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PP-241 [Beekeeping Technology and Quality]

Analysis of nectar production characteristics and quality of Buckwheat honey in Taiwan

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Abstract
Buckwheat honey is rich in protein and phenolic compounds, has high nutritional value and excellent antibacterial and antioxidant capacities, and is a functional food. In Taiwan, bee colonies lack nectar sources in winter, and beekeepers must feed them sugar to help them survive the winter. As a winter crop in Taiwan, buckwheat can provide a supplementary nectar source for bee colonies. This study compared the total flavonoid content and antioxidant capacity of Taiwan buckwheat honey with other nectar source of honey and explored the weekly changes in the number of flowers and nectar production during the flowering period of buckwheat, as well as the daily changes in nectar production, to evaluate the potential of producing buckwheat honey in Taiwan. The results showed that the total flavonoid content of buckwheat honey was significantly higher than that of lychee honey and Chinese tallow honey, and the antioxidant capacity was also better than that of longan honey, lychee honey, Chinese tallow honey, and Chinese chaste tree (Vitex negundo) honey. Buckwheat reached its blooming stage on the 50th day after planting, and the highest nectar production per plant was 35.71 µL on the 43rd day after planting. The average nectar production per flower was highest during the pre-blooming stage, and the morning period was usually higher than the afternoon, with nectar production varying with the flowering period and time. This study confirms that Taiwan buckwheat honey has nutritional value and commercial production potential, which can provide a reference for future beekeepers to utilize the buckwheat as a supplementary nectar source and produce buckwheat honey.

Introduction
Buckwheat (*Fagopyrum esculentum* Moench), as an important nectar plant in Taiwan during winter, has garnered significant attention due to the distinctive flavor and potential health benefits of its honey. To gain a comprehensive understanding of the quality characteristics and nectar production potential of Taiwanese buckwheat honey, this study aims to investigate the flowering characteristics and nectar yield variation of buckwheat in Taiwan. Additionally, two key bioactivity indicators of buckwheat honey—total flavonoid content and DPPH radical scavenging capacity were evaluated.

Materials and Methods
Weekly Flowering Quantity and Nectar Yield during Buckwheat Blooming Period:
Buckwheat was cultivated in a greenhouse trial plot using common buckwheat (*Fagopyrum esculentum* Moench). Six plants were randomly selected, and surveys were conducted once a week during the flowering stage at three time points: 7:30 a.m., 11:30 a.m., and 15:30 p.m., over five weeks. For each survey, the number of flowers and total nectar volume per plant were recorded. Nectar was collected using 5-µL micro-capillary tubes (Figure 1), and the volume was measured to calculate the nectar yield per plant. This was further converted into nectar yield per unit area.

Honey Bioactivity Indicators:
Samples included five types of honey from Taiwan: buckwheat, longan, Chinese chaste tree (*Vitex negundo*), Chinese tallow, and lychee, one sample per type. Total flavonoid content and DPPH radical scavenging activity were measured three times per sample, and the average values were recorded.

1. Total Flavonoid Content (TFC): The aluminum chloride colorimetric method was used. A standard curve was established using quercetin dissolved in methanol (MeOH) at concentrations of 0, 25, 50, 75, 100, and 150 ppm. Each honey sample was diluted 1:1 (v/v) with ddH_2O. For each test, 250 µL of diluted sample or standard solution was mixed with 50 µL of 10% aluminum nitrate, 50 µL of 1 M potassium acetate, and 1.3 mL of ddH_2O. After mixing, the solution was incubated in the dark at room temperature for 40 minutes. Absorbance was measured at 415 nm using a spectrophotometer to calculate total flavonoid content.
2. DPPH Radical Scavenging Capacity: The DPPH colorimetric assay was conducted. DPPH solution was prepared by dissolving 2 mg of DPPH in methanol (MeOH) and bringing the volume to 50 mL (0.1 mM), stored protected from light. Each honey sample was diluted 1:1 (v/v) with ddH_2O. The assay was divided into three groups: Control group (A): 150 µL ddH_2O + 1.35 mL 0.1 mM DPPH solution; absorbance measured at 528 nm. Sample group (B): 150 µL diluted honey sample + 1.35 mL 0.1 mM DPPH solution; incubated at room temperature for 5 minutes; absorbance measured at 528 nm. Sample background group (C): 150 µL diluted honey + 1.35 mL methanol; absorbance measured at 528 nm. Scavenging rate was calculated as Scavenging Rate = [A - (B - C)] / A × 100%

Results
Weekly Flowering Quantity and Nectar Yield:
Flowering of buckwheat began on day 23 after sowing. Flower surveys were conducted once a week on days 28, 36, 43, 50, and 58 after sowing. The average number of open flowers per plant on these days was 17.3, 180.5, 537.0, 695.8, and 128.7, respectively. The number of flowers increased weekly, reaching a peak of 695.8 flowers per plant on day 50 (Figure 2). The peak nectar yield per plant occurred on 43 days after sowing, reaching 35.71 µL., Due to potential interference by dew or residual nectar at 7:30, only data from 7:30–11:30 and 11:30–15:30 time periods were used to calculate cumulative nectar yield. After adjustment, the highest corrected nectar yield per plant was 7.19 µL on 43 days after sowing (Table 1). With an average plant density of 162 plants/m², the total nectar yield per square meter also peaked on 43 days after sowing, reaching 1,165 µL/m² (Figure 3).

Honey Bioactivity Indicators:
1. Total Flavonoid Content: The average total flavonoid content of buckwheat, longan, Chinese chaste tree, Chinese tallow, and lychee honey was 132.6, 110.0, 71.9, 26.4, and 35.1 ppm, respectively. Buckwheat honey exhibited higher flavonoid content than the other honey types, particularly compared to Chinese tallow and lychee honey (Figure 4).
2. DPPH Radical Scavenging Capacity: The average DPPH radical scavenging rates of buckwheat, longan, Chinese chaste tree, Chinese tallow, and lychee honey were 96.7%, 22.7%, 32.1%, 15.8%, and 14.4%, respectively. Buckwheat honey showed significantly higher scavenging activity compared to the other honey samples (Figure 5).

Discussion
Weekly Flowering Quantity and Nectar Yield:
Total nectar production peaked on day 43, while the highest flower count occurred on day 50, one week apart. This suggests that although the number of open flowers was highest on day 50, the number of newly opened flowers had begun to decline. Since new flowers tend to produce more nectar, the higher nectar yield on day 43 is likely due to a greater number of freshly opened flowers. Therefore, for bee colonies, the optimal time to collect buckwheat nectar may be before the peak bloom, rather than during blooming. In terms of diurnal nectar variation, more nectar was observed in the afternoon (11:30–15:30) on days 28 and 36, whereas more nectar was found in the morning (7:30–11:30) after day 43. This could result in the peak foraging time of bees shifting earlier than the actual full bloom period. This study provides valuable data on nectar production during buckwheat blooming, offering practical references for beekeepers considering buckwheat as a supplementary nectar source or for buckwheat honey productivity.

Honey Bioactivity Indicators:
Longan, lychee, and Chinese tallow kinds of honey are commonly found in Taiwan, while Chinese chaste tree honey is a specialty from southern Taiwan. This preliminary comparison shows that buckwheat honey exhibits higher total flavonoid content and DPPH radical scavenging activity than the other samples, indicating its potential as a distinctive honey rich in antioxidants. These advantages in flavonoid content and antioxidant activity may be attributed to the accumulation of specific secondary metabolites in buckwheat plants. As only one sample per honey type was tested in this study, future studies involving a larger number of samples are needed to further assess the nutritional and health potential of buckwheat honey, providing strong support for its market promotion.

Table 1. Weekly nectar production per plant at 7:30, 11:30 and 15:30 by buckwheat.

Days from sowing	Nectar volume (µL)			
	7:30	11:30	15:30	Total
28	1.04 ± 0.60[z]	0.10 ± 0.04	0.34 ± 0.15	1.47 ± 0.74
36	0.82 ± 0.23	0.54 ± 0.14	1.07 ± 0.33	2.43 ± 0.60
43	28.52 ± 10.23	4.52 ± 2.69	2.67 ± 1.04	35.71 ± 13.73
50	4.53 ± 3.07	1.23 ± 0.41	0.61 ± 0.20	6.37 ± 3.41
58	6.47 ± 4.00	0.66 ± 0.21	0.24 ± 0.10	7.38 ± 4.07

[z]Mean ± standard error (n = 6).

Figure 1. Buckwheat nectar was collected using a 5 µL capillary tube.

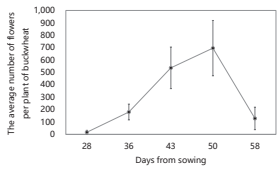

Figure 2. The average number of flowers per plant of buckwheat per week. Error bars represent ±SD (n = 6).

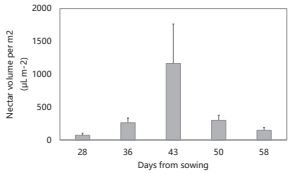

Figure 3. Corrected weekly nectar production per m² at 11:30 and 15:30 by buckwheat. Error bars represent ±SE (n = 6).

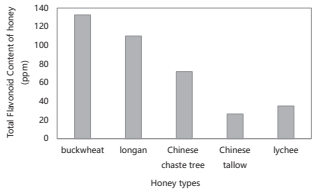

Figure 4. The total flavonoid content of honeys.

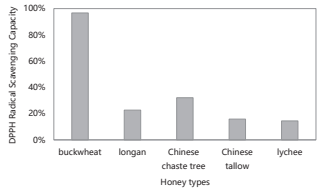

Figure 5. DPPH radical scavenging capacity of honeys.

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