

Comparative Evaluation of Antioxidant Potential and Basic Chemical Properties of Thai honeys from Four Floral Sources

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Abstract

This study aimed to investigate the antioxidant activities and chemical compositions of honeys derived from four floral sources: coffee, lychee, longan, and Siam weed. Honey samples were collected from commercial honey producers in Chiang Mai Thailand. The antioxidant activities were evaluated using FRAP and DPPH assays, while total phenolic content and chemical compositions, including total soluble solids ($^{\circ}\text{Brix}$), total acidity, and pH, were also analyzed. The results showed that coffee flower honey exhibited the highest antioxidant capacity, with FRAP and DPPH inhibition values of $36.33 \pm 2.01 \mu\text{mol mg GAE}/100 \text{ g honey}$ and $39.53 \pm 0.76\%$, respectively, along with a total phenolic content of $49.91 \pm 1.88 \text{ mg GAE}/100 \text{ g honey}$. Lychee and longan honeys demonstrated similar moderate levels of antioxidant activity, whereas Siam weed honey showed the lowest values across all antioxidant parameters. In terms of chemical composition, coffee flower honey had the highest $^{\circ}\text{Brix}$ value ($81.03 \pm 0.49^{\circ}\text{Brix}$), while lychee honey exhibited the highest total acidity ($2.09 \pm 1.33 \text{ mEq}/100 \text{ g honey}$) and the lowest pH (3.38 ± 0.06). Siam weed honey presented the lowest total soluble solids and total phenolic content values, corresponding with its weak antioxidant properties. These findings indicate that coffee flower honey has the highest potential as a biologically valuable ingredient suitable for development into natural health supplements or beauty products. Lychee and longan honeys also demonstrated promising chemical and biological properties. This study provides essential baseline data for selecting high-value Thai honeys and for adding commercial value through product innovation.

Keywords: Honey, Floral honey, Antioxidant activity, Phenolic compounds, Chemical composition

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1. Introduction

Honey is a natural product derived from the process in which bees collect nectar from flowers and store it in the honeycomb, where it undergoes both chemical and physical transformations. It ranges in color from light yellow to dark brown, has a viscous consistency, and possesses a sweet taste, which varies depending on the floral source specific to each region [1]. Honey has long been popular as a health food in both nutritional and medicinal contexts. For example, honey consumption has been used to restore energy prior to athletic competitions [2] and as a wound-healing agent due to its antibacterial properties [3]. Honey exhibits several notable natural properties, including antimicrobial activity, acidity, and the production of hydrogen peroxide, which contributes to pathogen inhibition [4]. Moreover, honey contains beneficial nutrients such as natural sugars, vitamins, minerals, organic acids, and bioactive compounds like flavonoids and phenolic compounds, which play significant roles in antioxidant and anti-inflammatory activities [5, 6].

Due to these components, honey is recognized as one of the natural products possessing the properties of a functional food. It plays roles in promoting health, preventing diseases, and nourishing the body. It has been reported that consuming honey in appropriate amounts can help lower blood lipid levels, reduce blood pressure, and regulate blood sugar levels [2]. Additionally, honey exhibits immunomodulatory effects, supports gut microbiota balance, and reduces the risk of chronic such as cardiovascular disease and cancer [7].

Furthermore, honey possesses skincare properties due to its antioxidant activity, which helps protect cells from damage caused by ultraviolet radiation and slows down skin cell aging [5, 6]. It also acts as a natural humectant that helps keep the skin soft and elastic [6]. These properties have contributed to the widespread popularity of honey as an ingredient in the development of health supplements, natural energy drinks, and personal care products for consumers who prioritize health and natural beauty.

Previous research has shown that the antioxidant properties of honey vary substantially according to floral origin and phenolic composition. [8] demonstrated that FRAP and DPPH radical scavenging activities are strongly associated with biochemical components, particularly phenolic acids and flavonoids. Similarly, [9] reported that honey from darker or phenolic-rich sources exhibits higher antioxidant activity compared to lighter honeys. Studies on Thai and regional honeys also confirm this trend: [10] observed that longan flower honey contains significant phenolic compounds contributing to its antioxidative capacity, while [11] found that monofloral honeys with higher TPC and TFC values demonstrate superior FRAP and DPPH activities. These findings highlight the importance of floral origin in determining the antioxidant potential of honey.

Due to these special properties, honey has gained considerable attention in the health, beauty, and high-value product industries. In particular, honey produced from a single floral source (mono/unifloral honey) is highly popular and commands a higher market price than honey derived from multiple floral sources (multi/polyfloral honey), owing to its distinctive taste, aroma, and color characteristics that are widely accepted by consumers [12]. For example, Manuka honey, derived from the Manuka flower (*Leptospermum Scoparium*), a medicinal plant native to New Zealand, contains methylglyoxal, which exhibits significantly higher antimicrobial activity than regular honey.

This has resulted in Manuka honey being sold at a price many times higher than that of ordinary honey [13].

In Thailand, particularly in the northern region, honey is produced from various local plants, such as longan (*Dimocarpus longan* Lour.), lychee (*Litchi chinensis* Sonn.), coffee (*Coffea arabica* L.), and Siam weed (*Chromolaena odorata* (L.) R.M.King & H.Rob.) flowers, which are key economic crops in the region. However, there is still a lack of systematic scientific studies on the chemical properties and biological activities of Thai honeys from different sources. This gap limits the ability to highlight the unique qualities of Thai honey and leverage them for commercial advantages, especially when compared to imported honeys that are supported by extensive research.

Thailand produces approximately 12,000–14,000 tons of honey annually, with longan honey accounting for more than 70% of the national output, particularly from northern provinces such as Chiang Mai, Lamphun, and Chiang Rai. In contrast, lychee, coffee, and Siam weed honeys represent smaller niche productions that fluctuate seasonally according to flowering periods and climatic conditions. These variations influence the consistency, availability, and overall commercial development potential of Thai unifloral honeys [14].

Honeys derived from different floral sources possess distinct chemical properties, including pH, total acidity, total soluble solids (°Brix), moisture content, reducing sugars, non-reducing sugars, as well as the quantity and type of phenolic compounds. These factors significantly influence the antioxidant activity and biological properties of honey [15, 16].

This study aims to investigate the antioxidant properties and chemical composition of honeys from four floral sources: coffee, lychee, longan, and Siam weed. The antioxidant activity was evaluated using the FRAP and DPPH inhibition assays, while the total phenolic content (TPC) was determined. Basic chemical parameters, including pH, total acidity, and °Brix, were also analyzed. The findings from this research will be valuable for selecting honeys with high potential for development into functional food supplements or natural products that meet the preferences of modern consumers who prioritize safety, health, and sustainability. Moreover, the results will contribute to promoting and enhancing the economic value and international trade competitiveness of Thai honey.

2. Materials and Methods

2.1 Sample Preparation

Honey samples from four floral sources—longan, lychee, coffee, and Siam weed—were used in this study. All honey samples were sourced from certified beekeepers in Chiang Mai, Thailand, during the 2024 flowering season. To ensure unifloral purity, beekeepers placed *Apis mellifera* hives directly within areas where the target floral species dominated the landscape (≥ 80 –90% blooming vegetation), and honey was harvested exclusively during the peak flowering period of each plant species. Each honey type was collected from a single production batch, provided in sealed food-grade containers, and transported to the laboratory within one week of harvest. Upon arrival, all samples were stored at room temperature ($25 \pm 2^\circ\text{C}$) in airtight, light-protected glass containers to prevent moisture absorption, fermentation, and degradation of heat-sensitive bioactive compounds. Analyses were performed within four weeks of collection to minimize variations caused by prolonged storage.

2.2 Determination of Antioxidant Activity by Ferric Reducing Antioxidant Power (FRAP)

The ferric reducing antioxidant power (FRAP) of the honey samples was determined following the method described by [17] with slight modifications. The FRAP reagent was prepared by mixing acetate buffer (300 mM, pH 3.6), ferric chloride solution ($\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$, 20 mM), and TPTZ solution (2,4,6-tripyridyl-s-triazine, 10 mM). A honey solution was prepared by dissolving 50 g of honey in distilled water and adjusting the volume to 100 mL to achieve a concentration of 0.5 g/mL (50% w/v). Subsequently, 0.2 mL of the honey solution was added to 1.5 mL of FRAP reagent, mixed thoroughly, and incubated at 37°C for 4 minutes. The absorbance was measured at 593 nm using a spectrophotometer (M509T, Spectronic Camspec Ltd., United Kingdom). All measurements were performed in triplicate. The results were compared with a standard curve prepared from gallic acid solutions at concentrations of 3-50 $\mu\text{g/mL}$ in distilled water. The antioxidant capacity was expressed as micromoles of ferrous equivalents per 100 grams of honey (mg GAE/100 g honey).

2.3 Determination of Antioxidant Activity by DPPH Radical Scavenging Activity Assay

The antioxidant activity of the honey samples was evaluated using the DPPH radical scavenging assay, based on the method of [18] with slight modifications. A honey solution with a concentration of 0.3 g/mL (30% w/v) was prepared. The 2,2-diphenyl-1-picrylhydrazyl (DPPH) solution was prepared at a concentration of 0.1 mg/mL. Then, 0.75 mL of the honey solution was mixed with 1.5 mL of the DPPH solution using a vortex mixer. The mixture was left to stand for 15 minutes at room temperature. The absorbance was measured at 517 nm using a spectrophotometer. All measurements were performed in triplicate. The percentage of DPPH inhibition (% inhibition) was calculated using the following equation:

$$\% \text{ inhibition} = \left(\frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}} \right) \times 100$$

Where A_{control} is the absorbance of the DPPH solution without the honey sample, and is A_{sample} is the absorbance of the DPPH solution containing the honey sample.

2.4 Determination of Total Phenolic Content (TPC)

A honey solution was prepared at a concentration of 0.1 g/mL (10% w/v). An aliquot of 1 mL of the honey solution was mixed with 2.5 mL of 0.2 N Folin-Ciocalteu reagent. The mixture was shaken thoroughly and allowed to stand for 5 minutes. Subsequently, 2 mL of sodium carbonate solution was added, and the mixture was incubated in the dark for 2 hours. The absorbance was then measured at 760 nm using a spectrophotometer. All analyses were performed in triplicate, with distilled water serving as the blank [19]. The results were compared against a standard calibration curve prepared using gallic acid at concentrations of 30-120 $\mu\text{g/mL}$ in distilled water. The total phenolic content was expressed as milligrams of gallic acid equivalents per 100 gram of honey (mg GAE/100 g honey).

2.5 Determination of Chemical Properties of Honey

The basic chemical properties of the honey samples were analyzed as follows. The total soluble solids (°Brix) were measured using a digital hand refractometer (ATAGO, Japan) [20]. The pH was determined using a pH meter [20]. The total acidity was assessed by dissolving 10 g of honey

in distilled water and adjusting the volume to 100 mL. A 20 mL aliquot of the resulting honey solution at a concentration of 0.1 g/mL (10% w/v) was titrated with 0.05 N sodium hydroxide (NaOH) until a pH of 8.50 was reached [20]. The total acidity was expressed in milliequivalents per kilogram (mEq/kg). All measurements were performed in triplicate.

2.6 Statistical Analysis

A completely randomized design (CRD) was used for the experimental design. Analysis of variance (ANOVA) was performed to assess differences between mean values, followed by a least significant difference (LSD) test at a 95% confidence level. Statistical analysis was conducted using SPSS software version 23 (SPSS Inc., USA).

3. Results and Discussion

3.1 Antioxidant Activities of Honeys from Different Floral Sources

The antioxidant activities of honey samples from four floral sources—longan flower, lychee flower, Siam weed, and coffee flower—are presented in Table 1. All honey samples exhibited statistically significant differences ($P \leq 0.05$) in FRAP values, percentage of DPPH radical inhibition (% inhibition), and total phenolic content (TPC). Coffee flower honey demonstrated the highest antioxidant activity, with a FRAP value of 36.33 ± 2.01 mg GAE/100 g honey and a DPPH inhibition of $39.53 \pm 0.76\%$. These values were higher than those of longan flower honey (26.61 ± 1.45 mg GAE/100 g honey; $37.96 \pm 0.43\%$) and lychee flower honey (32.19 ± 2.86 mg GAE/100 g honey; $36.36 \pm 2.03\%$). Longan and lychee honeys exhibited comparable antioxidant activities. In contrast, Siam weed honey showed the lowest values across all parameters, with a FRAP value of 15.35 ± 1.69 mg GAE/100 g honey and a DPPH inhibition of $21.84 \pm 0.91\%$. These results corresponded with the lowest total phenolic content in the group, indicating that Siam weed honey possessed markedly lower antioxidant properties compared to the other honey types.

When comparing the total phenolic content of the four floral honeys, it was observed that lychee, longan, and coffee flower honeys had similar levels of bioactive compounds, measured at 52.77 ± 4.17 , 52.50 ± 2.76 , and 49.94 ± 1.88 mg GAE/100 g honey, respectively. In contrast, Siam weed honey exhibited the lowest total phenolic content at 31.71 ± 5.84 mg GAE/kg honey, which corresponded with its lowest antioxidant activities across all evaluated parameters.

According to Table 1, coffee flower honey exhibited significantly higher antioxidant activities than longan and lychee flower honeys, demonstrating outstanding potential among the honeys produced under standard processing conditions. This finding aligns with the report by [8], which indicated that honey derived from coffee flowers possesses high levels of antioxidant compounds, including various organic acids and flavonoids known for their effective free radical scavenging properties. Longan and lychee flower honeys showed lower FRAP and DPPH inhibition values than coffee flower honey but had similar total phenolic contents. In contrast, Siam weed honey displayed the lowest antioxidant activities, corresponding to its lowest total phenolic content among the samples.

These results were also consistent with the findings of [21], who investigated honeys from longan, lychee, and wildflowers and found that longan flower honey contained higher levels of ascorbic acid and phenolic compounds, along with significantly greater DPPH inhibition compared to other honey types. This reflects the direct influence of the floral source on the antioxidant activity

of honey. When comparing the antioxidant properties of honeys derived from coffee, longan, lychee, and Siam weed flowers, coffee flower honey exhibited the highest antioxidant activity, which corresponded to its higher phenolic and flavonoid contents. These findings support the reports of [11], which stated that polyphenols and flavonoids are the primary components enhancing the antioxidant potential of honey due to their electron-donating properties and their ability to inhibit oxidation reactions in biological systems. Similarly, [22] identified polyphenols as key contributors to the antioxidant capacity of honey.

Although longan and lychee honeys exhibited similar total phenolic contents to coffee flower honey, their FRAP and DPPH inhibition values were comparatively lower. This discrepancy may be attributed to differences in flavonoid composition rather than phenolic quantity alone, as specific flavonoids such as quercetin, kaempferol, and caffeic acid derivatives—reported to be abundant in coffee-related honeys [8, 22]—are known to contribute more strongly to redox activity.

The importance of flavonoids in determining antioxidant activity has been consistently supported by previous studies, which reported that honey types rich in flavonoid subclasses exhibit higher FRAP and DPPH values regardless of total phenolic content [11].

When benchmarked against antioxidant values reported for monofloral honeys in earlier studies (typically 20–45 mg GAE/100 g for FRAP and 20–40% for DPPH inhibition), the antioxidant activities observed in Thai honeys fall within or above these commonly reported ranges, especially for coffee flower honey, which demonstrated values at the upper end of the spectrum [11, 22].

The findings of this study demonstrated that honeys derived from the four floral sources—coffee, lychee, longan, and Siam weed—exhibited significantly different antioxidant activities. Coffee flower honey presented the highest antioxidant activity, surpassing those of longan and lychee honeys. Longan and lychee honeys displayed similar antioxidant capacities, while Siam weed honey showed the lowest antioxidant activity across all parameters. These results were consistent with the lower phenolic and flavonoid contents observed in Siam weed honey. This study provides fundamental information for selecting honey sources with high antioxidant potential for the development of health supplements, which are increasingly popular among consumers seeking natural wellness solutions. Notably, coffee flower honey demonstrated superior potential and is domestically produced, making it a valuable raw material with promising commercial applications.

Table 1. Antioxidant activities of honeys from different floral sources.

Honey sample	Antioxidant Activity		
	FRAP value (mg GAE/100 g honey)	DPPH inhibition (%)	Total Phenolic Content (mg GAE/100 g honey)
Longan flower honey	26.61±1.45 ^c	37.96±0.43 ^b	52.50 ±2.76 ^a
Siam weed honey	15.35±1.69 ^d	21.84±0.9 ^c	31.71±5.84 ^b
Lychee flower honey	32.19±2.86 ^b	36.36±2.03 ^b	52.77±4.17 ^a
Coffee flower honey	36.33±2.01 ^a	39.53±0.76 ^a	49.91±1.88 ^{ab}

- Values are presented as mean ± standard deviation from triplicate determinations.

- Means with different superscript letters within each column indicate statistically significant

3.2 Chemical Properties of Honeys from Different Floral Sources

From Table 2, honeys derived from longan, Siam weed, lychee, and coffee flowers exhibited significantly different chemical properties, including total soluble solids ($^{\circ}\text{Brix}$), total acidity, and pH values ($P \leq 0.05$). The results showed that coffee flower honey had the highest total soluble solids at $81.03 \pm 0.49^{\circ}\text{Brix}$, followed by lychee flower honey and longan flower honey, which had values of 80.02 ± 0.50 and $79.90 \pm 0.52^{\circ}\text{Brix}$, respectively. In contrast, Siam weed honey exhibited the lowest total soluble solids at $76.63 \pm 0.39^{\circ}\text{Brix}$.

The results also revealed that the four types of honey exhibited significant differences ($P \leq 0.05$) in both total acidity and pH values. Lychee flower honey showed the highest total acidity at $2.09 \pm 1.33 \text{ mEq/100 g honey}$, which corresponded to the lowest pH value of 3.38 ± 0.06 , indicating the most pronounced acidity. Following this, longan flower honey presented moderate acidity ($1.98 \pm 0.71 \text{ mEq/100 g honey}$) with a pH of 3.47 ± 0.06 . In contrast, Siam weed and coffee flower honeys demonstrated the lowest acidity levels at 1.64 ± 0.42 and $1.63 \pm 0.92 \text{ mEq/100 g honey}$, respectively, which corresponded to the highest pH values of 3.74 ± 0.02 and 3.81 ± 0.03 . These findings reflect a consistent relationship between total acidity and pH among the honey samples.

The chemical properties of honey, such as total soluble solids, total acidity, and pH, are important indicators of quality, stability, and suitability for developing functional food and cosmetic products. The total soluble solids reflect the sugar content, which influences viscosity, taste, and storage potential. High-quality honey should have a total soluble solid content of no less than 80°Brix , according to [1] and the [23]. The results indicated that the three honey types—longan, lychee, and coffee flower honeys—had total soluble solid values close to 80°Brix . Although the Siam weed honey exhibited a slightly lower $^{\circ}\text{Brix}$ value, it still fell within an acceptable range.

Acidity and pH are strongly associated with honey's antioxidant and antimicrobial properties. Lower pH enhances the stability of phenolic compounds and improves resistance to microbial growth, while higher acidity can promote redox reactions that contribute to antioxidant capacity [7, 24]. In this study, lychee and longan honeys—with the highest acidity and lowest pH—may therefore exhibit stronger chemical stability and biological activity compared with coffee and Siam weed honeys.

The pH value also plays a significant role in controlling microbial growth and chemical reactions, such as browning reactions and enzymatic changes. Lower pH levels generally help slow product spoilage [7]. Lychee and longan flower honeys, which exhibited the highest total acidity levels, demonstrated pronounced acidity and potentially enhanced antimicrobial activity and product stability. Meanwhile, coffee and Siam weed honeys, with the lowest acidity values, indicated milder acidity, suggesting lower antimicrobial potential and influencing chemical stability and storage properties.

The findings of this study demonstrated that the four types of floral honeys exhibited significantly different chemical compositions. Although the total soluble solid of Siam weed honey was slightly below 80°Brix , it remained within an acceptable range. Lychee flower honey, which exhibited the highest total acidity and the lowest pH among the samples, indicated pronounced acidity that may contribute to stronger antimicrobial activity and stability. Longan flower honey showed moderately high acidity, while coffee and Siam weed honeys reflected the mildest acidity. These results provide essential data for selecting honey types suitable for developing health supplements.

and cosmetic products, particularly lychee and longan flower honeys, which exhibited favorable chemical properties.

Table 2. Chemical properties of honeys from different floral sources.

Honey Sample	Chemical properties		
	Total Soluble Solid (°Brix)	Total Acidity (mEq/100 g honey)	pH Value
Longan flower honey	79.90±0.52 ^b	1.98±0.7 ^{ab}	3.47±0.06 ^c
Siam weed honey	76.63±0.39 ^c	1.64±0.42 ^b	3.74±0.02 ^b
Lychee flower honey	80.02±0.50 ^b	2.09±1.33 ^a	3.38±0.06 ^d
Coffee flower honey	81.03±0.49 ^a	1.63±0.92 ^b	3.81±0.03 ^a

- Values are presented as mean ± standard deviation from triplicate determinations.

- Means with different superscript letters within each column indicate statistically significant differences at a 95% confidence level ($P \leq 0.05$); ns means no significant difference ($P > 0.05$).

4. Conclusion

The study revealed that honeys derived from four floral sources-coffee flower, lychee flower, longan flower, and Siam weed-exhibited distinct antioxidant activities and chemical compositions. Coffee flower honey demonstrated the highest antioxidant activity, as indicated by both FRAP and DPPH inhibition values. In contrast, Siam weed honey showed the lowest values across all parameters, including the total phenolic content, which corresponded with its minimal antioxidant activity. Lychee and longan flower honeys exhibited moderate antioxidant activities at comparable levels. However, lychee flower honey presented the highest total acidity and the lowest pH value. The total soluble solids (°Brix) values for all honey types were within the acceptable standard range. The findings from this study provide essential baseline data for selecting honey from floral sources with high potential for the development of functional food supplements or natural beauty products. Notably, coffee flower honey, with its outstanding antioxidant properties and domestic availability, represents a valuable raw material with high market potential and opportunities for commercial advancement in the future.

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6. References

- [1] Codex Alimentarius Commission. (2001) Revised codex standard for honey: CODEX STAN 12-1981 (Rev. 1). Rome, Italy: Food and Agriculture Organization of the United Nations/World Health Organization.

- [2] Eteraf-Oskouei, T., & Najafi, M. (2013) Traditional and modern uses of natural honey in human diseases: A review. *Iranian Journal of Basic Medical Sciences*, 16(6), 731-742.
- [3] Nolan, V. C., Harrison, J., & Cox, J. A. (2019) Dissecting the antimicrobial composition of honey. *Antibiotics*, 8(4), 251.
- [4] Albaridi, N. A. (2019) Antibacterial potency of honey. *International Journal of Microbiology*, Article ID 2464507.
- [5] Al-Mamary, M., Al-Meer, A., & Al-Habori, M. (2002) Antioxidant activities and total phenolics of different types of honey. *Nutrition Research*, 22(9), 1041–1047.
- [6] Samarghandian, S., Farkhondeh, T., & Samini, F. (2017) Honey and health: A review of recent clinical research. *Pharmacognosy Research*, 9(2), 121–127.
- [7] Bogdanov, S., Jurendic, T., Sieber, R., & Gallmann, P. (2008). Honey for nutrition and health: A review. *Journal of the American College of Nutrition*, 27(6), 677–689.
- [8] Chua L. S., Rahaman N. L. A., Adnan N. A., Tan T. T. E. (2013) Antioxidant activity of three honey samples in relation with their biochemical components. *Journal of Analytical Methods in Chemistry*, 2013, 313798.
- [9] Moniruzzaman M, Sulaiman S.A., Khalil M.I., Gan S.H. (2013) Evaluation of physicochemical and antioxidant properties of sourwood and other Malaysian honeys: A comparison with Manuka honey. *Chemistry Central Journal*, 7, 138.
- [10] Chaikham P., & Prangthip P. (2015) Alteration of antioxidative properties of longan flower-honey after high pressure, ultrasonic and thermal processing. *Food Bioscience*, 10, 1-7. <https://doi.org/10.1016/j.fbio.2015.01.002>
- [11] Gül A, Pehlivan T. (2018) Antioxidant activities of some monofloral honey types produced across Turkey. *Saudi Journal of Biological Sciences*, 25(6), 1056-1065.
- [12] Madras-Majewska, B., & Skonieczna, L. (2021) Diversification of morphological features of the dark European honey bee of the ‘Augustow M’ line. *Animals*, 11(4), 1156.
- [13] Libonatti, C., Varela, S., & Basualdo, M. (2014) Antibacterial activity of honey: A review of honey around the world. *Journal of Microbiology and Antimicrobials*, 6(3), 51–56. <https://doi.org/10.5897/JMA2014.0308>
- [14] FAOSTAT. (2023) Honey production statistics: Thailand. Rome: Food and Agriculture Organization of the United Nations, Available from: <https://www.fao.org/faostat>. Accessed 27 Jan 2025.
- [15] Truchado, P., Ferreres, F., & Tomas-Barberan, F. A. (2009) Liquid chromatography-tandem mass spectrometry reveals the widespread occurrence of flavonoid glycosides in honey, and their potential as floral origin markers. *Journal of Chromatography*, 1216(43), 7241–7248.
- [16] Martos, I., Ferreres, F., & Tomás-Barberán, F. A. (2000) Identification of flavonoid markers for the botanical origin of Eucalyptus honey. *Journal of Agricultural and Food Chemistry*, 48(5), 1498–1502.
- [17] Benzie, I. F., & Strain, J. J. (1996) The ferric reducing ability of plasma (FRAP) as a measure of antioxidant power: The FRAP assay. *Analytical Biochemistry*, 239(1), 70–76.

- [18] Meda, A., Lamien, C. E., Romito, M., Millogo, J., & Nacoulma, O. G. (2005) Determination of the total phenolic, flavonoid and proline contents in Burkina Faso honey, as well as their radical scavenging activity. *Food Chemistry*, 91(3), 571–577.
- [19] Alves, A., Ferreira, I. C. F. R., Froufe, H. J. C., Abreu, R. M. V., Martins, A., & Pintado, M. (2013) Antimicrobial activity of phenolic compounds identified in wild mushrooms, SAR analysis and docking studies. *Journal of Applied Microbiology*, 115(2), 346–357.
- [20] AOAC. (2010). *Official methods of analysis of AOAC International* (18th ed.). Gaithersburg, MD, USA: AOAC International.
- [21] Liu, J. R., Ye, Y. L., Lin, T. Y., Wang, Y. W., & Peng, C. C. (2013) Effect of floral sources on the antioxidant, antimicrobial, and anti-inflammatory activities of honeys in Taiwan. *Food Chemistry*, 139(1-4), 938–943.
- [22] Biluca, F. C., Braghini, F., Gonzaga, L. V., Costa, A. C. O., & Fett, R. (2016) Physicochemical profiles, minerals and bioactive compounds of stingless bee honey (*Meliponinae*). *Journal of Food Composition and Analysis*, 50, 61–69.
- [23] Thai Industrial Standards Institute. (2004) *Community Product Standard: Honey (TCPS 290/2004)*. Bangkok: Ministry of Industry.
- [24] Estevinho, L., Pereira, A. P., Moreira, L., Dias, L. G., & Pereira, E. (2008) Antioxidant and antimicrobial effects of phenolic compounds extracts of Northeast Portugal honey. *Food and Chemical Toxicology*, 46(12), 3774–3779.