RESEARCH | Egyptian Journal of Agricultural Research | Plant Protection

Assessing quality attributes of autumn honey produced in Upper Egypt

Mostafa A. Seddik; Mahmoud A.H. Nasrallah; Rasha S. Sakla *

Address:

Plant Protection Research Institute, Agriculture Research Center, Dokki, Giza, Egypt.

*Corresponding author: ***Rasha Sakla.***email: *rasha.s.sakla@gmail.com*

Received: 05-05-2025**; Accepted:** 12-07-2025**; Published:** 30-07-2025 **DOI:**10.21608/EJAR.2025.381385.1662

ABSTRACT

The current study, carried out during the autumn honey flow season in September 2023, aimed to evaluate the distinct quality characteristics of autumn honey produced in three governorates (Sohag, Qena and Luxor) of Upper Egypt. Pollen spectrum and physicochemical properties were the parameters assessed for each honey sample as they are instrumental in discerning the botanical origin and quality of honey. Pollen analysis of the honey revealed distinct variability among samples, reflecting their diverse geographical origins. Luxor and Qena honey samples were classified as unifloral whereas, those from Sohag were multifloral. Physicochemical analysis demonstrated that key parameters including electrical conductivity, granulation, viscosity, moisture content, pH, acidity profile, sugar composition (fructose, glucose, sucrose &maltose), hydroxymethylfurfural levels, and diastase activity aligned well with most international standards confirming the overall good quality of samples. Notably, samples from Qena governorate recorded the highest electrical conductivity (0.7mS/cm) and granulation index (0.93) while the highest viscosity (148.00 poise) was observed in honey from Luxor. Sohag samples exhibited the highest total acidity (37.5 meq/Kg). Across all samples, sucrose content remained below the accepted 5%threshold. Diastase activity peaked in Sohag samples (62.18 Gothe units), while those from Qena had the highest HMF contents (7.16 mg/kg).The findings of this research highlighted that the variations in honey quality and physicochemical attributes across the three governorates depending on both geographical and botanical origins.

Keywords: Honey quality, physicochemical attributes, Upper Egypt, pollens spectrum.

INTRODUCTION

Renowned for its ancient beekeeping practices and abundant botanical diversity, Egypt offers a variety of honey types known for their unique flavors and health-boosting properties. Evidence of the country's historical relationship with bees is documented in hieroglyphics and ancient writings that frequently reference bees and honey. By tapping into Egypt's diverse ecosystems from the fertile Nile Delta to the dry, expansive deserts beekeepers produce honey from various floral sources. This ecological diversity shapes the unique taste and nutritional qualities of Egyptian honey (El-Seedi *et al*., 2022).Egyptian honey is valued for its medicinal benefits and has long been a part of traditional medicine to address issues like wounds, coughs, and digestive disorders. Moreover, modern science has validated many of these health claims highlighting the antioxidant, anti-inflammatory and antibacterial effects of honey (Yupanqui *et al*., 2022).

The distinct qualities of various honey types arise from the variety of flowers that honeybees forage on, which can influence their health benefits, so, assessing the quality and distinguishing between local and imported honey samples can be achieved by analyzing their botanical sources (Pătruică *et al.*, 2022). Additionally, examining physicochemical properties like color, electrical conductivity, moisture content, pH, free acidity, hydroxymethylfurfural (HMF), sugar content, and enzymes activity help in evaluating honey quality(El Sohaimy *et al*., 2015; Ismail *et al.*, 2021).The chemical composition of honey is mainly shaped by the botanical source of its nectar (Chakir *et al*., 2016; Solayman *et al*., 2016). Other influential factors include the geographical region of production (Draiaia *et al*., 2015; Taha *et al*., 2017), the duration of storage and the age of the honey combs (Al-Ghamdi *et al*., 2019).

The sugar profile of honey has a notable impact on its physicochemical properties like, thickness, moisture absorption, and tendency to crystallize (Kang and Yoo, 2008). Various studies have explored the sugar composition of different honey types(De La Fuente *et al*., 2011) revealing that it is largely dependent on the floral sources visited by forager bees as well as the environmental and regional conditions (Gómez *et al.,*2000). Hydroxymethylfurfural content serves as an important parameter of honey's freshness, quality or overheating. It is considered one of the most critical parameters serves as a reliable indicator of both the purity and freshness of honey (Ali, 2024). Researches also, had demonstrated the free acidity present in honey serves as a measure of its organic acid concentration. This parameter plays a crucial role in assessing the potential for honey fermentation (Pauliuc *et al*., 2021). The moisture content in natural honey samples serves as a key indicator of both maturity level and the way of storage employed. Consequently, moisture assessments have traditionally been conducted to gauge the quality of natural honey samples (Puścion-Jakubik *et al*., 2020).

Additionally, the moisture level of honey and the fructose-to-glucose (F/G) ratio are essential factors in determining its crystallization rate, which in turn affects its flow properties (Witczak *et al*., 2011). The level of these physical and chemical indicators detected in a honey sample gives an indication of its quality (Muli *et al*., 2007). Moreover, honey's physicochemical characteristics vary based on honey bees species or subspecies responsible for its production, enabling to distinguish between different types of honey (Taha *et al*., 2021). Additionally, the antimicrobial properties of honey is influenced by a numerous factors such as botanical origin, hydrogen peroxide content, acidity and some bioactive components (Almasaudi, 2021). The main objective of this study was to evaluate the local Egyptian autumn honey obtained from three different regions in Upper Egypt (Sohag, Qena and Luxor) governorates, and compare them with standard specification of the Egyptian Standards and Metrology Organization.

MATERIALS AND METHODS

1. Pollen spectrum in honey Samples:

1.1. Sample Collection:

The current study was conducted during the autumn honey flow season of September 2023for physicochemical analyzing of honey. The current work was carried out at the Bee Research Department, Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza. A total of nine autumn honey samples were sourced from three governorates in Upper Egypt (Sohag, Qena and Luxor), with three replicates from each region. Samples, provided by professional beekeepers, stored in airtight plastic containers at 4-5°C until analysis.

1.2. Preparing samples for examination:

To prepare the honey samples for analysis, 5 g of each studied sample was weighed into a 10ml plastic tube. Honey samples were diluted by mixing with 8 mL of distilled water heated to at least 40°C to ensure complete dissolution. After confirming complete solubility, 2 mL of 95% ethanol was incorporated into the mixture to aid further processing. The solution was continuously stirred, aiding in the separation and sedimentation of pollen grains. Subsequently, samples underwent centrifugation at 3700 rpm for 3 minutes following the procedure described by (Jones and Bryant, 2014). The settled precipitate at the bottom of the plastic tube was subsequently stained with saffron dye (500 microns per liter of distilled water) to enhance visibility for microscopic examination (Erdtman, 1960).

2. Physical properties:

The physical characteristics of nine autumn honey samples were examined, specifically evaluating four key properties: electrical conductivity (EC), viscosity, granulation, and moisture content.

2.1. Electrical conductivity (EC):

The electrical conductivity (EC) of the tested honey samples was evaluated using an Electro-Conductivity Model EN50081-1 at room temperature. A solution was prepared by dissolving 2 g of honey in 10 mL of distilled water, and the EC measurement was expressed in mS/cm, following the method described by (Adenekan *et al*., 2010).

2.2. Granulation:

The granulation of the studied honey samples was evaluated using the method reported by (White, 1962), by assessing the glucose-to-fructose (D/L) ratio.

2.3. Viscosity:

The viscosity of the autumn honey samples was determined at 29°C using a viscometer, following the method described by (Munro, 1943).

2.4. Moisture content (%):

A refractometer was utilized to measure the refractive index, with the value corrected for temperature and then converted into moisture percentage (%) based on the table provided by (White, 1962).

3. Chemical properties:

The chemical composition of the collected autumn honey samples was analyzed. The tested parameters included pH value, acidity profiles (free acidity, lactone and total acidity), sugar composition (glucose, fructose, sucrose, and maltose), key sugar ratio glucose/fructose, as well as hydroxymethylfurfural (HMF) and diastase number.

3.1. PH value:

The pH value was determined using a HANNA pH meter (Model H19321) following there commended protocol described by (Cunniff, 1995).

3.2. Free acidity, lactone and total acidity:

Acidity was measured using the accumulated equivalence point titration method according to the procedure described by (Bogdanov *et al*., 2002), and the results were expressed in mille equivalents per kilogram (meq/kg).

3.3. Sugars content:

Collected honey samples were analyzed to evaluate their sugar content. The concentrations of fructose, glucose, sucrose, and maltose percentages were identified and quantified using High- Performance Liquid Chromatography (HPLC), following the standard method outlined by (Cunniff, 1995). Additionally, glucose/fructose (G/F) ratio was calculated.

3.4. Hydroxymethylfurfural (HMF):

The determination of hydroxymethylfurfural (HMF) in honey samples was conducted using Carrez reagents I and II, followed by sodium bisulfate, according to (Cunniff, 1995). Absorbance was determined at 284 and 336 nm in a 1cm quartz cuvette using a Labomed, inc. Spectro UV-Vis R.S. Spectrophotometer.

3.5. Diastase activity:

Diastase activity was determined after shading following the method of (Schade *et al.,* 1958), to obtain a diastase number (D.N), which represents the Gothe unit. One Gothe unit is defined as the amount of diastase enzyme in 1 g of honey required to convert 0.01 g of starch to the prescribed end-point within one hour at 40°C, under the test conditions used by the (Commission, 2009).

4. Statistical analysis:

Data from physical and chemical analysis were expressed as mean ± SD. The data were analyzed using one-way analysis of variance (ANOVA). Tukey's HSD test was utilized to identify significant differences among means. The analysis was performed using the Costat statistical software package (Costat, 2005), with significance determined at the 0.05 probability level.

RESULTS

1. Pollen spectrum in honey Samples:

Pollen analysis of honey samples collected from three governorates in Upper Egypt (Luxor, Qena, and Sohag) was summarized in (Table 1). Honey samples obtained from Luxor are grouped as unifloral honey because they contain dominant pollen grains, *M. sativa* at an average rate of 70%, whereas *S. indicum* pollen was recorded at 20% and the remaining 10% was classified as unidentified pollen. Likewise, the pollen qualitative analysis in all autumn honey samples collected from Qena governorate was classified as unifloral (monofloral) honey, where the percentage of predominant pollen in tested honey was 45%and defined as *S. indicum*, while secondary pollen of *Zea mays* was represented by 30 % in addition, 25% was unidentified pollen. On the other hand, in honey samples from Sohag governorate, the average *Z. spina-christi* pollen reached 30 %, *S. indicion* was 30%, 10% rare *P. oleracea* pollen and 30% unidentified pollen which was classified as multifloral honey.

Table 1. Main pollen types of honey samples collected from different governorates in Upper Egypt.

Governorates	Pollen type	Pollen Percentage (%)
Sohag	*Ziziphus spina-christi*	30%
	Sesamum indicum	30%
	Portulaca oleracea	10%
	Unidentified	30%
Qena	*Sesamum indicum*	45%
	Zea mays	30%
	Unidentified	25%
Luxor	*Medicago sativa*	70%
	Sesamum indicum	20%
	Unidentified	10%

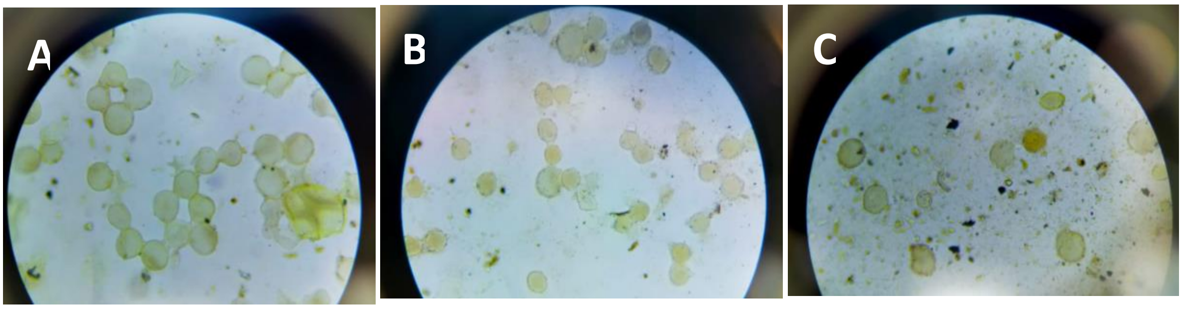

Fig. 1. Photomicrograph of pollen grains recovered from autumn honey samples collected from different governorates in Upper Egypt (A: Sohag B: Qena and C: Luxor).

2. Physical properties:

2.1. Electrical conductivity (EC):

The honey samples analyzed in our study exhibited EC values ranging between the lowest values of 0.3 mS/cm obtained from Luxor to the highest record 0.7mS/cm obtained in honey samples from Qena (Table 2). Significant variations were detected among the three regions.

2.2. Granulation (G/ F):

Data presented in (Table 2) revealed that the lowest granulation (G/ F) value (0.76) was obtained in honey samples from Sohag, and this was significantly different from those collected from Qena (0.93) and Luxor (0.88) regions. Results showed that fructose to glucose ratio ranged between 0.76 and 0.93, below 1.0 indicating that all the tested honeys exhibit a slow crystallization tendency during storage.

2.3. Viscosity:

Data in (Table 2) showed the viscosity values of the studied autumn honey samples from Luxor, Qena, and Sohag governorates. The maximum viscosity value (148.00 poise) was observed in the honey sample from Luxor governorate, whereas, samples from Qena and Sohag had significantly lower values of 142.67 and 138.33 poise, respectively.

Table 2. Physical properties of Egyptian autumn honey obtained from different governorates.

Governorates	EC mS/cm (Mean±SD)	Granulation F/G ratio (Mean±SD)	Viscosity Poise (Mean±SD)	Moisture (%) g/100g (Mean±SD)
Sohag	0.50^{b}±0.01	0.76^{b}±0.02	138.33^{b}±0.01	18.33±1.26
Qena	0.70^{a}±0.02	0.93^{a}±0.03	142.67^{b}±0.02	17.27±1.42
Luxor	0.30^{c}±0.01	0.88^{a}±0.02	148.00^{a}±0.01	17.17±0.76
P	0.0080**	0.0003***	0.0060**	0.4551Ns
LSD 0.05	0.1997	0.0480	4.5656	——

2.4. Moisture content percentage:

The moisture content in autumn honey samples from Sohag, Qena and Luxor in Upper Egypt is presented in (Table 2). The obtained results indicated that Sohag bee honey had the highest moisture value (18.50%), with slightly lower levels observed in Qena (17.20%) and Luxor (17.17%). Nevertheless, the differences among these samples were statistically insignificant.

3. Chemical properties:

3.1. Acidity profile:

The acidity (pH, Free acidity, Lactone and Total acidity) levels in autumn honey samples from (Sohag, Qena, and Luxor), in Upper Egypt are shown in (Table 3). Data analysis revealed that Luxor honey samples exhibited the highest pH value, followed by Sohag and Qena honeys, with a statistically significant difference among the samples. In contrast, Qena bee honey recorded the highest level of free acidity (57.50 meq/kg), followed by Luxor and then Sohag, with a significant difference among them. Regarding lactone content, the highest values (10meq/kg) were observed in Sohag honey, followed by Qena and Luxor; however, the differences were not statistically significant. In terms of total acidity, Sohag again showed the highest levels, followed by Qena and Luxor, with significant differences detected between samples.

Table 3. Acidity profile in fresh honey samples obtained from different governorates.

Governorates	PH (Mean±SD)	Free acidity meq/Kg (Mean±SD)	Lactone meq/Kg (Mean±SD)	Total acidity meq/Kg (Mean±SD)
Sohag	5.8^{a}±0.2	27.5^{c}±2.5	10.0±2.0	37.5^{a}±2.5
Qena	5.3^{b}±0.2	57.5^{a}±3.0	8.5±0.5	28.0^{b}±2.0
Luxor	5.9^{a}±0.3	47.5^{b}±2.5	7.0±1.0	20.0^{c}±1.0
P	0.0444 *	0.000***	0.0837NS	0.000***
LSD 0.05	0.4755	5.3484	——	3.8668

3.2. Sugars content percentage:

The mean percentages of analyzed sugars in autumn honey samples obtained from the studied localities Luxor, Qena and Sohag governorates, Upper Egypt are illustrated in (Table 4).Results showed that the high fructose content (%) of the examined honey samples was 39.26% in Sohag, followed by 38.7 % and 38.06% for Luxor and Qena, respectively with no statistical difference between them. On the contrary, the highest glucose content (35.34 %) was recorded in honey from Qena governorate, while the lowest value (29.88%) was found in honey from Sohag governorate, with a significant statistical difference. Trace amounts of sucrose were detected in most of analyzed autumn honey specially collected from Sohag (0.20%). Regarding maltose content, honey samples recorded 8.78, 7.40 and 10.17% for Sohag, Qena and Luxor, respectively, with statistically significant differences.

Table 4. Sugar content percentage of Egyptian honey samples obtained from the studied governorates Luxor, Qena, and Sohag in Upper Egypt.

Governorates	Fructose (g/100g) Mean±SD	Glucose (g/100g) Mean±SD	Sucrose (g/100g) Mean±SD	Maltose (g/100g) Mean±SD
Sohag	39.26±0.8	29.88^{b}±1.5	0.20^{b}±0.02	8.78^{ab}±0.77
Qena	38.06±0.6	35.34^{a}±1.7	0.21^{b}±0.02	7.40^{b}±0.53
Luxor	38.7±0.4	34.22^{a}±0.89	0.42^{a}±0.03	10.17^{a}±0.97
P	0.1352Ns	0.0071**	0.000***	0.0138*
LSD 0.05	——	2.8089	0.04755	1.5538

3.3. Hydroxymethylfurfural (HMF):

Data presented in (Table 5) showed the HMF contents in autumn honey samples obtained from Sohag, Qena, and Luxor, in Upper Egypt. The analysis of HMF contents in honey samples ranged from3.26 mg/kg inthe Sohag honey sample and the highest level of 7.16 mg/kg detected in samples from Qena governorate. Statistical analysis showed a significant difference in the HMF concentrations across the samples, indicating variability in the levels of HMF between the different regions.

3.4. Diastase activity:

Results indicated that diastase activity exhibited considerable differences among the tested samples (Table 5), as samples from Sohag recorded the highest diastase number (DN)(62.18) followed by Qena (60.09) and Luxor (37.37) Gothe unit**.** Statistical analysis revealed a significant difference in diastase activity between Luxor and other governorates.

Table 5. HMF content and diastase enzymes activity of honey samples obtained from different governorates in Upper Egypt.

Governorates	HMF (mg/kg) (Mean ±SD)	Diastase (DN) (Mean ±SD)
Sohag	3.26^{c} ± 0.55	62.18^{a} ± 2.77
Qena	7.16^{a}± 0.79	60.09^{a} ± 2.73
Luxor	5.85^{b} ±0.45	37.37^{b} ± 1.10
P	0.0007***	0.0000***
LSD 0.05	1.2339	4.6704

DISCUSSION

The quantitative and qualitative assessment of pollen in Egyptian autumn honey is one of the important criteria that distinguish it from other similar types of honey. It can be considered alongside the physical and chemical properties of Egyptian autumn honey, with the goal of preserving the reputation and quality of Egyptian honey and exposing fraud involving other types of honey. Pollen analysis of our honey samples collected from three regions in Upper Egypt (Luxor, Qena, and Sohag) revealed that honey samples from Luxor were grouped as unifloral honey as they contain dominant pollen grains, *M. sativa* at an average of 70%, while *S. indicum* pollen accounted for 20% and the remaining 10% was classified as unidentified pollen. Likewise, the qualitative pollen analysis in all autumn honey samples from Qena governorate was also classified as unifloral (monofloral) honey, with *S. indicum* as predominant pollen at 45%, secondary pollen of *Z. mays* at 30 % and 25% unidentified pollen. On the other hand, honey samples from Sohag governorate were classified as multifloral honey, with *Z. spina-christi* and *S. indicum* pollen each averaging 30 %along with 10% rare *P. oleracea* pollen and 30% unidentified pollen. In the same context, (Alwaseai *et al.,*2022) reported that Sidr (*Ziziphus* sp.) pollen comprised 63% of the total pollen content in autumn honey samples from Shabwah, indicating a monofloral origin. In addition, the pollen spectrum analysis of honey samples from Panama by (Rivera*et al*., 2023) confirmed their multiflora nature, based on the presence of 15 - 37 different pollen types per sample and no single pollen type exceeded 45% of the total pollen content. This dispersion pattern complies with the standard threshold for identifying honey as multiflora rather than unifloral.

A high proportion of unidentified pollen was found in honey samples from Sohag, which may be due to the limited representation of wild or secondary floral sources in regional reference collections. Supporting this, (El-Sofany *et al*., 2020) reported significant mismatches between labeled and actual pollen content in honeys from various Egyptian governorates, highlighting the challenges of melissopalynology when local flora are under-documented. On the other hand, physicochemical analysis of honey is essential for assessing its quality, ensuring its botanical and geographic origin, and determining its suitability for safe consumption or medicinal applications. Honey is a complex, viscous substance whose quality is influenced by several key physical properties, including EC, granulation, viscosity and moisture content(Faustino and Pinheiro, 2021; Vîjan *et al*., 2023).

Electrical conductivity plays a crucial role in determining the physical characteristics of honey (Chettoum *et al*., 2023)**.** The EC of honey was measured to gain insights into the mineral composition of honey samples. The analyzed samples in our study exhibited EC values ranging from a minimum of 0.3 mS/cm in honey from Luxor to a maximum of 0.7mS/cm in samples from Qena. As per the Codex Alimentarius, the EC for nectar honey must not exceed 0.8 ms/cm (Alimentarius, 2001a; Council, 2002). Since the EC of honey reflects the mineral richness and serves as a key quality indicator, our findings confirm that all studied honey samples fall within the acceptable limits, complying with international honey quality standards.

The glucose-to-fructose (F/G) ratio plays a crucial role in the granulation process of honey. Studies by (Al-Jouri *et al*., 2017) identified the F/G ratio as the key determinant of crystallization rate. A fructose-to-glucose ratio of 1.14 indicates a higher tendency for granulation compared to honeys with much lower ratios (Sathianarayanan *et al*., 2024). In our study, all analyzed honey samples exhibited glucose to-fructose ratios ranging between 0.76 and 0.93. Science these values are below 1.0, they indicate a slow crystallization tendency on storage, a feature commonly preferred by consumers. Viscosity is a key physical and sensory property of honey, influencing both its quality and the efficiency of honey-processing operations. It plays a crucial role across various production stages, including extraction, filtration, blending, pumping, processing, and packaging (Yanniotis *et al*., 2006).In the present study, viscosity values of autumn honey ranged from a maximumof148.00 poise in Luxor honey samples to the minimum of 138.33 poise in those from Sohag. These variations are influenced by temperature and moisture content, as their higher levels of both factors lead to reduce viscosity.

In the same context, honey is considered unripe when its moisture content exceeds 20%. Monitoring moisture levels is essential as it is a key quality parameter that directly impacts honey's shelf life. Variety of factors, including climate, season, botanical origin, and the degree of maturity within the hive significantly influence the moisture levels in honey (Puścion-Jakubik *et al*., 2020). In our study, the moisture content of all examined autumn honey samples, did not exceed 18.50%, aligning with the limits accepted by both Egyptian standards and Codex Alimentarius International Standard (Yong *et al*., 2022; Omran *et al*., 2023) which stipulate that moisture content should not exceed 20%**.** Excess moisture can lead to fermentation, making the honey less stable and more prone to spoilage. Therefore, maintaining optimal moisture levels is essential for ensuring the quality and longevity of honey products (Sharma *et al*., 2023)**.** Likewise, the acidity of honey is primarily due to organic acids, in particular, gluconic acid, which contributes to its flavor, texture, shelf life, and stability of honey (Warui *et al*., 2019)**.**

The pH values of our samples ranged between 5.9 and 5.3, which are considered preferable for honey stability and lower fermentation risk. Regarding free acidity, honey samples from Luxor and Sohag governorates recorded low values (<50 meq/kg) which is a sign of good quality honey. Elevated free acidity suggests fermentation or degradation. In contrast, the honey sample from Qena recorded a higher value of 57.50 meq/kg, offering convincing evidence of the delicate connection between honey composition and its botanical origin (Sharaf El-Din *et al.,* 2024). Moreover, total acidity values for all analyzed autumn honey samples remained below 40 meq/kg, which aligns with the preferred limit for good honey quality as proposed by the Codex Alimentarius (Commission, 2009). Another important parameter in assessing honey quality, is its sugar content, which a key factor of both authenticity and purity (Geană *et al*., 2020). Analyzing the sugar composition of honey serves as a crucial indicator to ascertain whether honeybees primarily foraged on flower nectar or were artificially fed a sugar solution. Discrepancies in the glucose and fructose levels can provide evidence of artificial feeding methods (Kanelis *et al*., 2022). Across all honey samples examined in the current study, sucrose content did not surpass 5%, a threshold accepted as indicative of pure and unadulterated honey. Monitoring sucrose levels is crucial for evaluating honey authenticity and quality, as higher sucrose levels may indicate either artificial bee feeding or adulteration of honey (Salvador *et al*., 2019). Turning to another property, HMF content serves as an important indicator of honey's freshness and quality.HMF is typically absent in freshly harvested honey but its levels gradually increase over time due to storage and heat exposure. It is considered one of the most critical parameters for assessing both the purity and freshness of honey (Mouhoubi *et al*., 2018; Ali, 2024).

Overall, the acceptable limit for HMF in honey is 40 mg/kg. However, in tropical regions characterized by hotter climates, this limit is extended to 80 mg/kg to account for the impact of higher temperatures on honey composition(Islam *et al.,* 2014). In our study, all tested samples were within the permissible range of HMF content not exceeding7.16 mg/kg that reflect the freshness of samples and indicate proper handling as avoiding heat exposure and reducing storage time prior to the experiment. Consequently, HMF serves as a reliable indicator of honey freshness and quality. Diastase enzymes are crucial components of honey, involving in converting nectar and honeydew into the final product. They act as catalysts for biochemical reactions and serve as indicators of honey processing and treatment. A reduction in diastase number can serve as a marker of honey adulteration particularly by adding inverted sucrose or hydrolyzed starch namely high fructose corn syrup (HFCS) (Voldřich *et al*., 2009; Alaerjani *et al*., 2022). In the current work, the enzyme activity varied among the honey samples from Sohag, Qena and Luxor governorates. Sohag samples recorded the highest activity (62.50) followed by Qena (60.00) and Luxor (37.50) Gothe unit corresponding to approximately 5.0, 4.8, and 3.0 Schade units, respectively. Despite the lower enzyme activity in samples, all are acceptable if their HMF content does not exceed 15 mg/kg. In this study, all samples were within this threshold (Alimentarius, 2001b). Therefore, based on the diastase–HMF relationship, all samples are considered of acceptable quality.

CONCLUSION

This work identifies and acknowledges the distinctive characteristics of autumn honey from different region of Upper Egypt. The findings from this study are intended to offer valuable recommendations for beekeepers and honey producers. Our results confirmed that the physical and chemical attributes of analyzed Egyptian autumn honey generally align well with the majority of international quality standard and are mostly of good quality. Variations in honey quality are influenced by several factors, particularly the floral source. Understanding the physicochemical properties of autumn honey is essential for establishing certification standards and improving local beekeeping practices. Additionally, this study emphasizes the importance of migratory beekeeping and encourages bee keepers to relocate their colonies to regions rich in floral resources to meet bees' nutritional needs an optimize honey production.

REFERENCES

Adenekan, M. O., Amusa, N. A., Lawal, A. O., & Okpeze, V. E. (2010). Physico-chemical and microbiological properties of honey samples obtained from Ibadan. *Journal of Microbiology and Antimicrobials*, *2*(8), 100–104.

Al-Ghamdi, A., Mohammed, S. E. A., Ansari, M. J., & Adgaba, N. (2019). Comparison of physicochemical properties and effects of heating regimes on stored Apis mellifera and Apis florea honey. *Saudi Journal of Biological Sciences*, *26*(4), 845–848.

Al-Jouri, E., Daher-Hjaij, N., Alkattea, R., Alsayed Mahmoud, K., & Saffan, A.-M. (2017). Evaluation of changes in some physical and chemical properties of syrian honey, affecting honey crystallization due to the different geographical sites. *Biological Forum-An International Journal, 9*, 185–193.

Alaerjani, W. M. A., Abu-Melha, S., Alshareef, R. M. H., Al-Farhan, B. S., Ghramh, H. A., Al-Shehri, B. M. A., Bajaber, M. A., Khan, K. A., Alrooqi, M. M., & Modawe, G. A. (2022). Biochemical reactions and their biological contributions in honey. *Molecules*, *27*(15), 4719.

Ali, H. M. (2024). Efficient and sensitive determination of storage time-temperature marker 5-hydroxy methyl furfural in bee honey based on Fluorescence quenching of human serum albumin. *Microchemical Journal*, *200*, 110427.

Alimentarius, C. (2001a). Commission standards. *Codex Standards for Honey,(1981/Revised 1987/Revised 2001), FAO–Rome*, 1–7.

Alimentarius, C. (2001b). Revised codex standard for honey. Rev. 2 [2001]. *24th Session of the Codex Alimentarius In*.

Almasaudi, S. (2021). The antibacterial activities of honey. *Saudi Journal of Biological Sciences*, *28*(4), 2188–2196.

Alwaseai, A. M., Alsharhi, M. M., & Algabr, H. M. (2022). Physicochemical Properties Evaluation for Some Yemeni Honeys. *International Journal of Food Science and Biotechnology*, *7*, 1–7.

Bogdanov, S., Martin, P., & Lullmann, C. (2002). Harmonised methods of the international honey commission. *Swiss Bee Research Centre, FAM, Liebefeld*, *5*(1), 1–62.

Chakir, A., Romane, A., Marcazzan, G. L., & Ferrazzi, P. (2016). Physicochemical properties of some honeys produced from different plants in Morocco. *Arabian Journal of Chemistry*, *9*, S946–S954.

Chettoum, A., Feknous, N., Boumendjel, M., Mekhancha, D.-E., Boudida, Y., Sedari, A., Berredjem, A., Ati, H., Zaidi, K., & Boumendjel, A. (2023). Biological, physicochemical and antibacterial properties of pure honey harvested at the municipality of Seraïdi (Annaba, north east of Algeria). *Food Science and Technology*, *43*, e41022.

Commission, I. H. (2009). Harmonised methods of the international honey commission. *URL< Http://Www. Bee-Hexagon. Net/En/Network. Htm> Accessed*, *23*, 16.

CoStat Statistical Software, 2005.Microcomputer program analysis version 6.311.CoHort Software, Monterey, California, USA.

Council, E. U. (2002). Council Directive 2001/110/EC of 20 December 2001 relating to honey. *Official Journal of the European Communities L*, *10*, 47–52.

Cunniff, P. (1995). Association of official analytical chemists. *Official Methods of AOAC Analysis*.

De La Fuente, E., Ruiz-Matute, A. I., Valencia-Barrera, R. M., Sanz, J., & Castro, I. M. (2011). Carbohydrate composition of Spanish unifloral honeys. *Food Chemistry*, *129*(4), 1483–1489.

Draiaia, R., Dainese, N., Borin, A., Manzinello, C., Gallina, A., & Mutinelli, F. (2015). Physicochemical parameters and antibiotics residuals in Algerian honey. *African Journal of Biotechnology*, *14*(14), 1242–1251.

El-Seedi, H. R., El-Wahed, A. A. A., Zhao, C., Saeed, A., Zou, X., Guo, Z., Hegazi, A. G., Shehata, A. A., El-Seedi, H. H. R., & Algethami, A. F. (2022). A Spotlight on the Egyptian Honeybee (Apis mellifera lamarckii). *Animals*, *12*(20), 2749.

El-Sofany, A., Naggar, Y. Al, Naiem, E., Giesy, J. P., & Seif, A. (2020). Authentication of the botanical and geographic origin of Egyptian honey using pollen analysis methods. *Journal of Apicultural Research*, *59*(5), 946–955.

El Sohaimy, S. A., Masry, S. H. D., & Shehata, M. G. (2015). Physicochemical characteristics of honey from different origins. *Annals of Agricultural Sciences*, *60*(2), 279–287.

Erdtman, G. (1960). *Pollen walls and angiosperm phylo-geny.*

Faustino, C., & Pinheiro, L. (2021). Analytical rheology of honey: A state-of-the-art review. *Foods*, *10*(8), 1709.

Geană, E.-I., Ciucure, C. T., Costinel, D., & Ionete, R. E. (2020). Evaluation of honey in terms of quality and authenticity based on the general physicochemical pattern, major sugar composition and δ13C signature. *Food Control*, *109*, 106919.

Gómez, J. A., Garcia-Villanova, R. J., Garcia, S. E., Rivas Palá, T., González Paramás, A. M., & Sánchez Sánchez, J. (2000). Geographical discrimination of honeys through the employment of sugar patterns and common chemical quality parameters. *European Food Research and Technology*, *210*, 437–444.

Islam, M. N.; Khalil, M. I.; Islam, M. A.& Gan, S. H. (2014). Toxic compounds in honey. *Journal of Applied Toxicology*, *34*(7), 733–742.

Ismail, M.; Abdallah, E. M., & Elsharkawy, E. R. (2021). Physico-chemical properties, antioxidant, and antimicrobial activity of five varieties of honey from Saudi Arabia. *Asia-Pacific Journal of Molecular Biology and Biotechnology*, *29*, 27–34.

Jones, G. D., & Bryant, V. M. (2014). Pollen studies of East Texas honey. *Palynology*, *38*(2), 242–258.

Kanelis, D.; Liolios, V.; Tananaki, C.& Rodopoulou, M.-A. (2022). Determination of the carbohydrate profile and invertase activity of adulterated honeys after bee feeding. *Applied Sciences*, *12*(7), 3661.

Kang, K.-M., & Yoo, B.S. (2008). Dynamic rheological properties of honeys at low temperatures as affected by moisture content and temperature. *Food Science and Biotechnology*, *17*(1), 90–94.

Laos, K.; Kirs, E.; Pall, R.& Martverk, K. (2011). The crystallization behaviour of Estonian honeys. *Agronomy Research*, *9*, 427–432.

Mouhoubi, T. Z., Ouchemoukh, S., Bey, B. M., Louaileche, H., & Tamendjari, A. (2018). Effect of storage on hydroxymethylfurfural (HMF) and color of some Algerian honey. *International Food Research Journal*, *25*(3), 1044–1050.

Muli, E., Munguti, A., & Raina, S. K. (2007). Quality of honey harvested and processed using traditional methods in rural areas of Kenya. *Acta Veterinaria Brno*, *76*(2), 315–320.

Munro, J. A. (1943). The viscosity and thixotropy of honey. *Journal of Economic Entomology*, *36*(5), 769–777.

Omran, N.S. M., Hassan, M. M. M., Abdel-rahman, M. F., & Desoky, A. E.-A. S. S. (2023). Some physicochemical properties of Egyptian Sidr bee honey in Upper Egypt. *Journal of Sohag Agriscience (JSAS)*, *8*(2), 319–328.

Pătruică, S., Alexa, E., Obiștioiu, D., Cocan, I., Radulov, I., Berbecea, A., Lazăr, R. N., Simiz, E., Vicar, N. M., & Hulea, A. (2022). Chemical composition, antioxidant and antimicrobial activity of some types of honey from Banat region, Romania. *Molecules*, *27*(13), 4179.

Pauliuc, D., Oroian, M., & Ciursă, P. (2021). Organic acids content, sugars content and physicochemical parameters of Romanian acacia honey. *Ukr. Food J*, *10*(1).

Puścion, J.A., Borawska, M. H., & Socha, K. (2020). Modern methods for assessing the quality of bee honey and botanical origin identification. *Foods*, *9*(8), 1028.

Rivera, M. A.; Marrone, M., Bruner-Montero, G., Gaitán, K., de Núñez, L., Otero-Palacio, R., Añino, Y., Wcislo, W. T., Martínez-Luis, S., & Fernández-Marín, H. (2023). Assessment of the quality, chemometric and pollen diversity of Apis mellifera honey from different seasonal harvests. *Foods*, *12*(19), 3656.

Salvador, L., Guijarro, M., Rubio, D., Aucatoma, B., Guillén, T., Vargas Jentzsch, P., Ciobotă, V., Stolker, L., Ulic, S., & Vásquez, L. (2019). Exploratory monitoring of the quality and authenticity of commercial honey in Ecuador. *Foods*, *8*(3), 105.

Sathianarayanan, M. P., Hemani, K., & Gaonkar, S. (2024). Analysis of sugar composition in honey samples using HPLC separation and RI detection. *BTRA Scan*, *53*(2), 5–8.

Schade, J. E., Marsh, G. L., & Eckert, J. E. (1958). Diastase activity and hydroxy-methyl-furfural in honey and their usefulness in detecting heat alteration. *Journal of Food Science*, *23*(5), 446–463.

Sharaf El-Din, H., Samir, R., & Yehia, Y. (2024). Non-Traditional Egyptian Honeys: A Comprehensive Analysis of Chemical Composition, Bioactive Compounds, and Biological Activities. *Egyptian Journal of Agricultural Sciences*, *75*(3), 116–130.

Sharma, R., Thakur, M., Rana, K., Devi, D., & Bajiya, M. R. (2023). Honey, its quality and composition and their responsible factors. *International Journal of Bio-Resource and Stress Management*, *14*(1), 178–189.

Solayman, M., Islam, M. A., Paul, S., Ali, Y., Khalil, M. I., Alam, N., & Gan, S. H. (2016). Physicochemical properties, minerals, trace elements, and heavy metals in honey of different origins: a comprehensive review. *Comprehensive Reviews in Food Science and Food Safety*, *15*(1), 219–233.

Taha, E.-K. A., Al-Jabr, A. M., & Al-Kahtani, S. N. (2017). Honey bees, bee-collected pollen and honey as monitors of environmental pollution at an industrial cement area in Saudi Arabia. *Journal of the Kansas Entomological Society*, *90*(1), 1–10.

Taha, E.-K. A., Al-Kahtani, S., & Taha, R. (2021). Comparison of the physicochemical characteristics of sidr (Ziziphus spp.) honey produced by Apis florea F. and Apis mellifera L. *Journal of Apicultural Research*, *60*(3), 470–477.

Vîjan, L. E., Mazilu, I. C., Enache, C., Enache, S., & Topală, C. M. (2023). Botanical origin influence on some honey physicochemical characteristics and antioxidant properties. *Foods*, *12*(11), 2134.

Voldřich, M., Rajchl, A., Čížková, H., & Cuhra, P. (2009). Detection of foreign enzyme addition into the adulterated honey. *Czech Journal of Food Sciences*, *27*(Special Issue 1), Detection-of.

Warui, M. W., Hansted, L., Gikungu, M., Mburu, J., Kironchi, G., & Bosselmann, A. S. (2019). Characterization of Kenyan honeys based on their physicochemical properties, botanical and geographical origin. *International Journal of Food Science*, *2019*(1), 2932509.

White, J. W. (1962). *Composition of American honeys* (Issue 1261). US Department of Agriculture.

Witczak, M., Juszczak, L., & Gałkowska, D. (2011). Non-Newtonian behaviour of heather honey. *Journal of Food Engineering*, *104*(4), 532–537.

Yanniotis, S., Skaltsi, S., & Karaburnioti, S. (2006). Effect of moisture content on the viscosity of honey at different temperatures. *Journal of Food Engineering*, *72*(4), 372–377.

Yong, C.H., Muhammad, S. A., Fadhullah, W., Hassan, H. M., Mohd Rodhi, A., Mustafa, M. Z., & Kelly, S. D. (2022). Addressing the unfulfilled codex standard for honey for stingless bee honey through lyophilization. *Isotopes in Environmental and Health Studies*, *58*(2), 180–194.

Yupanqui M. J.; Vyas, C.; Aslan, E.; Humphreys, G.; Diver, C., & Bartolo, P. (2022). Honey: An advanced antimicrobial and wound healing biomaterial for tissue engineering applications. *Pharmaceutics*, *14*(8), 1663.

تقييم سِمات الجودة لعسل الخريف المُنتَج في صَعيد مصر.

مصطفى عبدالنعيم صديق أحمد ومحمود على حسن نصرالله ورشا شوكت شكرى سكلا
معهد بحوث وقاية النباتات، مركز البحوث الزراعية، الدقى، الجيزة، مصر.
* بريد المؤلف المراسل:rasha.s.sakla@gmail.com

الملخص

يتم تقييم العسل بشكل عام عن طريق التحليل الفيزيائي الكيميائي لمكوناته. ويعتمد تكوين العسل وخصائصه على أصله الزهري، وموقعه الجغرافي، والعوامل البيئية، وموسم الانتاج، وممارسات مربي النحل. الهدف الرئيسي من هذاالعمل هودراسة وتقييم جودة عسل الخريف المصري الذي يتم إنتاجه في بعض محافظات صعيد مصر. حيث تم جمع عينات عسل نحل الخريف المصري من ثلاث محافظات وهي الأقصروقنا وسوهاج بصعيد مصر، وذلك خلال شهر سبتمبر2023. حيث أُجري التحليل الكمي والنوعي لحبوب اللقاح بالإضافة الي التحليلات الكيميائية والفيزيائية المتعلقة بخواص العسل والتي أُجريت بقسم بحوث النحل– معهد بحوث وقاية النباتات - مركز البحوث الزراعية – الدقي- الجيزة. أظهرت نتائج التحليل الكمي والنوعي لحبوب اللقاح في العينات المختبرة، ان جميع العينات من محافظتي الاقصر وقنا تم تصنيفها على أنها احادية الزهرة بينما كانت عينات العسل من محافظة سوهاج متعددة الزهرة، ويمثلها اكثر من نوع من حبوب اللقاح. كما أكدت النتائج أن الخصائص الفيزيائية والكيميائية لعسل الخريف المصري والتي تمثلت في درجة التوصيل الكهربائي، التبلور، اللزوجة، محتوى الرطوبة، محتوى السكريات، الرقم الهيدروجيني، الحموضة، هيدروكسي ميثيل فورفورال (HMF) بالاضافة الي نشاط انزيم الدياستيز، تتوافق جيدًا مع معظم المواصفات القياسية الدولية. وقد سجلت عينات محافظة قنا أعلى قيمة للتوصيلية الكهربائية (0.7mS/cm) وأعلى مؤشر للتبلور (0.93)، في حين تم تسجيل أعلى لزوجة (148.00 poise) في عسل محافظة الأقصر. أما عينات محافظة سوهاج فقد أظهرت أعلى حموضة كلية (meq/kg 37.5). وبصفة عامة كانت نسبة السكروز أقل من الحد المقبول (5%) في جميع العينات. وسجل اعلي نشاط لإنزيم الدياستيز في عينات سوهاج (62.18 Gothe unit)، بينما احتوت عينات قنا على أعلى تركيزمن (7.16 mg/kg) HMF. وبصفة عامة يُعدّ فهم الخصائص الفيزيائية والكيميائية لعسل الخريف أمرًا أساسيًا لإنشاء علامات الاعتماد وتحسين تربية النحل المحلية وتقديم توصيات قيّمة لمربي النحل ومنتجي العسل.

الكلمات المفتاحية: جودة العسل، الخصائص الفيزيوكميائية، صعيد مصر،طيف حبوب اللقاح