

Crystallization of Honey

Khalil Hamdan
Apeldoorn, the Netherlands

Honey crystallization or granulation is a natural phenomenon by which honey turns from liquid (runny) state to a semi-solid state. Beekeepers refer to this as set honey.



Naturally Crystallized honey
Photo source: Draperbee.com

Crystallization of honey is little understood by the consuming public. Many assume that honey appears crystallized to be an adulterated or unnatural product. That is not so. Actually, crystallization process is natural and spontaneous. Most pure raw or unheated honey has a natural tendency to crystallize over time. Crystallization does not affect the honey except for colour and texture. Crystallized honey is not spoiled and preserves the flavour and quality characteristics of the liquid honey. Some honey users like it in this state since it is easy to spread on bread or toast without dripping off and the taste is richer.

Bear in mind that crystallization of honey has no bearing on its quality, but it is an attribute of pure and natural honey.

Why honey crystallizes?

Honey is a highly concentrated sugar solution. It contains more than 70% sugars and less than 20% water. There is much sugar in honey relative to the water content. This means that the water in honey contains an extra amount of sugar than it could naturally hold. The overabundance of sugar makes honey unstable.

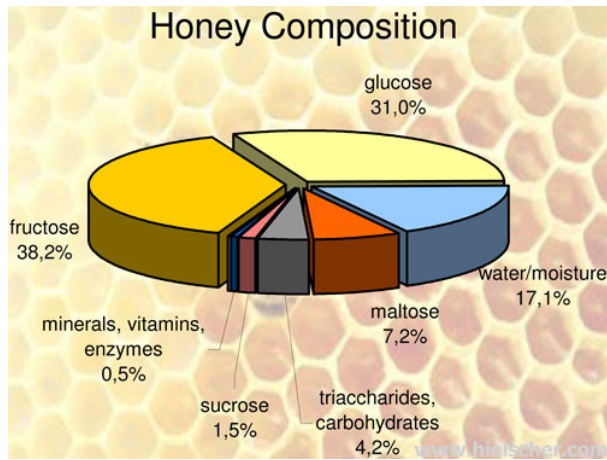


Image source: hielschr.com

It is natural for honey to crystallize since it is an over-saturated sugar solution. The two principal sugars in honey are fructose (fruit sugar) and glucose (grape sugar). The content of fructose and glucose in honey varies from one type of honey to the other. Generally, the fructose ranges from 30- 44 % and glucose from 25- 40 %. The balance of these two major sugars is the main reason that leads to crystallization of honey, and the relative percentage of each determines whether it crystallizes rapidly or slowly. What crystallizes is the glucose, due to its lower solubility. Fructose is more soluble in water than glucose and will remain fluid. When glucose crystallizes, it separates from water and takes the form of tiny crystals. As the crystallization progresses and more glucose crystallizes, those crystals spread throughout the honey. The solution changes to a stable saturated form, and ultimately the honey becomes thick or crystallized.

Some honeys crystallize uniformly; some will be partially crystallized and form two layers, with the crystallized layer on the bottom of the jar and a liquid on top. Honeys also vary in the size of the crystals formed. Some form fine crystals and others large, gritty ones. The more rapid honey crystallizes, the finer the texture will be. Crystallized honey tends to set a lighter/paler colour than when liquid. This is due to the fact that glucose sugar tends to separate out in dehydrating crystals form, and that glucose crystals are naturally pure white. Darker honeys retain a brownish appearance.



Onset of crystallization in liquid honey
Image source: Ford's honey farm

Honey partly crystallized and partly liquid

How fast will honey crystallize?

Different types of honey will crystallize at different rates. Some honey crystallizes within a few weeks after extraction from the combs, whereas others remain liquid for months or years. The following factors influence the speed of crystallization:

- (i) the nectar source collected by bees (the sugar composition of honey),
- (ii) the methods in which honey is handled (processed) and
- (iii) the temperature in preservation.

The time it will take the honey to crystallize depends mostly on the ratio of fructose to glucose, the glucose to water ratio. Honey high in glucose sugar, with a low fructose to glucose ratio will crystallize more rapidly, such as alfalfa, cotton, dandelion, mesquite, mustard and rape (brassica napus). Honey with a higher fructose to glucose ratio (containing less than 30% glucose) crystallizes quite slowly and can stay liquid for several years without special treatment, for example, robinia (black locust), sage, longan, tupelo and jujube/sidr (ziziphus spina-christi).

The higher the glucose and the lower the water content of honey, the faster the crystallization. Oppositely, honey with less glucose relative to water is a less saturated glucose solution and is slow to crystallize. Honey with heightened water content often crystallizes unevenly (not as a homogeneous mass) and separates into crystallized and liquid parts.

The speed of honey to crystallize depends not only on its composition, but also on the presence of catalysts, like seed crystals, pollen grains and pieces of beeswax in the honey. These minute particles serve as nuclei for crystallization. Raw honey (unheated and unfiltered) contains bits of wax, pollen and propolis, and crystallizes faster. Honey that has been processed (e.g. heated and filtered) will remain in its liquid form longer than raw honey due to the elimination of nuclei, which encourage the growth of glucose crystals. Honey prepared for commercial market is usually heated and filtered. Heating and filtration of the honey dissolve any sugar crystals and remove foreign particles that might be present in it. Therefore, the crystallization is hindered.

The storage temperature has a big effect. Honey crystallization is most rapid around 10-15 °C (50- 59 °F). At temperature below 10 °C (52 °F) the crystallization is slowed down. Low temperature increases the viscosity of honey (honey is thicker when cool), and this retards the formation and diffusion of crystals. Honey resists crystallization best at higher temperatures more than 25 °C (77 °F). When the temperature is 40 °C (104 °F) the crystals dissolve. Temperature above 40 °C (104 °F) will damage the properties of honey.

The table below shows the relative speed of crystallization in descending order of various honeys.

Relative Crystallization Speed of Various Honey

Honey Type	Crystallization
Australian acacia	Very slow
Black locust (<i>Robinia pseudoacacia</i>)	Very slow
Cranberry	Very slow
Litchi	Very slow
Longan	Very slow
Milk vetch (<i>Astragalus</i>)	Very slow
Milkweed (<i>Asclepia syriaca</i>)	Very slow
Sage (<i>Salvia officinalis</i>)	Very slow
Sidr/jujube	Very slow
Tulip poplar	Very slow
Tupelo	Very slow
Bell heather (<i>Calluna cinerea</i>)	Slow
Blackberry	Slow
Borage (<i>Borago officinails</i>)	Slow
Buckwheat	Slow
Chestnut (<i>Castania sativa</i>)	Slow
Citrus (Orange blossom honey)	Slow
Eucalyptus	Slow
Fireweed (<i>Epilobium angustifolium</i>)	Slow
Linden/lime/basswood (<i>Tilia</i>)	Slow
Maple (<i>Acre spp.</i>)	Slow
Hawthorn (<i>Crataegus spp.</i>)	Slow
Nodding thistle (<i>Carduus nutans</i>)	Slow
Rosemary	Slow
Sourwood (<i>Oxydendrum arboreum</i>)	Slow
Spanish Lavender (<i>Lavendua Stoechas</i>)	Slow
Thyme (<i>Thymus vulgaris</i>)	Slow
Alfalfa	Rapid
Apple, pear, plum and cherry	Rapid
Clover (<i>Trifolium</i>)	Rapid
Cotton	Rapid
Dandelion	Rapid
Lavender (Common lavender) *	Rapid
Phacelia (lacy or tansy phacelia)	Rapid
Field bean (<i>Vicia faba</i>)	Rapid
Goldenrod (<i>Solidago</i>)	Rapid
Holly (<i>Ilex aquifolium</i>)	Rapid
Ivy (<i>Hedera Helix</i>)	Rapid
Mesquite (<i>Prosopis spp.</i>)	Rapid
Mustard	Rapid
Oilseed rape	Rapid
Raspberry	Rapid
Star thistle (<i>Centaurea solstitialis</i>)	Rapid
Sunflower	Rapid
Wild thyme (<i>Thymus serpyllum</i>)	Rapid

* It is temperature dependent. It tends to crystallize quickly when stored below 21-23° C (70-75° F). If it is stored at higher temperatures like 23-32°C (75-90° F) it usually does not crystallize very quickly.

Liquefying crystallized honey

Crystallized honey can be brought back to liquid consistency by gently heating it in a hot water bath (Bain Marie) or warming cabinet (box) until the honey re-liquefies. Heating should be applied indirectly, not by direct flame to a container.

The temperature in the beehive is about 35 °C (95 °F) and can rise to 40°C (104 °F) during summer periods when bees are ripening honey. In order to liquefy honey, it is best to heat it at 35-40 °C (95-104 °F). The temperature should not go beyond 40 °C (104 °F) to avoid overheating. Overheating honey for any period of time will reduce its quality by destroying its enzymes, loss the delicate flavour, aroma and darkening the honey colour. Heating must be done with care if the nutritional value of the honey is not to be spoiled. It is possible to re-liquefy crystallized honey without damaging its quality by the methods described below.

Hot water bath – heat a saucepan filled with enough water to reach the level of honey in the jar to 35 - 40°C (95-104 °F), then remove it from the heat or turn off the heat. Take the lid off of the honey jar and immerse the jar in the water. Let it stand for about 20-30 minutes. The heat will slowly dissolve the glucose crystals and become liquid again. Stir occasionally to even the heat throughout the honey, as crystallized honey is a poor conductor of heat. Replace the hot water if needed. Remove the jar of honey from the water bath when honey becomes liquid again.

This works well with honey in glass jars, but not so well with plastic containers. They can warp or melt. If honey is packaged in a plastic container set in warm water, not hot water.

Honey in a plastic bucket can be re-liquefied by transferring or scooping it into glass jars, and the process above is used.



A hot water bath

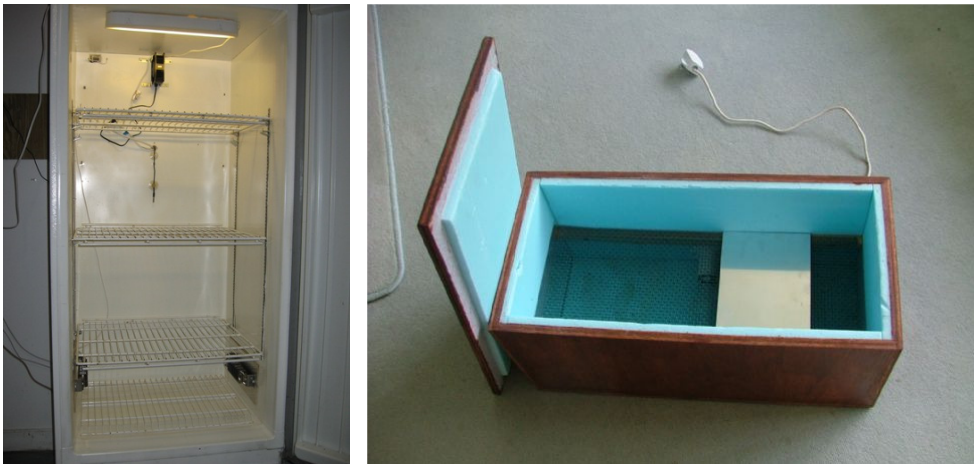
Image source: 3 bees honey.com

Honey warming cabinet – another method to re-liquefy honey on a small scale is to heat it in a warming box with a 40 watt light bulb until it is liquid. This is a slow process and may take 12- 48 hours. The ideal box temperature is between 35-40 °C, although some beekeepers use higher

temperature to speed up liquefaction of the honey. A lower temperature at longer time is better for the honey. When the honey to be re-liquefied is in buckets, stir the bucket from time to time to speed up the process.

A warming cabinet can be an insulated wooden box or a modified old refrigerator fitted with an electric light bulb at the base as the heat source and a thermostat to monitor the temperature. It is suitable for decrystallizing a stack of honey jars, or one or two buckets of 30 lb.

Building a warming box for your honey is easy. Basically, the process of construction is to heat the space with a light bulb. A light bulb provides a constant, steady heat. For information regarding making a honey heater, see the links below.



Left: A well insulated buckets and jars warming cabinet. Courtesy of Windmill Hill Farm
Right: A warming box insulated with polystyrene. It holds 12 jars and runs on electric - 40watt bulb.

Avoiding crystallization

- Store honey at room temperature in tightly closed containers. The optimum temperature for storing honey is 21 to 27 °C (70-80 °F). Avoid storing honey in cold temperature of 11 to 18 °C (52- 64°F), which is ideal for crystal formation. Don't store in the refrigerator. Refrigerator temperatures accelerate the process of crystallization.
- Filter honey through 80 micro filter, or pass it through one or more sheets of fine nylon cloth supported with a wire sieve to remove any small particles such as pollen grains, flecks of wax, crystals and air bubbles that could initiate crystallization.
- Heat honey in a double boiler or in a hot air to 40°C or 104 °F to melt any sugar crystals may be present and delay crystallization. Check the honey temperature with a candy thermometer to avoid the risk of overheating.
Honey packers of supermarket honey in the US heat liquid honey to 63

°C (145 °F) for thirty minutes, or 71 °C (160 °F) for one minute or so (flash heat) and then quickly cooled at 49- 52 °C(120-125 °F) for minimization of heat damage. This high temperature kills the yeast cells that cause fermentation and keeps honey from crystallizing on the market self for a long period of time. The resulting honey contains very little of the nutritional value of minimally processed or raw honey including amino acids, minerals, vitamins, live enzymes, and antioxidants that are considered essential for good health.

- When storing supers of empty combs for winter it is important to get your supers thoroughly cleaned after the extraction of the honey. Place them back on the hive for the bees to clean the residual honey from the cells and store it in the brood chamber. Extracted combs stored with traces of wet honey can form micro-crystals causing next year's honey to crystallizes prematurely.

Note: Using an inner hive cover with an open feeder hole between the wet supers and the brood chamber makes the bees more likely to move the honey below it.

Related Books

Eva Crane, *Honey: A Comprehensive Survey* (Heinemann, London, 1979).

Robin Chapman, *How to Make a Warming Cabinet (box) for two Honey Buckets* (A BeeCraft Publication).

This is a booklet on manufacturing your own Warming Cabinet in order that honey stored in 30lb buckets may be easily poured out into jars after warming.

Links

Building A Honey Heater ["In the Beekeeper's Work Shop"](#)

Homemade Honey Warmer [Honey Run Apiaries | Beekeeping | Honey Warmer](#)

A Honey Heater for the Hobbyist Beekeeper [Honey Heater Guide2](#)