

Research Article

Effects of crystallization and processing on sensory and physicochemical qualities of Thai sunflower honey

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Abstract

Honey is a highly concentrated liquid food, containing mostly glucose and fructose. Crystallization in honey is common in many types of honey, especially those containing high glucose. Crystallization of glucose in a saturated solution like honey is more likely to occur compared to fructose, due to its lower solubility. Sunflower honey is one of the few Thai honeys that faces crystallization problems, which often lead to consumer rejection. Crystallization in sunflower honey can occur within a few months after processing, while still on market shelves or in the store. Melting is generally applied in order to sell the honey. This work was aimed to evaluate the sensory quality and physicochemical properties of honey due to crystallization and processing, especially melting, in order to raise proper understanding and change consumer points of view towards crystallized honey. Sunflower honey was allowed to crystallize at ambient conditions and sensory quality was evaluated at initial, 25%, 75% and complete crystallization, using a 9-point hedonic scale test. To determine the effect of processing on honey quality, crystallized honey was separated out from the liquid honey by centrifugation, then melted at 50°C and non-crystallized honey was used for comparison. Physicochemical and sensory qualities were also determined. It was found that initial crystallized honey was moderately liked, whereas the consumer preference dropped significantly when honey crystallized at 25% of its content ($p \leq 0.05$). Consumers disliked the honey at higher levels of crystallization. Crystallization of honey caused a decrease in lightness (L value), slight increase in a_w and a significant increase in texture/firmness ($p \leq 0.05$). Separation of honey crystals from liquid honey significantly increased moisture content and a_w of the honey without changing pH. Melted honey had similar properties to non-crystallized honey. Sensory evaluation revealed that melted and

crystal-separated liquid honey were as acceptable as the initial crystallized honey ($p > 0.05$). The crystallized honey was not acceptable to the consumers. Because melting was done only once, the thermal changes may not be significant and physicochemical properties were maintained. Excessive heat processing of crystallized honey will cause severe quality degradation.

Keywords: Honey crystallization, melting, sensory quality, physicochemical properties

Introduction

Thailand produces a range of honey varieties for both domestic and export markets. Some of the major varieties are longan, sunflower, sab sua and lychee. Some of these varieties, such as sunflower and sab sua honeys tend to crystallize rapidly during storage and on the market shelves. Crystallization of honey causes a reduction in its market value and it becomes largely unacceptable to Thai consumers. Because the principle of honey crystallization is not widely known to the consumers, crystallized honey is often perceived to be an adulterated product. The consumers generally anticipate that crystallized honey is artificially produced or contains sucrose which beekeepers use to feed the bees during the non-flowering season.

Crystallization causes several physical, chemical and biological changes in honey leading to quality degradation. Zamora and Chirife [1] investigated changes in water activity of honey during crystallization and found that glucose concentration in liquid honey was reduced causing an increase in the water activity. This increase in water activity may allow growth of osmophilic yeasts such as *Saccharomyces spp.* Water activity changes were in the range of 0.003-0.004. Melting of the crystallized honey will reduce the water activity of the liquid honey to a level sufficient for prevention of yeast growth and fermentation. A similar water activity change due to honey crystallization was reported by Gleiter *et al.* [2].

Due to the loss in market value, honey producers and traders tend to apply thermal treatments to melt crystallized honey so it is presented on the market shelves without any trace of crystals. Even though there have been several reports on honey crystallization and its effects on honey quality, characterization of physical and chemical changes, consumer acceptability of crystallized and processed Thai honey has not been reported. Therefore, the aim of this paper was evaluate the impact of crystallization and processing on sensory, physical and chemical qualities of Thai honey, using sunflower honey, which can rapidly crystallize at room temperature, as a model for the study.

Materials and Methods

Preparation of sunflower honey

Sunflower honey was purchased from local honey manufacturer as fresh, non-crystallized honey. The honey was left to crystallize naturally at room temperature. Formation of honey crystals was physically observed. Samples from four stages of crystallization (initial stage of crystallization, 25% crystallization, 75% crystallization and 100% crystallization) were taken for sensory analysis. The initial crystallization was taken as when the crystals can be detected by the naked eye. For melted honey sample, the naturally crystallized honey was melted at 50°C water bath. Completely crystallized honey was subjected to crystal separation using a basket centrifuge with filter cloth lining. The liquid honey was collected

for further testing.

Sensory evaluation

The honey samples at different crystallization stages, melted honey and crystal separated liquid honey were subjected to sensory evaluation to determine consumer acceptance on the colour, turbidity, texture, odour and flavour attributes. A 9-point hedonic scale test was used with 50 panelists. The score of 1 indicates “extremely unacceptable”, whereas the score of 9 indicates “extremely acceptable”. The score of 5 shows “neither unacceptable nor acceptable”.

Determination of physicochemical properties

Physicochemical properties were analyzed for non-crystallized, completely crystallized, melted and crystal separated liquid honey samples. They include the following analysis:

- ✚ Moisture content using AOAC method [3].
- ✚ Water activity using a water activity meter (AquaLab TE3, Decagon Devices Inc., Pullman, USA).
- ✚ pH using a pH meter (Cosort C380, Belgium).
- ✚ Turbidity: Turbidity was measured according to the procedure used by Escobedo *et al.* [4], using a UV spectrometer (UV WinLab, Perkin Elmer Co., Ltd., USA.) and measured at 660 nm wavelength.
- ✚ Colour (L* values or lightness) using a chroma meter (CR 300 Series, Minolta Co., Japan).
- ✚ Firmness: Firmness of the honey was analyzed using a texture analyzer (TA-XTplus, Stable Microsystems Co., UK). An aluminum cylindrical probe (35 mm diameter) was used to compress the sample in the storage glass jar at a speed of 1.0 mm/s to the depth of 7 mm. The maximum compression force was recorded.

Experiment and Statistical analysis

The experiment was conducted in a complete randomized design with 3 replicates. The experimental data was subjected to an analysis of variance and Duncan’s multiple range tests in order to determine significant differences between the mean values.

Results and Discussion

Sensory acceptability of crystallized and processed sunflower honey

The results of sensory evaluation are shown in Figures 1 and 2. It can be seen that consumer acceptability for all sensory attributes of the honey at initial stage of crystallization was quite high (sensory scores in the range of 6.28-7.38). As crystallization proceeded further, the honey was less acceptable to the taste panelists. The sensory scores were reduced from 5.34-6.58 to 4.28-6.16 to 2.92-5.76 when the honey crystallized at 25, 75 and 100%, respectively. The overall acceptability score for 100% crystallized honey was 4.39, which shows that the quality of the honey was not acceptable to the taste panelists. Therefore, it can be seen clearly that crystallization significantly affected sensory acceptability of the honey. When the crystallized honey was melted, the sensory acceptability increased to the scores of 6.42-7.76. A similar effect was found when honey crystals were separated from the liquid honey. The crystal separated liquid honey received sensory scores of 6.22-7.52. Hence, melting and separation of crystals helped maintained the sensory quality of the honey. Melting of honey did not cause severe affect on the sensory quality of the honey in this study due to low temperature melting.

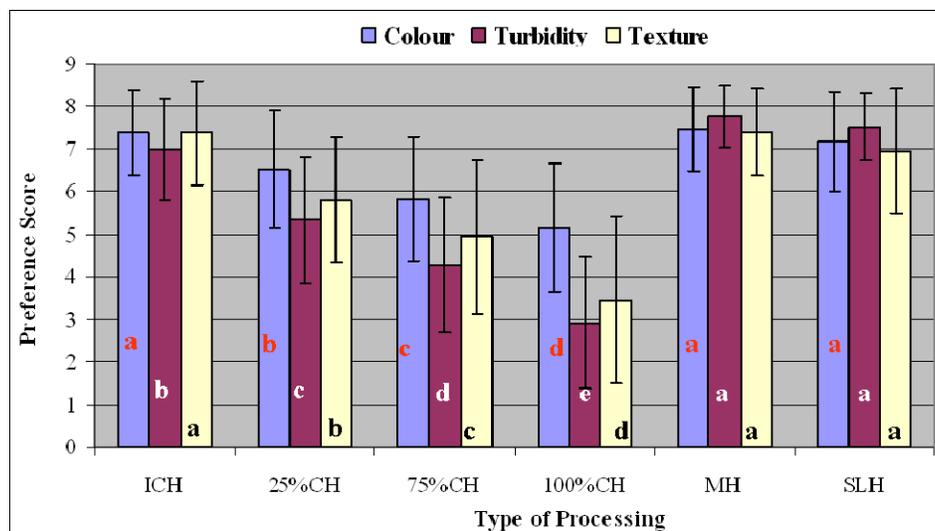


Figure 1. Preference scores for physical attributes of honey samples.

(ICH=Initial crystallize, 25%CH=25% crystallized, 75%CH=75% crystallized, 100%CH=complete crystallized, MH=melted honey, SLH=crystal separated liquid honey). Different scripts in the same data series shows significant differences between the means ($p \leq 0.05$).

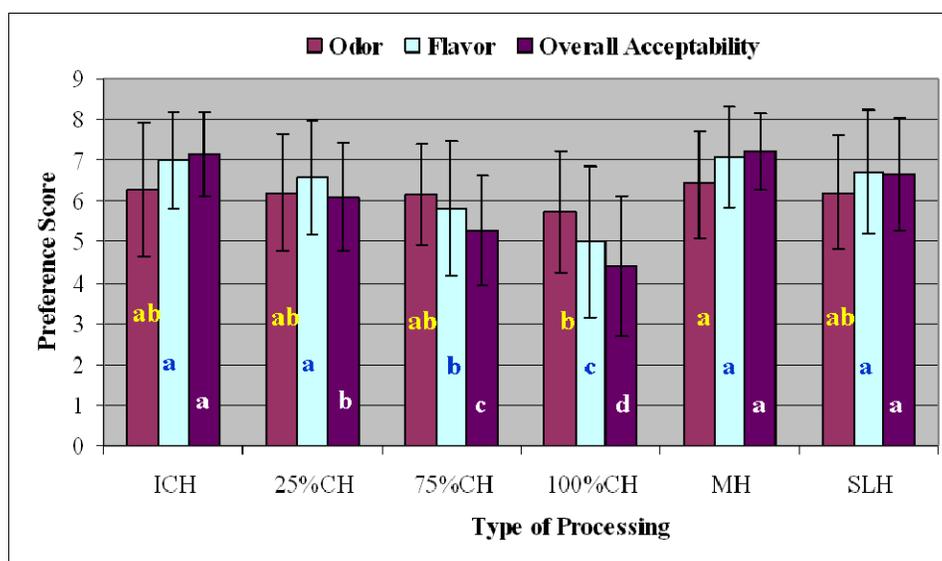


Figure 2. Preference scores for odour, flavour and overall acceptability of honey samples.

(ICH=Initial crystallize, 25%CH=25% crystallized, 75%CH=75% crystallized, 100%CH=complete crystallized, MH=melted honey, SLH=crystal separated liquid honey). Different scripts in the same data series shows significant differences between the means ($p \leq 0.05$).

Amongst the sensory attributes being evaluated, colour, odour and flavour were less affected by crystallization. Acceptability in terms of texture and turbidity were greatly affected by crystallization. As honey crystallized, colour may change to a darker tone, causing a reduction in acceptability score. Crystallization may alter odour and flavour of the honey if fermentation occurred [1]. However, it is most likely that the odour and flavour

acceptability scores were affected by consumer bias based on other physical properties. The honey sample at initial stage of crystallization was acceptable to the taste panelists because the crystals were fine and did not exhibit a sandy texture in the mouth. Because crystallization occurred naturally, the crystal size can be unacceptably large. However, crystallization under controlled conditions, such as that for creamed honey production, produces uniformly fine crystals that are stable and do not have a negative impact on the texture of the honey [5]. It can be noticeable that the scores for texture and turbidity reduced significantly ($p \leq 0.05$) when crystallization increased. When the honey crystals were removed, the sensory scores increased significantly, even though the chemical composition of the honey has been changed due to crystal separation. Honey crystallization involves competitive formation of glucose crystals [1, 2] due to its lower solubility than fructose. Hence, crystal separation reduced the glucose content of the honey, which raised the expectation that the flavour of crystal separated liquid honey would be less acceptable. The sample received a slightly lower score for flavour than the initial crystallized and melted honeys, but was still moderately acceptable. The overall acceptability of the initial crystallized, melted and crystal separated liquid honeys were not significantly different ($p > 0.05$). This suggests that a controlled melting at low temperature and partial separation of the honey crystals could be suitable approaches for solving the issue of consumer rejection of crystallized honeys. However, repeated melting should be avoided since it can cause quality degradation [6, 7].

Physicochemical properties of sunflower honey

Moisture content of honey is regulated at $\leq 21\%$ w/w [8]. The original, crystallized and melted honeys had a moisture content complying to the standard. Separation of crystals significantly increased moisture content of the honey. Moreover, crystal separation significantly increased water activity to 0.61, which is above the recommended level for microbiologically safe storage [1]. Crystallization and processing did not significantly change the pH of the honey. Its pH ranged between 3.49-3.56. As the honey crystallized, the L^* value significantly reduced. This could be a result of accelerated browning reaction during crystallization as the honey's free water increased. Melting and crystal separation also significantly darkened the colour of the honey, but not to the same extent as crystallization. Crystallization increased firmness of the honey, making it harder to spread or pour out from a container. From the colour and texture properties, it was understood that consumers did not prefer the honey with dark colour and firm texture due to crystallization.

Table 1. Physicochemical properties of sunflower honey from different processes.

Honey Property	Type of Processing			
	Non-crystallized honey	Crystallized honey	Crystal separated liquid honey	Melted honey
Moisture (% wet basis)	18.47 ^b ±0.13	17.79 ^c ±0.23	25.14 ^a ±0.32	17.70 ^c ±0.13
Soluble solids (°Bx)	80.50 ^b ±0.00	78.87 ^c ±0.11	75.00 ^d ±0.00	81.00 ^a ±0.00
a_w	0.52 ^c ±0.00	0.54 ^b ±0.00	0.61 ^a ±0.00	0.52 ^c ±0.00
pH	3.56 ^a ±0.02	3.49 ^b ±0.00	3.56 ^a ±0.02	3.54 ^a ±0.01
Colour (L^* value)	59.76 ^a ±0.17	42.60 ^c ±0.30	51.50 ^b ±0.58	51.06 ^b ±0.03
Firmness (N)	0.24 ^b ±0.01	0.26 ^a ±0.02	0.20 ^c ±0.00	0.21 ^c ±0.00

Note: Different superscripts indicate significant differences between mean values ($p \leq 0.05$).

Conclusion

Crystallization of honey affected its sensory acceptability and physicochemical properties. Sensory qualities in terms of colour, texture, turbidity, odour and flavour were significantly reduced by crystallization. The initial crystallized, melted and crystal separated honeys were moderately acceptable to the consumers. Texture and turbidity changes due to crystallization significantly contributed to a reduction in consumer acceptance. The consumers did not prefer a firm texture caused by crystallization. Crystallization caused a significant reduction in L* value. Crystallization significantly increased water activity of the honey, whereas separation of the crystals caused the liquid honey to have water activity above the level for microbiologically safe storage. Melting at low temperature and partial separation of honey crystals may be practiced since they did not significantly reduce consumer acceptance. However, repeated melting can cause severe quality degradation and a reduction of soluble solids by crystal formation can change the honey into an unstable state which is not suitable for long storage.

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