



(RESEARCH ARTICLE)



EVALUATING ACACIA HONEY QUALITY THROUGH BIOCHEMICAL MARKERS OF AUTHENTICITY

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World Journal of Advanced Research and Reviews, 2026, 32(01), 019–025

Publication history: Received on 18 August 2026; revised on 24 September 2026; accepted on 26 September 2026

Article DOI: <https://doi.org/10.30574/wjarr.2026.32.1.2483>

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ABSTRACT

Saudi acacia (Talh) honey, produced from the nectar of *Acacia gerrardii* trees prevalent in Saudi Arabia, is regarded as one of the most distinguished varieties of honey in the region. Locals use it extensively, for therapeutic and medical purposes, and it is also incorporated into various foods. This study examined two key quality indicators hydroxymethylfurfural (HMF) level and diastase activity (DN) in fresh Talh honey. Adherence to guidelines is crucial for the health and purity of honey. Measuring the HMF and DN is important because elevated HMF or reduced DN may indicate prolonged storage, poor conditions, overheating, or adulteration. These indicators also reflect how effectively beekeepers maintain honey quality during extraction, storage, and marketing. The mean HMF levels were 2.93 ± 1.0 and 1.32 ± 0.3 mg/kg in the first and second years, respectively, while the mean DN values were 12.49 ± 0.1 and 19.3 ± 1.8 Schade units in the same years, respectively. These results were well within local and international standard requirements. Such measurements are valuable for assessing honey quality, which is essential for both worldwide trade and medical use. The present study therefore provides baseline information on acacia (Talh) honey.

Keywords: *Acacia gerrardii*; Acacia honey; Hydroxymethylfurfural (HMF); Diastase Activity (DN); Quality honey; Saudi Arabia.

1 INTRODUCTION

Talh trees, native to the Middle East and particularly Saudi Arabia, are trees that provide food for honey bees (Awad et al., 2017). Bees rely heavily on acacia trees for pollen and nectar (Adgaba et al., 2017; Alqarni et al., 2015). Talh honey is one of the most popular and extensively used honeys for food and medicine (Adgaba et al., 2017; Awad et al., 2017) in Saudi Arabia and the Arabian Peninsula. The local name of Talh honey refers to its floral source, as the honey is produced from the nectar of *Acacia gerrardii* Benth. trees (Adgaba et al., 2017; Alqarni et al., 2016; Raweh et al., 2023), which are a main source of highly prized and costly honeys (Alqarni et al., 2015). Honey content and quality are influenced by the nectar's conditions, weather and humidity level inside the hive, and handling during extraction and storage. Other factors also have a negative effect, including overfeeding with sucrose and other sucrose variations, harvesting before maturity, improper storage conditions, and misuse of veterinary drugs (Draiaia et al., 2015). When diving into the fascinating realm of honey's chemical analysis, there are several key parameters such as hydroxymethylfurfural (HMF) content, activity of diastases, acidity levels, and moisture content. Each of these parameters is vital for understanding the honey quality (Pasias et al., 2017). HMF content and diastase activity are the most crucial criteria for the quality control of honey samples. HMF is a furanic compound formed by the acid catalyzed dehydration of sugars during the heat treatment of food (caramelization), and as intermediate in the Maillard reaction. A maximum limit of 40 mg/ kg of 5-HMF content in honey has been set by the European Union and the Codex Alimentarius (Korkmaz, 2023). Honey naturally contains enzymes called diastases, which break down starch into a mixture of maltose (a disaccharide) and maltotriose (a trisaccharide). These enzymes are heat-sensitive (thermolabile) and can indicate overheating and the degree of preservation of the product (da Silva et al., 2016; Escuredo & Seijo, 2019); (Ahmed et al., 2013). Like 5-HMF, the diastatic activity may decrease during storage or when honey is heated above 60 °C, so it can serve as a signal of aging and temperature increase (da Silva et al., 2016; Korkmaz, 2023). The minimum diastase value required by the current regulations are 8.00 Göthe units. Diastase activity in honey can fluctuate, because a high flow of concentrated nectar results in lower enzyme content and lower pollen consumption. The variations in the enzyme content in honeys is also influenced by the bees' age, the nectar collection period, the physiological period of the colony, the amount of nectar flow, and its sugar content (Haouam et al., 2019). This study aimed to evaluate the quality of 40 Talh honey samples sourced from local beekeepers throughout Saudi Arabia over two-years. It aimed to investigate not only the quality of the honey itself, but also to compare the results with local and international standards. It focused on two pivotal quality parameters: activity of the diastase (DN) and HMF level.

2 MATERIAL AND METHODS

2.1 Honey Samples

During the 2023-2024 season, forty samples of natural Talh honey were collected from local beekeepers in Saudi Arabia. Twenty Talh honey samples were collected each year. Before analysis, the honey samples, each weighing 500 grams, were stored at 24°C in sterile glass jars in a dry, dark environment. Each sample was homogenized prior to analysis to ensure homogeneity.

2.2 Hydroxymethylfurfural (HMF) Analysis

AOAC (2010) protocol was used to determine HMF. Five grams of honey sample were dissolved in twenty-five mL of distilled water, and then five mL of each of the Carrez I and Carrez II clarifying solutions were added. A fifth of the filtrate was then scraped from the surface, and the final volume was raised to 50 mL. Next, a GenesysTM10S UV-visible spectrometer was employed. The HMF content was calculated using the following formula: $\text{HMF (mg/kg)} = \frac{A_{284} - A_{336}}{149.7}$, where A_{284} and A_{336} represent the absorbances at 284 and 336 nm, respectively. 149.7: a component based on the mass of the sample and the HMF molecular weight.

2.3 Diastase Activity (DN) Analysis

Diastase activity was measured using the enzymatic-spectrophotometric approach (Bogdanov et al., 2004; Raweh et al., 2023), which involved incubating samples of honey and buffered soluble starch in a thermostatic water bath at 40 °C. In order to measure the sample's absorbance at 660 nm, 1 mL of an aliquot from the mixture was taken out every 5 minutes. Next, using the absorbance versus time plot, the reaction time (tx) in minutes needed to get the absorbance value below 0.235 nm was determined. The diastase value was calculated using the formula $\text{DN} = 300/\text{tx}$. The amount of enzyme in 1 g of honey that can hydrolyze 1% starch after a 1-hour incubation at 40 was expressed as Schade units/g of honey.

2.4 Statistical Analysis

The findings were compared with international regulatory standards. Means, standard deviations, and the correlation coefficient (HMF-Diastase index) were calculated using Statistic version 8 software. Tukey's test was used to compare the means.

3 RESULTS

In this investigation, the Talh honey samples' HMF values for the first year were statistically significant ($p < 0.05$) (Table 1), ranging from 0.13 ± 0.0 to 18.0 ± 0 mg/kg with an overall average of 2.93 ± 1.0 mg/kg. All samples were well below the maximum limit of 40 mg/kg set by local and international standards for honey, indicating that the honey was fresh and had not been subjected to high heating or long-term storage. HMF content is also a good indicator of the beekeeping practices during honey harvesting, sorting, packaging, and marketing, as high HMF levels indicate excessive heating, prolonged storage periods, or unsuitable storage conditions.

According to Table 1, the average diastase Activity in Saudi Talh honey for the first year varied from 7.67 ± 0.3 to 27.3 ± 0.7 , with an overall average of 12.49 ± 0.1 . All samples were within the international and local standards for diastase activity, with a minimum of 8 units on the Schade scale. This clearly indicates that the honey samples were fresh and had not been exposed to high temperatures, heating, or improper storage for extended periods. This reflects compliance with recommended processing standards during and after harvesting. Because a low levels of diastase number is evidence that the honey was exposed to unfavorable conditions during the sorting, storage and marketing process.

Table 1: Hydroxymethylfurfural values and diastase enzyme activity of Saudi Talh honey in the first year (means $\pm$ SE).

Sample	HMF	DN
1	0.13 ± 0.0^f	27.3 ± 0.7^a
2	2.0 ± 0.6^{cdef}	14.0 ± 2.8^{bc}
3	1.30 ± 0.1^{cdef}	10.3 ± 0.9^{bc}
4	1.70 ± 0.1^{cdef}	12.3 ± 1.3^{bc}
5	2.0 ± 0.6^{cdef}	9.0 ± 0.6^{bc}
6	3.0 ± 0.6^c	8.33 ± 0.3^c
7	2.60 ± 0.2^{cd}	9.67 ± 0.7^{bc}
8	0.5 ± 0.3^{ef}	17.3 ± 5.5^b
9	1.76 ± 0.2^{cdef}	15.7 ± 0.9^{bc}
10	1.0 ± 0.3^{def}	11.7 ± 1.2^{bc}
11	1.33 ± 0.3^{cdef}	11.7 ± 0.3^{bc}
12	0.63 ± 0.0^{ef}	15.0 ± 2.5^{bc}
13	0.40 ± 0.1^{ef}	16.0 ± 1.0^{bc}
14	14.7 ± 0.9^b	7.67 ± 0.3^c
15	2.27 ± 0.1^{cde}	9.0 ± 0.6^{bc}
16	0.67 ± 0.2^{def}	8.0 ± 0.3^c
17	0.80 ± 0.1^{def}	16.0 ± 0.6^{bc}
18	1.67 ± 0.3^{cdef}	11.3 ± 1.2^{bc}
19	18.0 ± 0.6^a	8.0 ± 0.6^c
20	2.17 ± 0.2^{cde}	11.3 ± 0.9^{bc}
Average	2.93 ± 1.0^b	12.49 ± 1.0^a

Means that have identical letters not statistically different ($p < 0.05$ Tukey's test).

In the second year, the HMF level ranged from 0.0 ± 0.0 to 5.23 ± 0.1 mg/kg, with an average of 1.32 ± 0.3 mg/kg. These values are within local and international limits and were lower than the values of the first year. While the level of diastase enzyme activity ranged from 10.7 ± 0.3 to 35.7 ± 0.3 , with an average of 19.3 ± 1.8 . These values are within local and international limits and were lower than the values of the first year. This indicates an improvement in the quality of Talh honey produced through HMF values and diastase enzyme activity for the second year as a result of the good treatments during its production and marketing stages, as shown in Table (2). On the other hand, diastase activity and HMF can be utilized to detect artificial honeybee feeding.

Table 2: Hydroxymethylfurfural values and diastase activity of Saudi Talh honey in the second year (means $\pm$ SE).

Sample	HMF (mg/kg)	DN
A	1.5 ± 0.3^{bc}	12.3 ± 2.3^d
B	0.9 ± 0.0^{bcd}	13.7 ± 0.9^d
C	0.0 ± 0.0^d	19.7 ± 0.9^{cd}
D	0.33 ± 0.1^{cd}	14.3 ± 4.3^d
E	0.17 ± 0.2^{cd}	26.3 ± 0.9^{bc}
F	1.33 ± 0.1^{bcd}	11.7 ± 0.3^d
G	0.67 ± 0.2^{bcd}	17.3 ± 0.3^{cd}
H	1.33 ± 0.3^{bcd}	19.7 ± 2.3^{cd}
I	0.20 ± 0.1^{cd}	16 ± 4.5^d
J	2.0 ± 0.6^b	15.7 ± 0.3^d
K	1.13 ± 0.1^{bcd}	18.3 ± 0.3^{cd}
L	5.23 ± 0.1^a	11.3 ± 0.3^d
M	0.70 ± 0.1^{bcd}	16.0 ± 1.5^d
N	1.43 ± 0.1^{bcd}	33.3 ± 0.9^{ab}
O	0.83 ± 0.0^{bcd}	35.7 ± 0.3^a
P	4.33 ± 0.9^a	18.0 ± 0.6^{cd}
Q	1.43 ± 0.1^{bcd}	11.3 ± 0.9^d
R	1.37 ± 0.1^{bcd}	10.7 ± 0.3^d
S	0.20 ± 0.0^{cd}	31.3 ± 0.3^{ab}
T	1.33 ± 0.0^{bcd}	32.3 ± 0.3^{ab}
Average	1.32 ± 0.3^b	19.3 ± 1.8^a

Means that have identical letters not statistically different ($p < 0.05$ Tukey's test).

Diastase enzyme activity (DN) and HMF have a negative correlation; the higher the DN value, the lower the HMF value tends to be, and vice versa (Table 3).

Table 3: Pearson correlation coefficients between HMF and DN of Talh honey.

Variables	HMF	DN
HMF	1	-0.3322
Year	-0.2305	0.4437

Correlation is significant at the 0.05 probability level.

The diastase activity of Saudi Talh honey samples significantly increased in the second year compared to the first, and the hydroxymethylfurfural values decreased, indicating a discernible improvement in honey quality. This shows that

better treatment techniques used by beekeepers during the production and marketing period have enhanced the quality of honey (Table3).

Table 4 Comparison between HMF values and diastase activity (DN) of Saudi Talh honey between the first and second years.

Variables	HMF	DN
1st	2.93±1.0 ^b	12.49±1.0 ^a
2nd	1.32±0.3 ^b	19.25±1.8 ^a
P< 0.05	0.0113	0.001

Means that have identical letters not statistically different (p <0.05)

4 DISCUSSION

Honey naturally contains HMF, which together with diastase activity is an important international criterion for assessing for honey quality, and an indicator of heat treatment and storage conditions. HMF level are essential for maintaining the nutritional value of honey and increasing its marketability depend on low levels of (HMF). The quality of honey is assessed by measuring its enzyme content (Draiaia et al., 2015; Iftikhar et al., 2014). According to Mouhoubi-Tafnine (2018) and Raweh et al. (2022), HMF is one of the most crucial factors for monitoring the freshness of honey, beekeeping methods, exposure to high temperatures, and storage conditions. The HMF content of fresh honey is generally low and increases when the honey, especially dark-colored honey is heated, stored for a long time, or improperly handled by beekeepers (Tesfaye et al., 2016).

Our result revealed that mean HMF content of the Saudi Talh honey samples was 2.93±1.0 and 1.32±0.3 mg/kd in the first and second years respectively, which are within the limits of the local and international standard limits and is evidence of the Talh honey's freshness. Honey quality is indicated by low levels of HMF (Manickavasagam et al., 2024; Raweh et al., 2023). Our findings are consistent with previous studies on the amount of HMF in fresh honey, which have demonstrated that fresh honey has either very little or no HMF (Alghamdi et al., 2020; Khan et al., 2015; Raweh et al., 2022). These findings also support those of (Ghoniemy et al., 2022; Kędzierska-Matysek et al., 2025). These findings, when looking at fresh honey, are also in line with research by Chou et al. (2020) and Manickavasagam et al. (2024). In contrast, poor storage and prolonged storage have been linked to a rise in HMF (Šarić et al., 2008).

The diastase enzyme is an important enzyme secreted by bees during the conversion of nectar into honey. A decrease in enzyme levels indicates that the honey has been heated or that beekeepers have handled it incorrectly during extraction, marketing, and storage. (Raweh et al., 2023; Sahin et al., 2020). Diastase converts polysaccharides such as amylose into glucose (Alaerjani et al., 2022). Despite it is produced by honey bees, the diastase enzyme can be utilized as a marker of the botanical origin of honey because nectar-producing plants are the source of the diastase activity's substrate (Manickavasagam et al., 2024). This is due to the fact that nectar-producing plants provided the substrate for the diastase activity. According to the Codex Alimentarius Standard and the Saudi Honey Directive, honey must have a minimum diastase activity of eight Schade units (Bogdanov & Martin, 2002; Raweh et al., 2022). Our results showed that the diastase enzyme activity in Saudi Talh honey samples met the requirements of international and local standards (≥ 8), with average values of 12.49 ± 0.1 in the first year and 19.3 ± 1.8 Schade units in the second year, which demonstrates the freshness of the Saudi Talh honey.

According to Chou et al. (2020), beekeepers must handle honey properly during sorting, storage, and selling in order to preserve its quality and the amount of activity diastase enzyme in it. Diastase activity in honey varies widely, and depends on factors such as the sugar content of the honey, the location of flowers, the region of honey origin, the time of nectar collection, the age of the bees, and the specific bee colony. Da Silva et al. (2020) found that the diastase activity ranges from 11.14 to 22.69, which is consistent with our study. The findings align with other earlier research investigations (Bell & Grainger, 2023; Huang et al., 2019; Lupu et al., 2025). Šarić et al. (2008) found diastase activity in the honeys they evaluated to be nearly identical to our findings. We found an inverse relationship between diastase activity and HMF in this work, meaning that if the level of HMF rises, diastase activity falls, and vice versa. These findings support the conclusion of (Pasiyas et al., 2017), who demonstrated that diastase activity and HMF content are indices of freshness. Our results are also consistent with those of (Draiaia et al., 2015; Iqbal et al., 2025; Lupu et al., 2025; Raweh et al., 2022).

5 CONCLUSION

The physicochemical requirements of honey quality are crucial for detecting adulteration, prolonged storage, heating exposure, and exposure to unconventional beekeeping practices during the sorting, and marketing processes. In this study, samples of Saudi acacia (Talh) honey from two consecutive years were examined for hydroxymethylfurfural and the diastase enzyme. These are some of the most crucial criteria for evaluating the freshness and quality of honey. They reflect how the quality, presentation and storage of Saudi Talh honey are managed. This suggests that beekeepers are aware of how to preserve the quality of Talh honey, The accessibility of this data regarding this honey variety is crucial for its promotion, considering its prevalent application in therapeutic medicine.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Acknowledgments

The authors are thankful for the research support through "Ongoing Research Funding program (ORF-2026-1692)", King Saud University, Riyadh, Saudi Arabia.

Funding Source

Ongoing Research Funding program (ORF-2026-1692), King Saud University, Riyadh, Saudi Arabia.

Disclosure of conflict of interest

The authors declare no conflicts of interest regarding this manuscript.

REFERENCES

- [1] Adgaba, N., Al-Ghamdi, A., Tadesse, Y., Getachew, A., Awad, A. M., Ansari, M. J., Owayss, A. A., Mohammed, S. E. A., & Alqarni, A. S. 2017. Nectar secretion dynamics and honey production potentials of some major honey plants in Saudi Arabia. *Saudi Journal of Biological Sciences*, 24(1), 180-191.
- [2] Ahmed, M., Djebli, N., Aissat, S., Khiati, B., Meslem, A., & Bacha, S. 2013. In vitro activity of natural honey alone and in combination with curcuma starch against *Rhodotorula mucilaginosa* in correlation with bioactive compounds and diastase activity. *Asian Pac J Trop Biomed*, 3(10), 816-821.
- [3] 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., & Mohammed, M. E. A. 2022. Biochemical Reactions and Their Biological Contributions in Honey. *Molecules*, 27(15), 4719.
- [4] Alghamdi, B. A., Alshumrani, E. S., Saeed, M. S. B., Rawas, G. M., Alharthi, N. T., Baeshen, M. N., Helmi, N. M., Alam, M. Z., & Suhail, M. 2020. Analysis of sugar composition and pesticides using HPLC and GC-MS techniques in honey samples collected from Saudi Arabian markets. *Saudi Journal of Biological Sciences*, 27(12), 3720-3726.
- [5] Alqarni, A. S., Awad, A. M., & Owayss, A. A. 2015. Evaluation of *Acacia gerrardii* Benth. (Fabaceae: Mimosoideae) as a honey plant under extremely hot-dry conditions: flowering phenology, nectar yield and honey potentiality. *Journal of Animal and Plant Sciences*, 25(6), 1667-1674.
- [6] Alqarni, A. S., Owayss, A. A., & Mahmoud, A. A. 2016. Physicochemical characteristics, total phenols and pigments of national and international honeys in Saudi Arabia. *Arabian Journal of Chemistry*, 9(1), 114-120.
- [7] AOAC. (2010). AOAC. *Officials Methods of Analysis* (17th ed ed., Vol. 59).
- [8] Awad, A. M., Owayss, A. A., & Alqarni, A. S. 2017. Performance of two honey bee subspecies during harsh weather and *Acacia gerrardii* nectar-rich flow. *Scientia Agricola*, 74, 474-480.
- [9] Bell, A. R., & Grainger, M. N. C. 2023. Accelerated loss of diastase in manuka honey: Investigation of manuka specific compounds. *Food Chemistry*, 426, 136614.
- [10] Bogdanov, S., & Martin, P. (2002). *Honey Authenticity: a Review*.
- [11] Bogdanov, S., Ruoff, K., & Oddo, L. P. 2004. Physico-chemical methods for the characterisation of unifloral honeys: a review. *Apidologie*, 35.
- [12] Chou, W., Liao, H., Yang, Y., & Peng, C. 2020. Evaluation of honey quality with stored time and temperatures. *J. Food Nutr. Res*, 8, 591-599.

- [13] Da Silva, M. P., Gonzaga, L. V., Biluca, F. C., Schulz, M., Vitali, L., Micke, G. A., Oliveira Costa, A. C., & Fett, R. 2020. Stability of Brazilian *Apis mellifera* L. honey during prolonged storage: Physicochemical parameters and bioactive compounds. *LWT*, 129, 109521.
- [14] da Silva, P. M., Gauche, C., Gonzaga, L. V., Costa, A. C., & Fett, R. 2016. Honey: Chemical composition, stability and authenticity. *Food Chemistry*, 196, 309-323.
- [15] Draiaia, R., Chefrou, A., Dainese, N., Borin, A., Manzinello, C., Gallina, A., & Mutinelli, F. (2015). Physicochemical parameters and antibiotics residuals in Algerian honey. *African Journal of Biotechnology*, 14, 1242-1251.
- [16] Escuredo, O., & Seijo, M. C. 2019. Honey: Chemical Composition, Stability and Authenticity. *Foods*, 8(11), 577.
- [17] Ghoniemy, H. A., Esmail, A. H. M., & Mahmoud, A. A. E.-T. 2022. Evaluation of vitamin C, proline, enzymes and hydroxymethylfurfural levels in clover honey at different storage conditions. *Egyptian Journal of Chemistry*, 65(132), 427-434.
- [18] Haouam, L., Dailly, H., Bruneau, E., & Tahar, A. 2019. The quality of honeys influenced by the traditional heating method. *J. Microbiol. Biotechnol. Food Sci*, 8(6), 1276-1280.
- [19] Huang, Z., Liu, L., Li, G., Li, H., Ye, D., & Li, X. 2019. Nondestructive Determination of Diastase Activity of Honey Based on Visible and Near-Infrared Spectroscopy. *Molecules*, 24(7).
- [20] Iftikhar, F., Mahmood, R., Islam, N., Sarwar, G., Masood, M. A., & Shafiq, H. 2014. Physicochemical analysis of honey samples collected from local markets of Rawalpindi and Islamabad, Pakistan. *American journal of Biochemistry*, 4(2), 35-40.
- [21] Iqbal, J., Owayss, A. A., Raweh, H. S., Abuagla, M. I., Abdelaziz, A. S., & Alqarni, A. S. 2025. Quality Assessment of Saudi Honeys Originated from *Acacia gerrardii* and *Ziziphus spina-christi* using Physicochemical Analyses. *Pak. J. Agri. Sci*, 62(4), 755-767.
- [22] Kędzierska-Matysek, M., Teter, A., Daszkiewicz, T., Topyła, B., Skąlecki, P., Domaradzki, P., & Florek, M. 2025. Effect of Temperature of Two-Year Storage of Varietal Honeys on 5-Hydroxymethylfurfural Content, Diastase Number, and CIE Color Coordinates. *Agriculture*, 15(6), 652.
- [23] Khan, Z. S., Nanda, V., Bhat, M., & Khan, A. 2015. Kinetic studies of HMF formation and diastase activity in two different honeys of Kashmir. *International Journal of Current Microbiology and Applied Sciences*, 4(4), 70-106.
- [24] Korkmaz, S. D. 2023. Determination of HMF value and diastase activities in strained honeys sold in markets. *Black Sea Journal of Engineering and Science*, 6(4), 522-526.
- [25] Lupu, D., Sammani, M. S., Palacio, E., Hancu, G., & Ferrer, L. 2025. Comprehensive honey analysis: A novel HPLC-DAD method for hydroxymethylfurfural quantification and quality evaluation via diastase activity and sugar profile determination. *Journal of Food Composition and Analysis*, 137, 106925.
- [26] Manickavasagam, G., Saaïd, M., & Lim, V. 2024. Impact of prolonged storage on quality assessment properties and constituents of honey: A systematic review. *J Food Sci*, 89(2), 811-833.
- [27] Mouhoubi-Tafnine, Z., Ouchemoukh, S., Bey, B. M., Louaileche, H., & Tamendjari, A. 2018. Effect of storage on hydroxymethylfurfural (HMF) and color of some Algerian honey.
- [28] Pasiadis, I. N., Kiriakou, I. K., & Proestos, C. 2017. HMF and diastase activity in honeys: A fully validated approach and a chemometric analysis for identification of honey freshness and adulteration. *Food Chemistry*, 229, 425-431.
- [29] Raweh, H. S. A., Badjah-Hadj-Ahmed, A. Y., Iqbal, J., & Alqarni, A. S. (2022). Impact of Different Storage Regimes on the Levels of Physicochemical Characteristics, Especially Free Acidity in Talh (*Acacia gerrardii* Benth.) Honey. *Molecules*, 27(18), 5959.
- [30] Raweh, H. S. A., Badjah-Hadj-Ahmed, A. Y., Iqbal, J., & Alqarni, A. S. 2023. Physicochemical Composition of Local and Imported Honeys Associated with Quality Standards. *Foods*, 12(11), 2181.
- [31] Sahin, H., Kolayli, S., & Beykaya, M. 2020. Investigation of variations of invertase and glucose oxidase degrees against heating and timing options in raw honeys. *Journal of chemistry*(1), 5398062.
- [32] Šarić, G., Matković, D., Hruškar, M., & Vahčić, N. 2008. Characterisation and classification of Croatian honey by physicochemical parameters. *Food Technology and Biotechnology*, 46(4), 355-367.
- [33] Tesfaye, B., Begna, D., & Eshetu, M. 2016. Evaluation of Physico-Chemical Properties of Honey Produced in Bale Natural Forest, Southeastern Ethiopia. 2(1), 21-27.