* or *waves* (ultrasound, microwaves, electromagnetic waves).

Thermic treatments

Heating is the most usually employed method, for liquefying crystallized honey. The thermic conductivity of crystallized honey is ten times inferior to that of the liquid honey (HORN, 1992). Thus, there would be necessary to diminish, by stirring up, the liquefaction time, in order to avoid excessive heating, as diminishing heating time and temperature help lessening damaging the quality of honey treated in such a way. For liquefying honey, there is necessary a temperature of, at least, 40°C. In order to dissolve all crystals in honey, one should resort to higher temperatures. Honeys that were liquefied by heating, are able to crystallize again, then showing a rough granulation. We were already asked to analyze several rape honeys, incriminated for their rough crystallization, and we screened that it was caused by a previous liquefaction. Saccharase, and diastase — natural enzymes of honey —, as well as HMF, are of honey's natural character. HMF causes sugar degradation, without an output of

Table 2

Effects of temperature and heating time upon diastase and saccharase

Temperature	Heating time, necessary for cancelling the activity of	
	diastase	saccharase
40° C	31 days	9.6 days
50° C	15.4 days	1.3 day
62.4° C	16 hrs.	3 hrs.
71° C	4.5 hrs.	40 min.
80° C	1.2 hr.	8.6 min.

toxic metabolites. An excessively intense and long thermic treatment diminishes the enzymatic activity in honey, and increases the HMF contents. Table 2 shows the effects of temperature, and heating time upon the enzymatic activity in honey.

HADORN et al. (1962) have studied the effect of heating upon the enzymes activity, and the HMF contents in honey. By heating honey up to 40°C during a whole day, there were no changes shown in the enzymatic activity, while by extending the heating time, this activity shall be diminished. Another sign of damage caused to honey by the heating in excess, that is HMF, keeps unchanged after short-time thermic treatments (e.g., of 1 or 2 days), at 40°C to 50°C.

Heating at higher temperatures (Pasteurization)

Pasteurization requires well operating equipment, supplied with temperature and time controls. In Switzerland, pasteurization is only incidentally used, as a thermic treatment of honey. On the contrary, in other countries, such as France, and the United States, this procedure is currently applied. This method helps dissolving completely the crystals in honey. Pasteurized honey stays liquid for a long time, without fermenting. Pasteurization, if correctly applied (that is, at 78°C, during a short time), does not change honey (GONET et al., 1964). The only effects refer to a slight modification of the diastase activity, and the HMF contents. In exchange, this operation entails a noticeable deterioration of invertase. Honeys treated by heating crystallize again, after a longer time, under the form of rough, and irregular crystals.

Heating at lower temperature

In order to effect this operation, the following means are employed:

— warm air bath;
— heating plates, with warm air buffer;
— water-bath (bain-marie);
— thermo-plunger;
— Melitherm appliance.

W a r m a i r b a t h

This kind of bath is, usually, effected in special stoves. The honey consumers can use their own home ovens, after a previous setting up of temperature at the lowest level (i.e., from 40°C to 50°C). Since the heat transfer is limited, the air-bath requires more time to heat honey, that a bain-marie does. This method is suit-

Table 3

Liquefaction of honey in a stove

Vessel capacity	40 °C	45 °C	50 °C
20 kg	24 hrs.	18 hrs.	16 hrs.
50 kg	48 hrs.	36 hrs.	24 hrs.
80 kg	108 hrs.	72 hrs.	60 hrs.
300 kg	—	108 hrs.	72 hrs.

ed to liquefying honey in small jars. To heat larger quantities, air ventilation is required, to avoid excessive heat accumulation, and, thus, honey damaging. As concerns fast crystallizing honey, which contains 17.5% of water, JEANNE (1970) established the relationship among vessel capacity, temperature, and liquefaction time (Table 3).

Values indicated in Table 3 are only approximative, as they can increase doubly, according to the honey variety, and its stage of crystallization.

Heating plates

Their use is very common in Switzerland. As such, it is enough to place the honey can on a heating plate, and to cover it all by means of a plastic box. The heating plate does not have to keep direct contact with the can. Therefore, between them a layer of warm air has to exist, of 5 to 6 cm thick, that is the operating mode is similar to that of the air-bath. A thermostat ensures keeping the suitable temperature of the heating plate, as it is not allowed to exceed 45°C. This method has the same shortcomings as the air-bath.

The heating plates manufacturers recommend using heating times from 24 to 48 hours, in order to liquefy honey in cans of 25 to 50 kg. Nevertheless, time can vary, according to the honey variety.

Bain-marie

It is a largely used method for liquefying honey. Notwithstanding, this method is commonly used only for liquefying smaller quantities of honey, that is, up to 25 kg. In Germany, this method was largely used in the sixties (GONTARSKI, 1962). In Switzerland, there are not to be found on the market special appliances for liquefying honey in a water-bath. Usually, the interested parties resort to the home use, that is, they put the honey vessel in a pan, filled with boiling water. As compared to the air-bath, this method offers the advantage of a better heat transfer. In order to heat a can of 25 kg of honey, at 40°C, in a water-bath, there are necessary 43 hours, while the air-bath only allows this temperature to be reached after 72 hours (BÜDEL, GRZIWA, 1959).

Thermo-plungers

As a rule, it comes to usual thermo-plungers, only of larger dimensions, and of a varied design, as the coils are disposed in a circular horizontal plane. Thus, the heating coils of the appliance are placed on the surface of the crystallized honey, and, as power is connected, and they start heating, honey begins becoming softer, and the coils are dipping, deeper and deeper, reaching at the end the bottom of the vessel. In order to avoid excessive heating, there is possible to equip the plunger with a thermostat, and a thermoregulator. At 40°C, honey becomes already fluid, thus still preserving its crystalline structure. Higher temperatures facilitate total

liquefaction of honey, but beyond 45°C they entail damage to the quality of honey.

Melitherm appliance

SPÜRGIN (1978) produced the Melitherm appliance, which is meant to facilitate the protective liquefying of honey. It has the double function of liquefying, and purifying honey. In the main, it is a thermo-plunger, affixed to the bottom of the honey can. Above the bottom, there is a filtering nylon tissue, which ensures the first filtration of honey. The crystallized honey, which is poured into the vessel, becomes liquefied when in contact with the heating coils, and then goes through the filtering tissue. The temperature reaches from 55°C to 60°C. The contact the heated honey maintains with the heating coils is very short, and then the former does not register any noticeable damage (VORWOHL, 1977).

Liquefaction by waves

Ultrasounds

In medecine and biology, ultrasounds are used, for various ends, such as cleaning certain metal parts, as well as for disaggregating biological cells. In milk industry, they are used for sterilizing milk and other liquids, above all, fruit juices. Unlike microwaves, ultrasounds do not effect liquefaction by heating, but by destroying the sugar crystals (KALOYEREAS, and OERTEL, 1958; LIEBL, 1978). The treatment by ultrasounds attacks the honey enzymes and aminoacids (HORN, 1992). This method is little used in Europe.

Electro-magnetic waves

Low-frequency electro-magnetic waves can destroy sugar crystals. RICHTER (1985) was wrapping up a honey can with the coil of an alternative field of 6.5 A. It seems that honey treated in this way stays liquid for several months. Nevertheless, this method is generally applied in order to slow down the honey crystallization rather, than to liquefy the already crystallized honey. This procedure didn't succeed in being accepted in practice.

Microwaves

They are high-frequency electromagnetic waves, that is, from 300 MHz to 300 GHz. Microwave ovens are used frequently for cooking and thawing out foodstuffs. The frequency, installed in the microwave ovens varies from 915 to 2,450 MHz.

DETTLING (1988), and SILVA & VALBUENA (1990) were assessing the use of the microwave oven for liquefying honey. To sum up, the results are the following:

— This treatment entails noticeable damage to glucoseoxidase (i.e., the honey inhibine), as well as to invertase.

— It has little effect upon the activity of diastase and the contents in HMF.

— Honeys of fine crystallization can be liquefied, in a more protective manner, than could be those of a rougher crystalline structure.

— Dark honeys (chestnut, honeydew) do not show, actually, any damage, while the floral ones show a more visible damage.

— From the sensorial point of view, the microwave treated honeys are no different, as compared with those no treated at all.

— Melesitose-based honeys won't allow their liquefaction in combs, by using microwaves.

Nevertheless, FILIPOV (1990) describes a procedure which allows liquefying crystallized honey in combs, by microwaves.

Conclusions

— Honey liquefaction can entail serious damage of its quality. Nevertheless, if applied with care, this treatment can limit harm.

— Thermic conductivity of honey is not good. When larger quantities of honey are liquefied, the treatment requires more time. Stirring honey helps shorten the liquefaction time.

— Generally, honey liquefied by heating shows the trend to crystallize again, in rough crystals (which lowers quality).

— The liquefaction conditions depend on the honey variety (i.e., contents in glucose and melesitose, crystalline structure. a.s.o.). Indications, concerning the heating time are approximative, as they can vary noticeably.

— The conventional liquefaction of honey by heating (i.e., heating plates, coil thermo-plungers, air- and water-baths) shows the advantage of controlling temperature, and, therefore, of avoiding excessive heating.

— The air (e.g., in stoves, heating plates, etc.) shows a lesser heat transfer than other vector agents (such as, water-baths, thermo-plungers, a.s.o.). Therefore, this method calls for more time, especially when wanting to liquefy larger quantities of honey. If liquefying time is exceeded, the heatsensible component parts should be damaged by heat.

— Low-frequency electromagnetic waves do not entail measurable damage of honey. Nevertheless, it does not turn out to be a sure method for liquefying honey, and, thus, it was not accepted in practice.

— Ultrasounds produce serious damage to the quality. As such, this method is not recommended for honey liquefaction.

— Home-use microwave ovens allow liquefying small quantities of honey (up to 1 kg), but they are damaging the hard honeys, that is, those having a rough crystalline structure. Notwithstanding this, it is not to be forgotten that these appliance were not conceived for honey liquefaction, and, then, it is not possible to recommend their use for this aim.

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