UNIVERSITY OF SINDH JOURNAL OF ANIMAL SCIENCES
DOI: https://doi.org/10.57038/usjas.v7i03.6509
Uni. Sindh. J. Anim. Sci., vol. 7(3); 62-67, 2023
Email: editors.usjas@usindh.edu.pk
ISSN (P): 2521-8328
ISSN (E): 2523-6067
Published by University of Sindh, Jamshoro.

EVALUATING THE SHELF LIFE OF *APIS MELLIFERA* HONEY COLLECTED IN SOUTH PUNJAB, PAKISTAN

SAMINA QAMER[1*], ABIR ISHTIAQ[2], BILAL AHMAD[2], ZULFIQAR HAIDER[3], NAVEED AHMAD KHAN[4], SHAKILA NAZ[5], HAZRAT USMAN SHERANI[3], MUHAMMAD SHAHJAHAN[5], MUHAMMAD ADRESS[5]

[1*]Department of Zoology, Rawalpindi Women University, Satellite Town, Rawalpindi
[2]Department of Zoology, Islamia University Bahawalpur, Bahawalnagar Campus.
[3]Department of Zoology, Government College University, Faisalabad
[4]Institute of Pure and Applied Biology, Zoology Division, Bahauddin Zakriya University, Multan
[5]Department of Zoology, Government College University Faisalabad, Layyah Campus

ARTICLE INFORMATION
Article History:
Received: 15th February 2023
Accepted: 20th March 2023
Published online: 30th September 2023

Author's contribution
SQ, analysis, AI conceptualization, BA compiled the data, ZH & HUS, collected NAK methodology, material, SN, MS & MA reviewed the data.

Key words:
Multi-floral, honey, Southern Punjab, pH, free acidity, Electrical conductivity, Diastase, Proline, *Apis mellifera*.

ABSTRACT

The study aimed to assess the shelf life of multi-floral honey collected from the southern region of Punjab Province, Pakistan, over 12 months. Fifty honey samples were analyzed for various physiochemical parameters every four months at room temperature. Initial values included pH, free acidity, electrical conductivity, diastase number, invertase number, HMF, proline content, fructose, glucose, and sucrose percentages. After 12 months, the pH, free acidity, electrical conductivity, diastase, invertase, glucose, and fructose values decreased, while HMF content, proline content, and sucrose percentage increased. These findings suggest that honey composition changes during storage, shortening its shelf life. Fresh A. mellifera honey is recommended for consumption within 6 to 8 months to maintain its quality.

1. INTRODUCTION

Honey is a nutritious substance which is obtain from floral sources by bees (da Silva et al., 2016; Dong et al., 2018). It's chemically composed of mono and dissaccrrides carbohydrates like fructose, glucose, maltose and sucrose (Sakač et al., 2019, Sajid et al., 2022). However, minerals, Protein, organic acid, amino acid, vitamins and aromatic substance are minor components found in honey (Amiry et al., 2017; Čanadanović-Brunet et al., 2014; Sakač et al., 2019). A further two hundred more substances are testified in honey (Ferreira et al, 2009). Due to presence of these components, that can act as antibacterial and anti-inflammatory chemicals (Liu et al, 2013). The quality of honey depends on various components including floral sources, climate condition, processing, Post harvesting handling and conditions for storage (Khan et al., 2016; Kaygusuz et al., 2016; Ansari et al, 2018).

Different types of chemical reactions caused changes in honey, like HMF is formed during sugar dehydration in acidic medium formed HMF, which is also used as honey freshness indicator parameter. The extracted fresh honey is usually present in liquid form, however, with the passage of time during storage honey may start crystallizing depending upon the nectar source and Glucose %. It is less valuable in market, so heat is used to liquefy the crystalline honey. As a result, honey lose their original chemical composition. The limited sources and excesses amount of honey price has provided an increased interest in adulteration (Barra et al., 2010; da Silva et al., 2016). Honey quality parameters are valuable for identifying these likely adulterations and to confirm hygiene conditions for handling and storing honey (Puscas et al., 2013). The aim of the present research was to evaluate the shelf life of fresh *A.mellifera* honey samples stored at room temperature for one year as per the International Honey Commission.

*Corresponding Author: samina.qamer@f.rwu.edu.pk

2. MATERIALS AND METHODS

Honey Collection

Fifty samples of honey were directly collected from beekeepers from the different areas/ districts such as Muzaffargarh, DG Khan, Multan and Bahawalpur of South Punjab Pakistan during the year 2021-2022. Plastic bottles and sealed glass were used to store fresh honey samples, then labeled and dated. In the laboratory samples were stored at room temperature, till analysis was completed. No preservatives or heating agents are done at any stage.

Honey quality tests

All physicochemical parameters were determined according to the European Honey Commission methods Bogdanov et al., (1999). pH and EC meter were used to determine Honey pH and Electrical Conductivity, 10g honey in 75ml deionized water. Same solution was used for the titration of free acidity AOAC (1975). Proline content was estimated according to Ough, (1969). For HMF determination Winkler method was used (Winkler, 1955). Honey Diastase and Invertase activity were determined according to the procedure of Siegenthaler (1977) and Schade et al. (1958). Reducing sugar (fructose and glucose) and apparent sucrose was determined by using Lane and Eynon procedure as described in AOAC (2000).

Statistical analysis

One way Analysis of variance (ANOVA) with P value at 0.05 significance level was used to analyze the data by using latest version of statistical software (SPSS-2001).

3. RESULTS AND DISCUSSION

Fig:1 shows the effect of one year storage on various quality parameters of 50 honey samples. According to Terrab et al., (2002) pH is an important factor that enhances honey quality and shelf life (Carreck, 2012; Dietemann et al., 2013). The current results showed that honey samples were more acidic as the average value of pH lies between 3.69-5.15. Sajid et al., (2022) also observed acidic pH (4.28) in *A.mellifera* Pakistani honeys. Laredj and waffa (2017) and Lokossou et al., (2017) reported Algerian and Burkina Fasan honey's pH in the range of 4.17-4.20 and 5-5.8, respectively. The upper value of 5-5.8 by Lokossou et al., (2017) and lower 3.67 by Boussaid et al., (2018) (3.67- 4.11) in Tunisian honey, 4.35 in Pakistani honey from same species (Sajid et al., 2020) seems related to present determined pH. More acidic honey or low pH of honey significantly support to the antimicrobial property of honey (Sajid et al 2020). Initially average free acidity was 21.54, which amplified to 40.80 meq/Kg by the end of 12 months, although was still within international limits (≤50 meq/kg). Acidity reported by Ciappini et al., (2016) 19.5-22.3 meq/Kg in Argentine honey, Alqarni et al. (2016) 55.5–145.5 meq/kg, Azonwade et al., (2018) 35.7-40.5 meq/kg in Benin honey, El-Haskoury et al. (2018) 16.50–59.50 meq/kg and was 33–46.5 meq/kg in Pakistani honey by Sajid et al., 2020. The honey acidity varies due to different floral sources and yielding seasons.

Similarly, EC ranges found by Gular et al. (2017) 0.11-0.25ms/cm in Tunisian honey, 0.11–0.61 mS/cm by Sajid et al., (2020) and 0.27mS/cm in 2022 in Pakistani honeys, seems related to the current research values of 0.13-0.27 meq/kg. Anhwange, et al., (2015) 0.86- 0.91mS/cm in Nigerian honey, Bousaid et al. (2018) (0.39–0.89 mS/cm), Lokossou et al. (2017) (0.37–1.43 mS/cm) reported higher EC than the present study. Variation in Electrical conductivity of honey depends on different botanical sources explored by honeybees as nectar.

According to the European Union Honey Directive, certain constituents must be determined for honeys proposed for human consumption. Diastase enzyme activity (diastase number) is one of them. In general diastase activity should not be less than 8. Heating the honey degrades the enzyme, which is why the EU directive states minimum values. Diastase in honey converts starch to short-chain sugars and the enzymes' activity hints at possible heating and/or poor storage conditions. It originated both from plant and honeybees salivary and hypophyrngeal gland secretions. It is quite a stable enzyme so considered as storage indicator parameter. It naturally deteriorates over time and also with storage. A decline from 39.05 DN to 19.19DN was observed for 12 months storage period, the limit was within the Codex range (≥8DN) yet. Moloudian et al. (2018) also recorded reduction in diastase activity from 28.68DN to 17.75DN in Iranian honey, this trend is similar to the current study. Sajid et al., (2020) measured 26.97–43.47(DN) in Pakistani fresh honeys from various floral origin. Anhwange, et al., (2015) determined diastase range below (7.61DN) and just above the minimum limit (10.18 (DN) in Riyom, Plateau State honey.

Invertase is another essential enzyme which is liable to convert nectar and honeydew into honey. It has high sensitivity towards temperature increase. Therefore, in some European countries invertase activity determination is also used as a parameter related to the freshness of honey, to its warming or storing condition. Boussaid et al., (2018) and Lichtenberg-Kraag, (2012) stated invertase range of 46.25-184.68 (IN) and 33.76-86.95(IN) in Tunisia and German honey, respectively, which is closely related to the current IN values (27.70-67(IN). Below the IHC limit, invertase activity (23.91-0.02(IN) was found by Parvanov et al., (2012) in Bulgarian honey.

Honey freshness and purity depends on HMF (Al-Ghamdi et al., 2019) which is an aldehydic compound formed by the dehydration of some sugars, mostly fructose (Rosatella et al., 2011; Chris & Cornelia, 2014) and its levels should not exceed 40mg/kg. It is also temperature and storage conditions sensitive (Al-Ghamdi et al., 2019). In the present study higher (43.62mg/kg), yet with IHC limit, HMF content were measured after12 months storage compared to initial 14.68mg/kg. Ciappini et al., (2016) was described HMF range from 12.07 to 27.43 mg/kg in Tunisia honey. Comparative to current findings low HMF values have been recorded in Argentine honey (6.7-7.2meq/Kg) and Indian honey (3.87-4.64mg/kg), respectively, by Boussaid et al., (2018) and Kirvak & Karababa (2017). Chris and Cornelia (2014) treated *Acacia* and *lime* honey under various storage conditions and later tested its freshness by measuring HMF content. Similarly, Sajid et al. (2019) kept multi-floral honey at different temperatures and then checked its freshness by estimating HMF content. Sajid et al., in 2020 and 2022 found averagely 30.85mg/kg and 29.2mg/kg HMF in fresh Pakistani honeys, respectively.

Proline is predominant non-essential amino acid making up almost 50% to 85% of total amino acid content. Its origin is mainly honeybee's salivary gland secretion mixed with nectar to convert it in honey Proline content are usually applied as honey maturation criterion and it should not be less than 180mg/kg in honey as per IHC standard (Qamer et al., 2007; de Slvia et al., 2016). In present study Proline content after 4 months storage at room temperature was 469.82mg/kg, however, it dropped up to 148.30mg/kg level after 12 months storage which was less than minimum limit set by IHC. Sajid et al., (2022) reported an average of 235.32mg/kg Prolin content in *A.mellifera* honey without storing or any other treatment. Aazza et al. (2018) and Nayik and Nanda (2015) investigated the proline content between 256.46-924.98mg/Kg and 205.3-551.74mg/Kg.

As far as monosaccharides and sucrose are concerned, Fructose (42%), Glucose (38%) and Sucrose (2.25%) were found well within limits set by IHC even after 4-month storage. Anyhow, lowering in monosaccharides and raising in sucrose (6.76%) beyond the standard limits was observed in next 8 months. Sajid et al., (2022) determined fructose (38.97%), glucose (32.10%) and sucrose (2.25%) values fairly below the maximum border line set by IHC in fresh *A.mellifera* honey collected from Punjab province. Guler et al., (2017) and Khaliq & Swaileh, (2017) were reported reducing sugar concentration range from 68.41-68.77g/100g and 68.9–83.6g/100g in Turkish and Palestine honeys without storage, respectively. Khan et al., 2016 documented minimum 32.45% in *Zizpus spp* honey and maximum 38.03% Fructose in *Clover* honey from Punjab and Khyber Pakhtunkhwa, respectively, from Provinces of Pakistan. Similarly, lowest (24%) from *Zizpus spp* and highest (32%) glucose in *Clover* and *Sunflower* was found from Punjab and Khyber Pakhtunkhwa honey samples, respectively. In the same way least sucrose (1.12%) was recorded in Acacia honey collected from Punjab and Khyber Pakhtunkhwa. Although he found more than 6% and 7% in *clover* and *Eucalyptus* honeys from Punjab Province and 9.7% sucrose in currant bush honey collected from Khyber Pakhtunkhwa. The maximum level of sucrose should not exceed 5% in honey as per recommendation of IHC. Khaliq and Swaileh, (2017) reported the sucrose% between 1.1-6.9g/100g in Palestine honey. While Guler et al., (2017) had sucrose concentration (0- 3.05g/100g) well within limits in Turkish honey.

4. CONCLUSION

From the above results it is evident that there took place some irreversible changes after one year storage at room temperature that shortens the freshness and shelf life of Pakistani honey produced by *A.mellifera*. Therefore, it is safe to consume honey within six months without compromising its quality.

5. CONFLICT OF INTEREST

All authors have declared that there is no conflict of interests regarding the publication of this article.

REFRENCES

Aazza, S., Elamine, Y., El-Guendouz, S., Lyoussi, B., Antunes, M. D., Estevinho, L. M. Ofélia, A. Jorge. D. Cailer, Maria.C. Coasta & Miguel, M. G. (2018). Physicochemical characterization and antioxidant activity of honey with Eragrostis spp. pollen predominance. *Journal of Food Biochemistry*, *42*(1), 124-131.

Al-Farsi, M., Al-Belushi, S., Al-Amri, A., Al-Hadhrami, A., Al-Rusheidi, M., & Al-Alawi, A. (2018). Quality evaluation of Omani honey. *Food Chemistry*, *262*, 162–167.

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 J. Biol. Sci., 26*(4), 845–848.

Alqarni, A. S., Owayss, A. A., Mahmoud, A. A., & Hannan, M. A. (2016). Mineral content and physical properties of local and imported honeys in Saudi Arabia. *Journal of Saudi Chemical Society*, *18*(5), 618-625.

Amiry, S., Esmaiili, M., & Alizadeh, M. (2017). Classification of adulterated honeys by multivariate analysis. *Food Chemistry, 224*, 390–397.

Anhwange, B. A., Yiase, S. G., Atoo, G. H., & Anzaki, A. J. (2015). Chemical Study of Natural and Farmed Samples of Honey from Riyom, Plateau State. *International Journal of Materials Chemistry and Physics,1 (3)*, 347-351.

Ansari, M. J., Al-Ghamdi, A., Khan, K. A., Adgaba, N., El-Ahmady, S. H., Gad, H. A. & Kolyali, S. (2018). Validation of botanical origins and geographical sources of some Saudi honeys using ultraviolet spectroscopy and chemometric analysis. *Saudi journal of biological sciences, 25*(2), 377-382.

AOAC. (2000). Sugars and sugar products. In: *Official Methods of Analysis*. Horwitz,W. (ed.). Association of Official Analytical Chemists International, Vol. 2 No. 44, 16th Edition. Washington, DC 22 -33.

Association of Official Analytical Chemists. (1975). Free, lactone and total acidity of honey (Electrophoretic Method), 12 Ed. No, 31.146, p 160.

Azonwade, F. E., Paraïso, A., Dossa, A., Cokou, P., Dougnon, V. T., N'tcha, C., Mousse, W., & Baba-Moussa, L. (2018). Physicochemical characteristics and microbiological quality of honey produced in Benin. *Journal of Food Quality, 2018*, 1-13.

Barra, M. P. G., Ponce-Díaz, M. C., & Venegas-Gallegos, C. (2010). Volatile compounds in honey produced in the central valley of Ñuble province, Chile. *Chilean Journal of Agricultural Research, 70*(1), 75-84.

Bogdanov, S., Lullmann, C., Martin, P., Ohe Vonder, W., Russmann, H., Vorwohl, G., Persano Oddo, l., Sabatini, A. G.,Marcazzan, G. L., Piro, R., Flamini, C., Morlot, M., Lheritier, J., Borneck, R., Marioleas, P., Tsigouri, A., Kerkvliet, J., Ortiz, A., Ivanov, T., D''Arcy, B., Mossel, B. and Vit, P., (1999). Honey quality and International Regulatory Standards: review by the International Honey Commission. *Bee World., 80*, 61-69.

Boussaid, A., Chouaibi, M., Rezig, L., Hellal, R., Donsì, F., Ferrari, G., & Hamdi, S. (2018). Physicochemical and bioactive properties of six honey samples from various floral origins from Tunisia. *Arabian journal of chemistry, 11*(2), 265-274.

Čanadanović-Brunet, J., Ćetković, G., Tumbas Šaponjac, V., Stajčić, S., Vulić, J., Đilas & S. Popović (2014). Evaluation of phenolic content, antioxidant activity and sensory characteristics of Serbian honey-based product. *Industrial Crops and Products, 62*, 1–7.

Carreck, N. L. (2012). COLOSS and EurBee meetings. *Bee World, 89*(4), 84-85.

Chis, A., & Cornelia, P. (2014). The Influence of Storage Conditions on the Freshness of selected Monofloral Honey. *Ecotoxicologie Zootehnic si Tehnologii de Industrie Alimentara. Vol XIII/B*, 141-148.

Ciappini, M., Vitelleschi, M., & Calviño, A. (2016). Chemometrics classification of Argentine clover and eucalyptus honeys according to palynological, physicochemical, and sensory properties. *International Journal of Food Properties, 19*(1), 111-123.

Codex Alimentarius Committee on sugars. (2001). Revised Codex Standard for Honey. *Standards and Standard Methods, 11*, 1-7.

da Silva, P. M., Gauche, C., Gonzaga, L. V., Costa, A. C. O., & Fett, R. (2016). Honey: Chemical composition, stability and authenticity. *Food Chemistry, 196*, 309-323.

Dietemann, V., Neumann, P., & Ellis, J. D. (2013). The COLOSS BEEBOOK Part 1. *Journal of Apicultural Research, 52*(1).

Dong, H., Xiao, K., Xian, Y., & Wu, Y. (2018). Authenticity determination of honeys with nonextractable proteins by means of elemental analyzer (EA) and liquid chromatography (LC) coupled to isotope ratio mass spectroscopy (IRMS). *Food Chemistry, 240*, 717-724.

El-Haskoury, R., Kriaa, W., Lyoussi, B., & Makni, M. (2018). Ceratonia siliqua honeys from Morocco: physicochemical properties, mineral contents, and antioxidant activities. *Journal of Food and Drug Analysis, 26*(1), 67–73.

Ferreira, I. C., Aires, E., Barreira, J. C., & Estevinho, L. M. (2009). Antioxidant activity of Portuguese honey samples: Different contributions of the entire honey and phenolic extract. *Food Chemistry, 114*(4), 1438-1443.

Guler, A., Ali, V. G., & Onder, H. (2017). Comparing biochemical properties of pure and adulterated honeys produced by feeding honeybees (Apis mellifera L.) colonies with different levels of industrial commercial sugars. *Kafkas Universitesi Veteriner Fakultesi Dergisi, 23*(2), 259-268.

Kaygusuz, H., Tezcan, F., Erim, F. B., Yildiz, O., Sahin, H., Can, Z., & Kolayli, S. (2016). Characterization of Anatolian honeys based on minerals, bioactive components and principal component analysis. *LWT-Food Science and Technology, 68*, 273-279.

Khaliq, A., & Swaileh, K. M. (2017). Physico-chemical properties of multi-floral honey from the West

Bank, Palestine. *International Journal of Food Properties, 20*(2), 447-454.

Khan, K. A., Al-Ghamdi, A. A., & Ansari, M. J. (2016). The characterization of blossom honeys from two provinces of Pakistan. *Italian Journal of Food Science, 28*(4), 625-638.

Kivrak, Ş., Kivrak, I., & Karababa, E. (2017). Characterization of Turkish honeys regarding of physicochemical properties, and their adulteration analysis. *Food Science and Technology (Campinas), 37*(1), 80-89.

Laredj, H., & Waffa, R. (2017). Microbiological and Physicochemical Characterization of Honeys from the Tiaret Region of Algeria. *Asian Journal of Pharmaceutical Research and Health Care, 9*(3), 85-91.

Lichtenberg-Kraag, B. (2012). Saccharose degradation over time in stored honey: influence of time, temperature, enzyme activity and botanical origin. *J. Food. Nutr. Res, 51*, 217-224.

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*, 938–943.

Lokossou, S. C., Tchobo, F. P., Yédomonhan, H., & Soumanou, M. M. (2017). Physicochemical Characterization and Polyphenolic Content of Beninese Honeys. *International Scholarly Research Notices, 37*(3), 1-8.

Moloudian, H., Abbasian, S., Nassiri-Koopaei, N., Tahmasbi, M. R., alsadat Afzal, G., Ahosseini, M. S. Yunesian, S., & Khoshayand, M. R. (2018). Characterization and Classification of Iranian Honey Based on Physicochemical Properties and Antioxidant Activities, with Chemometrics Approach. *Iranian Journal of Pharmaceutical Research: IJPR, 17*(2), 708.

Nayik, G. A., & Nanda, V. (2015). Physico-chemical, enzymatic, mineral and colour characterization of three different varieties of honeys from Kashmir valley of India with a multivariate approach. *Polish Journal of Food and Nutrition Sciences, 65*(2), 101-108.

Ough, C. S. (1969). Rapid determination of proline in grapes and wines. *Journal of Food Science, 34*(3), 228-230.

Parvanov, P., Dinkov, D., & Tananaki, C. (2012). Invertase activity and carbohydrate spectrum of time, temperature, enzyme activity and botanical origin. *Journal of Food and Nutrition Research, 51*, 217-224.

Puscas, A., Hosu, A., & Cimpoiu, C. (2013). Application of a newly developed and validated high-performance thin-layer chromatographic method to control honey adulteration. *Journal of Chromatography A, 1272*, 132-135.

Qamer, S., Ehsan, M., Nadeem, S., & Shakoori, A. R. (2007). Free amino acids content of Pakistani uni-floral honey produced by Apis mellifera. *Pakistan Journal of Zoology, 39*(2), 99-102.

Rosatella, A. P., Simeonov, R. F., Frade, M., & Carlos, A. M. A. (2011). 5-Hydroxymethylfurfural (HMF) as a building block platform: Biological properties, synthesis and synthetic applications. *Green Chemistry, 13*, 754.

Sakač, M. B., Jovanov, P. T., Marić, A. Z., Pezo, L. L., Kevrešan, Ž. S., Novaković, A. R., & Nedeljković, N. M. (2019). Physicochemical properties and mineral content of honey samples from Vojvodina (Republic of Serbia). *Food Chemistry, 276*, 15-21.

Sajid, M., Yamin, M., Asad, F., Yaqub, S., Ahmad, S., Mubarik, M., Ahmad, B., Ahmad, W., & Qamer, S. (2020). Comparative study of physio-chemical analysis of Fresh and Branded honeys from Pakistan. *Saudi Journal of Biological Sciences, 27*(1), 173-176.

Sajid, M., Shaheen, M., Fareed, M., Javid, K., & Qamer, S. (2022). Comparative physicochemical and minerals analysis of A. mellifera and A. cerana honeys from Punjab and Khyber-Pakhtunkhwa of Pakistan. *Fresenius Environmental Bulletin and Advances in Food Sciences, 31*(4), 4028-4036.

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.

Siegenthaler, U. (1977). Eine Einfache und RaschMethode zur Bestimmung der -Glucosidase (Saccharase) in Honig. *Mitt. Geb. Lebensmittelunters. Hyg., 68*, 251-258.

Terrab, A., Dıez, M. J., & Heredia, F. J. (2002). Characterization of Moroccan unifloral honeys by their physicochemical characteristics. *Food Chemistry, 79*(3), 373-379.

Tornuk, F., Karaman, S., Ozturk, I., Toker, O. S., Tastemur, B., Sagdic, O., Dogan, A., & Kayacier, A. (2013). Quality characterization of artisanal and retail Turkish blossom honeys: Determination of physicochemical, microbiological, bioactive properties and aroma profile. *Industrial Crops and Products, 46*, 124-131.

Winkler, O. (1955). Beitrag zum Nachweis und zur Bestimmung von Oxymethylfurfural in Honig und Kunsthoing. *Z. Lebensmittelunters. U. Forsch., 102*, 161-167.

Yıldırım, O., Acar, U., Turker, A., Sunar, M. C., & Kesbic, O. S. (2014). Effects of Replacing Fish Meal with Peanut Meal (Arachishypogaea) on Growth, Feed Utilization and Body Composition of Mozambique Tilapia Fries (Oreochromism ossambicus). *Pakistan Journal of Zoology*, *46*(2), 497-502.

Zhu, X., Liu, D., Singh, A. K., Drolia, R., Bai, X., Tenguria, S., & Bhunia, A. K. (2018). Tunicamycin mediated inhibition of wall teichoic acid affects Staphylococcus aureus and Listeria monocytogenes cell morphology, biofilm formation and virulence. *Frontiers in Microbiology*, *9*, 1352.

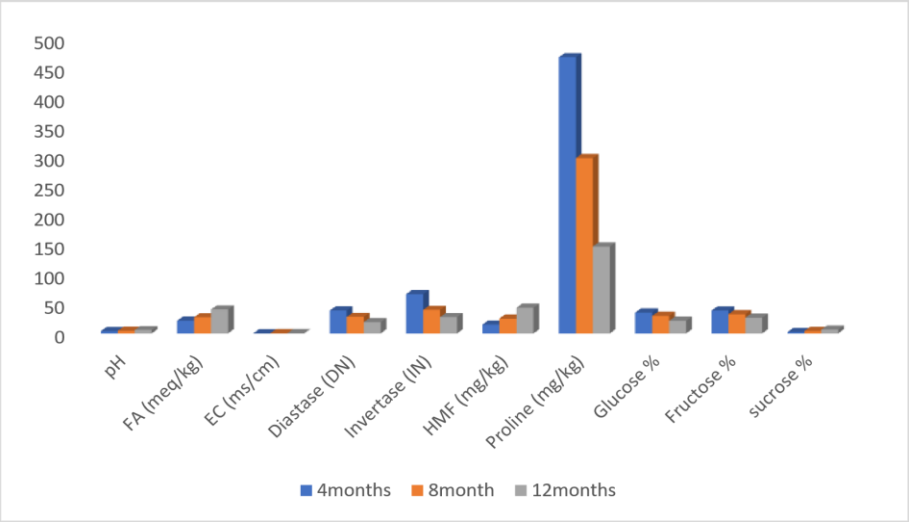

Fig.1. Graphic representation of Change in quality parameters of honey during 12th month's storage