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Honey Crystallization – Myth and Concept

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Honey crystallization, also called granulation, is a process where the liquid honey turns into a semi-solid state. But the people consuming honey are unaware of this fact, and often misjudge the crystallized honey as adulterated or unnatural one. Pure, crude or unheated honey appears to crystallize over time, as it is a spontaneous natural phenomenon. In actuality, crystallization guarantees the honey authenticity. It is well known that, crystallization does not influence the honey quality, only affect the colour and appearance.

Why does honey crystallize?

Honey is a supersaturated solution, mainly composed of a complex mixture of carbohydrates (Saxena *et al*., 2010). This supersaturated nature of honey is responsible for spontaneous crystallization. Fructose (levulose) and glucose (dextrose) are the two main sugars found in honey, which differ in amount from one to another type of honey. Generally, the fructose ranges from 30 - 44 % and glucose from 25 - 40 %. The combination of these two major sugars is the main reason that allows the honey to crystallize, and the relative percentage of each decides whether it crystallizes quickly or slowly (Hamdan, 2010). Glucose, which is less soluble than fructose, precipitates out of the supersaturated solution and forms glucose monohydrate crystals. Therefore, glucose crystallization reflects crystallization of honey (Gleiter *et al*., 2006). As the process progresses, the liquid state of honey transforms into a saturated thick or crystallized form.

Crystallization may be uniform or uneven and in uneven type two layers exist, lower with crystallized layer and upper with liquid layer formed. This uneven type of crystallization affects the shelf life, as the non-crystallized portion of honey will contain higher moisture content, which makes it vulnerable to yeast growth, resulting in fermentation. Crystals also vary in size and quick crystallization resulting in fine texture. Generally crystallized honey appears as lighter or pale in colour due to presence of pure white glucose crystals. But the darker honey shows a brownish appearance.

Factors imparting rapidness of crystallization:

Crystallization rate or speed varies from one type to another, some crystallizes immediately after harvest, whereas some retains liquidity

for longer period. Different aspects like sugar composition, preservation temperature, presence of impurities etc. accelerate the crystallization rate in honey.

The main factors that influence crystallization are fructose, glucose, moisture content and sugar ratio (Escuredo *et al*., 2014). The fructose to glucose ratio (F/G) indicates how quickly the honey granulates. Honey with a higher F/G ratio (i.e., containing less than 30% glucose), resulting in less or slow crystallization and vice-versa. Honey crystallizes quickly when the F/G ratio is 1.14 or less; honey with an F/G ratio exceeding 1.58 does not have a crystallization propensity (Venir *et al*., 2010); and honey with an F/G ratio of 1.3 crystallizes slowly (Dobre *et al*., 2012). Simultaneously, the rate of glucose crystallization depends on glucose to water ratio (G/W). Honey with higher G/W ratio is expected to granulate rapidly and vice-versa.

Temperature during storage also has an impact on crystallization rate. The optimum temperature for crystallization is between 10 - 15°C, whereas it is restricted at temperatures greater than 25 ºC (Zamora and Chirife, 2006). Low temperatures (4 - 10°C) resulted in slowing down of crystallization; because of an increase of honey viscosity (thickness), it reduces the glucose diffusion making it more difficult for crystals to move (Costa *et al.*, 2015).

Apart from honey composition, presence of foreign entities like pollen grains, pieces of bee wax and other impurities accelerate the crystallization rate. Basically, all these impurities present in honey serve as nuclei or centres for crystallization. A study revealed that degree of crystallization was positively correlated with absolute pollen count (Grégrová *et al*., 2015). Thus, raw unprocessed or unfiltered honey crystallizes faster than processed or filtered honey.

How to liquefy crystallized honey?

Crystalized honey can be brought into liquid state simply by heating, but heat should be given indirectly, not directly. One must also remember that the heating temperature should be in a particular range, otherwise overheating as well as direct heating will reduce the honey quality by means of destroying its enzymes, loss in flavour and aroma etc. Similarly, the overheated honey appears dark in colour, hence both loss in nutritive value and physical appearance make the honey unmarketable. Generally, the normal or average bee hive temperature is 30-35^{0}C, though sometimes it raises up to 40^{0}C during the hot summer period and in this temperature range honey remains still liquid in the hive throughout the period. So, it is best to heat the crystalized honey at 35-40 ºC for liquefying it and heating with excess temperature should be avoided to prevent overheating damage. One of the important negative impacts of overheating is formation or increase of 5-Hydroxymethyl furfural (HMF), which deteriorates the honey quality.

The best method for liquefying the crystallized honey through heating is hot water bath method. Here the heat is provided

indirectly through water *i.e.* the honey containing jar is placed in warm water for liquefying the honey. In large scale or in industrial use where the bulk amount has to be liquefied the hot water bath machine is used. On the contrary, in small or individual purpose simple household water heating technique is used. In this technique at first one large container with water is heated allowing the temperature up to 35-40 ºC, then the honey containing jar has to be placed into this hot water container and kept it for at least 30 minutes until the honey came in liquid state. Sometimes, stirring of honey is required during liquefying period to evenly distribute the heat, as the crystallized honey is a poor conductor of heat. But if the water cools rapidly, heating should be done in the same way or by replacing the hot water if needed. In this process of honey heating the following precautions should be taken, viz., (i) avoiding overheating of honey and (ii) honey must always be taken in a glass jar, and plastic ones must be avoided

Methods to prevent crystallization

Several issues starting from honey harvest to storage accelerate the honey crystallization, hence proper care should be taken to prevent this process.

Honey harvest should be done from the comb having 2/3 part or 75% of honeycomb cells sealed *i.e.* the sealed ripen honey. Generally, the sealed honey having moisture less than 20% keeps or maintains the honey in good quality, as the excess moisture leads to deterioration of honey quality.

Harvested honey should be filtered properly before storage. During harvesting, the impurities like bee broods, comb wax, pollen grains etc. are also mixed with honey in the extractor machine and all these form the nuclei of honey crystallization and accelerate the crystallization process during the period of storage. Hence, harvested honey should be filtered properly by one or more sheets of fine nylon cloth to remove all these crystallization centres (Amariei *et al.*, 2020).

Honey always must be stored in closed container and never kept in open. Honey kept in the open or in earthen pots leads to accumulation of moisture in honey as it is hygroscopic in nature and absorbs the air moisture. Excess moisture leads to loss in honey quality as it is fermented easily.

Honey storage should be done at room temperature of 25-30^{0}C and one must avoid the cold temperature of 10-15^{0}C which is ideal for crystal formation. Similarly, storage of honey in high temperature (>40^{0}C) for longer period also leads to the deterioration of quality as the high temperature causes breakdown of enzymes.

Processing of honey

Honey processing denotes the post-harvest management of honey, which also sometimes includes bottling and labelling. But mainly moisture reduction and filtration are the main aspects of post-harvest management of honey during processing. It must always be

remembered that no chemical addition or any such type should ever be done during the honey processing. Excess moisture and external impurities are the major causes of quality deterioration; hence moisture reduction and filtration have to be done prior storage properly. In industrial or large-scale honey processing, processing machines of various capacities (5qt, 10qt, 50qt etc.) are used, where both moisture reduction and filtration process occur simultaneously in a single unit. But individually one can process his/her honey by means of separate household methods, where moisture reduction can be done by hot water bath method and filtration by repeating sieving through nylon sheets.

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