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De-crystallization in sunflower (*Tithonia diversifolia*) honey

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Abstract

Honey crystallization is a natural phenomenon that happens when the glucose in honey forms solid crystals. Therefore, crystallized sunflower honey is good; however, some people are under the impression that crystallized honey is fake, spoiled, adulterated, and of poor quality. Thus, this study used 9 bottles of crystallized sunflower honey from the Cordillera Administrative Region, Philippines, to determine the appropriate temperature, the number of hours to de-crystallize sunflower honey, and the effect of heat on the color of the honey after the de-crystallization process. The results of the experiment indicate that the use of natural solar heat (43.71 ˚C) and hot water (55.37 ˚C) were the appropriate temperatures for de-crystallizing sunflower honey. Though they exceeded the standard temperature range (34.5 to 35.5 ˚C), the color of the honey was not affected based on the Pfund scale rating (31–40 mm: extra light). Likewise, the use of a solar wax melter recorded the highest temperature (70.30 ˚C), and through visual assessment of the color of the honey after the de-crystallization process, it showed a slight change in the original color with a rating (41–50 mm: amber). Moreover, the use of a solar wax melter (5 h) had the shortest period of time to de-crystallize sunflower honey as compared to hot water (7 h) and natural solar heat (12 h); however, a solar wax melter is not recommended to de-crystallize sunflower honey because the color of the honey changes after the process.

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Introduction

Honey production is one of the traditional livestock and sources of income in the provinces of Benguet and Mountain Province, Philippines. Honey bees gather nectar from the blossoms' of wild sunflower (*Tithonia diversifolia*) plants and produce sunflower honey, which is packaged by honey producers in the region.

Likewise, Lixandru, 2019 revealed that sunflower honey crystallizes naturally in 3 weeks to 2 months due to its higher glucose and fructose content, along with water, temperature, agitation, time, and the presence of seed crystals. The crystallized honey looks opaque, duller, and has a lighter yellow color. Along with this natural honey chrystallization process, most of the honey producers encountered problems in packaging and selling their honey products in the local market in the Cordillera Administrative Region (CAR), Ilocos region, and other regions of the country because some of the people were under the impression that crystallized honey is fake, spoiled, old, unnatural, adulterated, and of poor quality.

Consequently, in order to address this scenario, the de-crystallizing process is done through the application of different methods and varying temperatures. To de-crystallize the sunflower honey, heat must be applied at the standard or optimal temperature ranging from 34.5 to 35.5°C (Vilar, 2023); this is the standard temperature being maintained by the honeybees inside their hive to maintain their honey in a liquid state. Apeldon, 2015 also mentioned that to liquefy honey, it is best to heat it at 35 to 40 °C and avoid overheating the honey so that the nutritional value will not be affected or destroyed and the enzymes, flavor, and aroma of the honey will be preserved. However, most honey producers heat their honey without considering the right temperature. Moreover, Bodor *et al.*, 2021 stated that the color of the honey can be evaluated by the most commonly used Pfund scale method, which provides a specific scale rating for honey ranging from 0-140mm. The Pfund scale is a standard method for grading and quantifying the color of honey, developed in the 20th century by Dr. William T. Bill. It measures the intensity of light that passes through the honey sample, and based on a visual assessment of the honey's color, the lower the Pfund rating, the lighter the honey, and the higher the Pfund rating, the darker the honey. Lighter honeys typically have a milder flavor, while darker honeys tend to have a robust flavor.

In the province of La Union, Philippines, where the Honey Processing Center is located, despite temperature differences from CAR, similar problems with honey crystallization beset the center and the honey consumers. Thus, the study attempted to generally de-crystallize crystallized bottled sunflower honey using different methods and varying temperatures, specifically to: (a) determine the appropriate temperature for de-crystallizing crystallized bottled sunflower honey; (b) determine the number of hours to de-crystallize crystallized bottled sunflower honey; and (c) determine the effect of heat on the color of the bottled sunflower honey after melting.

Materials and methods

Research design

The study employed an experimental completely randomized design (CRD) with 3 replications and 3 treatments: (a) hot water; (b) natural solar heat; and (c) solar wax melter.

Methods and parameters

Nine bottles of crystallized sunflower honey from the provinces of Benguet and Mountain Province were used. Three (3) bottles of crystallized honey were soaked in hot water in a casserole at a controlled temperature ranging from 34.5 to 60 °C in the bee product laboratory room, while the remaining 6 samples were subjected to natural solar heat (3) and a solar wax melter (3) at an uncontrolled temperature from 9:00 a.m. to 4:00 p.m. outside the laboratory room. Consequently, the digital thermometer was used to gather data on temperature every hour until all the crystallized honey was fully de-crystallized. Likewise, the number of hours was also gathered,

after which the de-crystallized honey was subjected to the Pfund scale (Fig. 1) to measure and determine the effect of heat on the color of the honey. A honey sample was placed in a glass cell and then matched to the scale color rating values.

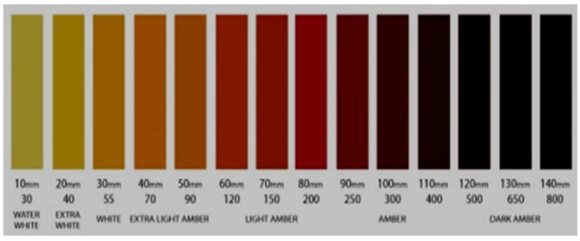

Fig. 1. Pfund scale for honey color classification (Source: https://ph.images.search.yahoo.com/search/images; Dr. William T. Bill Pfund)

Statistical analysis

Gathered data were tabulated and subjected to analysis using STAR 2.0, 2013, IRRI, Philippines, at a 5% level of significance, and further testing using Turkey's Honest Significant Difference (HSD) Test for mean separation.

On the other hand, the Pfund scale was used to determine the effect of heat on the color of the honey after the de-crystallization process with the following rating scales: 0–10 mm: water white, 11–20 mm: extra white, 21–30 mm: white, 31–40 mm: extra light, 41–50 mm: amber, 61–80 mm: light amber, 81–110 mm: amber, and 111–140 mm: dark amber.

Results and discussion

Temperature (°C) to de-crystallize sunflower honey

The use of a solar wax melter recorded the highest mean temperature (70.30 °C) compared to hot water and natural solar heat (55.37 °C) and 43.71 °C, respectively, as shown in Table 1. The average temperature was measured every hour from 9:00 a.m. to 4:00 p.m. using the digital thermometer, and the recorded data was subjected to statistical analysis. Analysis of variance showed that the different treatments significantly differed from each other (HSD at 5% level), which implied that de-crystallizing crystallized sunflower honey using different methods varied in recorded temperature. The results of the study conform to the claim of Apeldon, 2015 that, in order to liquefy crystallized honey, it is best to heat it at 35–40°C. Norton (2018) also stated that the melting point of crystallized honey is between 40°C and 50°C. Acero *et al.*, 2021 revealed that after 15 minutes of ultrasound, the gallic acid/100g of honey in phenols showed an increase in flavonoids (5.64mg of quercetin/100 g of honey) and an improvement in inhibition of 13.1%. In some honey, the correlation between phenols or flavonoids and antibacterial activity was significant ($P < 0.05$). The ultrasound treatment effect on the crystal size, phenols, flavonoids, and antibacterial activity of crystallized honey was different for each honey. Likewise, Nayik *et al.*, 2022 mentioned that heat treatment of honey at high temperatures (80°C) was found to be more efficacious than at 70 and 60 °C, respectively. The findings showed that at higher temperatures, browning pigments were formed, which considerably enhanced the antioxidant activity of honey.

Number of hours

Natural solar heat had the longest recorded mean number of hours (12 h) to de-crystallize sunflower honey, followed by hot water with a mean of 7 hours and solar wax melter with 5 hours, respectively. Results showed that the solar wax melter had the least number of hours to de-crystallize the crystallized bottled sunflower honey. This implied that the higher the temperature, the shorter the time needed to de-crystallize sunflower honey. Similar results were claimed by Maslowski, 2009 where a crystallized honey jar was placed in a slow cooker and left on low for 8 hours. Another method was to place a honey jar in the oven for 30 minutes to de-crystallize the honey. Hot water method in a pan, where the jar of honey is placed in the pan until the hot water is cool and repeatedly until the honey is completely de-crystallized. Dzugan, 2021 stated that decrystallizing honey using ultrasound (sonic bath, 40 kHz, 800 W) and conventional thermal processing (water bath, 40°C) showed that ultrasound processing significantly shortened the time of honey liquefaction (from 24 h to 15 min) and delayed the re-crystallization process compared to the conventional method (from 1 to 4 mos).

Table 1. Temperature, number of hours and color of sunflower honey after de-crystallization process

Treatment	Temperature (°C)	Number of hours	Color of sunflower honey after melting
T1–Hot water	55.37 b	7 h	31-40mm: extra light
T2–Natural solar heat	43.71 c	12 h	31-40mm: extra light
T3–Solar wax melter	70.30 a	5 h	41-50mm: amber

*Mean in a column followed by the same letter is not significantly different at 0.05 levels (Turkey's Honest Significant Difference (HSD) Test. C.V. 0.1185%. GM.56.46

Color of sunflower honey

The sunflower honey subjected to hot water (55.37°C) and natural solar heat (43.71°C) was observed to have maintained its original color after the de-crystallization process. Honey subjected to a solar wax melter (70.30°C) had a slight change in color after the melting process. Based on the Pfund scale measurement rating, both the honey subjected to hot water and natural heat had a measurement range of 31–40 mm, which is classified as an extra-light color. Further, the color of the sunflower honey is typically light to medium amber in color. It may sometimes appear almost clear or have a slight yellowish tint. The texture generally has a smooth and liquid consistency, but it can cystallize over time again, depending on the honey's glucose-to-fructose ratio. In terms of its aroma, it has mild, pleasant, and floral hints of sunflower, and it also has a mild and sweet flavor of sunflower nectar. Moreover, the sunflower honey subjected to a solar wax melter had a Pfund scale measurement of 41–50 mm, which is classified as an amber color. The color amber is described as a dark golden color, and it is darker than typical sunflower honey. With the visual assessment, it is evident that the color changes from extra light to amber, which is a sign that the honey was slightly overheated or exceeded the standard temperature (34.5 to 35.5°C) requirement to de-crystallize the sunflower honey. The results showed that overheating the honey at a temperature of 70.30°C can significantly darken the color to amber due to the caramelization of sugar in the honey. It also looks less transparent or even opaque as the heat alters the structure of the honey, and the flavor tastes burnt or smoky. As stated by Koerner, 2005 honey color assessment was typically done with the Pfund scale grader. The honey sample was placed in front of the jar opening and observed to match the honey's color to a spot on the chart. The Pfund method (Al-Farsi *et al.*, 2018) was used to measure color, the aluminum chloride method for flavonoid determination, the Folin-Ciocalteu method for phenolic measurement, and the assay to determine antioxidants. Likewise, Apeldon, 2015 disclosed that overheating honey for a long period of time will reduce its quality by destroying its enzymes, losing its delicate flavor and aroma, and darkening the color of the honey. Heating must be done with care if the nutritional value of the honey is not to be spoiled. Tosi *et al.,* 2004 revealed that heating can produce a decrease in honey quality, which is made evident by a simultaneous reduction in the diastase activity, referred to as the diastase number, and an increase in the hydroxymethylfurfural content. Consider the minimum admissible diastase number and the maximum admissible hydroxymethylfurfural content values, according to the present regulations.

Conclusion

Based on the results of the study, the following was concluded: (a) The appropriate temperature to de-crystallize sunflower honey ranges from 43.71 to 55.37 °C; even though it exceeded the standard temperature range of 34.5 to 35.5 °C, the color of the honey did not change from its original state or color after the process; (b) The shortest number of hours to de-crystallize sunflower honey was the use of a solar wax melter (5 hours); however, it is not recommended because it affects the color of the honey; (c) High temperature (70 °C) slightly affected the color of the bottled sunflower honey from extra light (31–40 mm) to amber (41–50 mm).

Recommendations

The use of a solar wax melter (7 hours) recorded the shortest number of hours to de-crystallize sunflower honey. However, it slightly changed the color of the

honey; thus, the natural solar heat and hot water method is recommended for de-crystallizing sunflower honey.

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