International Food Research Journal 25(3): 982-988 (June 2018)
Journal homepage: *http://www.ifrj.upm.edu.my*

Hygienic quality of the honey samples produced in the Iran in comparison with international standards

[1]Zahedi Namini, N., [1]Mousavi, M.H., [1,2*]Mahmoudi, R. and [1]Hassanzadeh, P.

[1]*Department of Food Hygiene and Aquatics, Faculty of Veterinary Medicine, University of Tabriz, Tabriz, Iran*
[2]*Medical Microbiology Research Center, Qazvin University of Medical Sciences, Qazvin, Iran*

Article history

Received: 22 February 2017
Received in revised form: 7 April 2017
Accepted: 9 April 2017

Keywords

Honey
International standards
Hygienic quality
Iran

Abstract

Honey is a sweet, viscous liquid that bees produce from nectar collected from plant nectarines and store as food. In this study, some physicochemical properties (pH, ash, reducing sugars, sucrose, moisture, electrical conductivity, diastase activity, hydroxymethylfurfural (HMF) and commercial glucose) and microbial contaminations of 180 honey samples from North-western regions of Iran (Ardabil province) were evaluated in one year period in different seasons of 2012. The levels of reducing sugars, sucrose content and HMF of 6.11%, 8.33% and 3.33% samples were unacceptable, respectively. Diastase activity of 4 samples (2.22%) was negative and 5 samples (2.77%) had commercial glucose. But moisture, ash content, pH and electrical conductivity values of all samples were in the required standard range. The amounts of moisture and electrical conductivity value during various seasons show statistically significant differences ($P \leq 0.05$). Microbial analyse results showed that of all the samples evaluated, only 13 samples (7.22%) contained mold, and 10 samples (5.55%) were contaminated with bacteria. The standard plate counts (SPC) were found in low numbers in most samples of honey with a mean count of 2.6 Log_{10} $CFU.g^{-1}$. The results of this study may help improve researchers' understanding of honey properties and their impact on consumer preference.

Introduction

Honey is a natural supersaturated sugar solution, which is mainly composed of a complex mixture of carbohydrates. Besides this, it also contains certain minor constituent's proteins, enzymes (invertase, glucose oxidase, catalase, and phosphatases), amino and organic acids (gluconic acid, acetic acid, etc.), lipids, vitamins (ascorbic acid, niacin, pyridoxine etc.), volatile chemicals, phenolic acids, flavonoids, and carotenoid like substances and minerals (Blasa *et al*., 2006). In almost all honey types, fructose predominates, glucose being the second main sugar. These two account for nearly 85–95% of the honey carbohydrates. More complex sugars made up of two or more molecules of glucose and fructose constitute the remaining carbohydrates, except for a trace of polysaccharide (Bogdanov *et al.*, 2004).

Moisture level of honey rep-resents a major importance to its stability against fermentation and granulation. The low moisture content protects honey from microbiological activity and thus it can be preserved for longer periods (Akhtar *et al.,* 2014; El-Metwally, 2015). The quality of honey is mainly determined by its sensorial, chemical, physical and microbiological characteristics (Erkan *et al.*, 2015). The composition of honey depends on the plant species visited by the honeybees and the environmental, processing and storage conditions (Bertoncelj *et al*., 2007; Guler *et al*., 2007). Blossom or nectar honey is derived from the nectaries of flowers and honeydew honey comes from the sugary excretion of some hemipterous insects on the host plant or from the exudates of the plants. It is rich in flavonoids and phenolic acids that exhibit a wide range of biological effects and act as natural antioxidants (Da Silva *et al*., 2016).Since ancient times honey has been used as natural unprocessed food and medicine (Jeffrey *et al.*, 1996). Some honeis produced in different areas had different qualities and this can be because of climate, origin of plants, season, processing and other factors. This factor can affect the physicochemical and microbial properties of honey (Bansal *et al*., 2005; Mahmoudi *et al*., 2012). Microorganisms in honey may influence the stability of the products and its hygienic quality (Erkan *et al*., 2015).

Honey has two sources of contamination with microorganisms: primary sources include pollen, the digestive tracts of honey bees, dust, air, soil and nectar; secondary sources are those

*Corresponding author.
Email: *r.mahmodi@yahoo.com*

arising from honey manipulation by people, they include air, food handlers, cross-contamination, equipment and buildings (Aureli *et al.*, 2005). Primary sources of honey contamination are very difficult to control. Conversely, secondary sources of honey contamination can be controlled by good manufacturing practices (Fenicila *et al*., 2009). The microbes of concern in honey are fungi, yeasts and spore-forming bacteria. Fungi and yeasts are responsible for honey fermentation when the moisture content is high (i.e., above 21%). Penicillium and Mucor are microorganisms usually found in honey (Migdal *et al.*, 2000).

Ardabil province's honeys are recognized throughout the country because of their quality. This province has the third position of honey production in the country (Moghadamnia *et al*., 2012). However, there is little scientific research published on Ardabil's honey on its physicochemical and microbiological quality. The quality of honey is mainly determined by its sensorial, chemical, physical and microbiological characteristics. Internationally, honey quality criteria are specified in Regulatory Standards, compiled in a Codex Alimentarius standard which at present is under revision (Bogdanov *et al*., 2004). The Codex Alimentarius Standard for honey quality includes several chemical and physical parameters, comprising moisture content, mineral content, acidity, HMF content, diastase activity, apparent sugar content, and water insoluble solids content (Codex, 2011). These analyses help the food analyst to determine the ''chemical'' quality of the honeys analyzed (Cantarelli *et al*., 2008).

The aim of the present work was to analyze the physicochemical and microbiological quality of some honey samples produced in Ardabil's province apiaries in warm and cold seasons. The results were compared to international standards available in this field and the effect of seasons on these parameters were studied.

Materials and Methods

Honey samples

A total number of 180 honey samples were collected from various areas of Ardabil province in Iran during different seasons in the year 2012 (Select the number of honey samples based on similar studies has been done in the field). 90 samples belonged to the first half of 2012 and 90 samples to the second half. Samples were transferred to laboratory under appropriate conditions for conducting physicochemical and microbial analysis, and were stored at 4°C until analysis time. All physicochemical and microbial tests were conducted in triplicate.

Moisture

The moisture percentages were evaluated using refractometer refractometer (ATAGO, ATC-1E, Japan) unit at 20°C, and calculated from obtained refraction index using Wedmore table (AOAC, 1990).

Reducing sugars and sucrose

Reducing sugars and apparent sucrose were determined by potentiometric titration, using the Fehling's test (Lane and Eyon modified method) (Gomes *et al*., 2010).

pH

pH measurements were conducted using a digital pH meter (Metrohm Herisua, Switzerland); 10 g of homogenized honey and 90 ml of distilled water was added, and the pH was read directly from the pH meter. The instrument was calibrated with standard buffer solutions of pH 7 and 4 prior to measuring the pH of samples (Saxena *et al*., 2010).

Ash

In order to determine ash content of honey samples, 3 g of each sample was weighted in a Chinese crucible and put in an electric furnace at 640°C for 6 h. Then, the amount of Ash was measured (AOAC, 1990).

Electrical conductivity

The measurement of electrical conductivity is based on the determination of the electrical resistance. The electrical conductivity was measured using a conductivity bridge (type CLOI/02A) for a 20% (w/v) solution of honey suspended in milli Q water (Bogdanove *et al.*, 1997). The electrical conductivity of the milli Q water was < 10 lS/cm. Each sample was analyzed in triplicate and the mean was expressed in mS/cm.

Diastase activity

Diastase activity was measured using Phadebas method based on the procedure of Siegenthaler (Singh *et al.*, 1998), modified by Bogdanov (Bogdanove *et al.,* 1987) and harmonized by the European Honey Commission (Bogdanove *et al*., 1997). Adsorption was determined using a spectrophotometer UV/VIS at λ= 620 nm.

HMF

HMF was determined by using the standard method AOAC (1990) Official Method 980.23. Five grams of honey were dissolved in 25 mL of

distilled water, treated with a clarifying agent (0.5 mL of Carrez I and 0.5 mL of Carrez II solutions) and volume made up to 50 mL. The solution was filtered, and the first 10 mL discarded. The absorbance of the filtered solution was measured at 284 and 336 nm against an aliquot of the filtered solution treated with $NaHSO_3$. HMF was determined as:

HMF/ 100g of honey = ($Abs_{284} - Abs_{336}$) × 14.97 × (5 g of honey).

Commercial glucose

The amount of commercial glucose was determined on the proposed method of AOAC, NO. 959,12, (AOAC, 2000).

Microbiological analysis

Ten grams of each honey sample were homogenized into 90 mL of peptone water solvent (Gomes *et al.*, 2010) in room temperature (25°C). Preparing decimal dilutions, the appropriate medium was inoculated by standard analysis methods. Aerobic mesophilic bacteria were counted onto PCA and incubated at 30˚C for 48 h (NP 3788:2002). Moulds and yeasts counts followed the protocol of ISO 21527-2:2008. Microbial counts were expressed as Log of colony-forming units per gram of honey (Log_{10} CFU.g^{-1}). Fecal coliforms were enumerated by the Most Probable Number technique defined in the protocol ISO 4831:2006. All microbial tests were performed in triplicate.

Results

Moisture content

The moisture content (%) in the investigated samples ranged from 3.8 to 19.15 (Table 1 and 2). All of the samples moisture was less than 20%. The amounts of moisture during various seasons show statistically significant differences ($P \leq 0.05$).

Reducing sugars and sucrose

Based on the results of the analysis of sugar compounds of honey samples, total reducing sugar levels were in the range of 58.91 to 85.05% (Table 1 and 2). The sucrose contents were between 1.2% to 14.8%. According to EU (2001), 11 samples of total samples had unacceptable value for reducing sugar and 15 samples for sucrose.

pH

All analyzed samples of honey in this study had an acidic pH in the range of 3.65 to 4.81 (Table 1 and 2).

Ash

The values of ash content varied in the range of 0.2% to 0.62% (Table 1 and 2).

Electrical conductivity

Values were between 0.03 and 0.19 mScm-1 (Table 1 and 2).

Diastase activity

In this study, four samples exceeded the limits of European Community Regulation with values less than 8˚ Gothe (Table 1 and 2).

HMF

The European Union (EU Directive 110/2001) fixed a HMF limit in honey of 40 mg/kg. Values were between 1.54 and 45.1 mg/kg (Table 1 and 2). Only 3 samples had more than 40 mg/kg HMF wich could be because of temperature abuse during processing and/ or bad storage practices.

Commercial glucose

In this study, five samples had commercial glucose.

Microbial analyze

Microbial analyze results are shown in Table 3 and 4. The SPC were found in low numbers in most samples of honey with a mean count of 2.6 Log_{10} CFU.g^{-1}. Few samples of honey contained detectable levels of yeasts, below 2.3 Log_{10} CFU.g^{-1}.

Discussion

Moisture content

Moisture content is one of the most important compositions to be considered as a quality parameter of honey since it affects storage life and processing characteristics. Our results are in agreement with the findings of Cantarelli *et al.* (2008) who reported that the moisture content in honey was recorded in the range of 14 to 18%; however it depends upon the season and geographic condition. Moisture values were within the values found in Algerian honeys (between 14.64% and 19.04%) (Ouchemoukh *et al.*, 2007). Chakir *et al*. (2011) in Morocco obtained similar result. It is less than those found in Northwest Moroccan honeys (between 14% and 24.1%) (Terrab *et al*., 2004). The low moisture content of honey also forms an important part of the system which protects honey from attack by microorganisms (Omafuvbe *et al.*, 2009). Similar results as our study (Nanda *et al*., 2003; Gomes *et al*., 2005) and higher (Przybylowsky *et al.*, 2001; Rodriguez *et al.,* 2004; Guler *et al.*,

Table 1. Physicochemical analysis of first half of 2012 honey samples (90 samples).

Parameter	Mean	SD	Min	Max	Satisfactory limit by EU	Unacceptable samples
Moisture (%)*	16.02	0.61	14.5	17.8	Almost 20%	-
Reducing sugars (%)	71.24	4.06	59.7	78.3	Almost 60%	6
Sucrose (%)	5.34	2.75	1.2	14.8	Almost 5%	7
pH	4.93	0.26	3.65	4.67	At least 3.5	-
Ash (%)	0.37	0.09	0.21	0.62	Almost 0.6	-
Electrical Conductivity(mS/cm)*	0.06	0.01	0.03	0.09	Almost 0.8	-
Diastase activity(°Gothe)	-	-	-	-	At least 8	1
HMF(mg/kg)	9.7	2.02	1.87	45.1	Almost 80	2
Commercial glucose	-	-	-	-	Should not be found	1

Table 2. Physicochemical analysis of second half of 2012 honey samples (90 samples).

Parameter	Mean	SD	Min	Max	Satisfactory limit by EU	Unacceptable samples
Moisture (%)*	15.64	1.16	3.8	19.15	Almost 20%	-
Reducing sugars (%)	71.8	5.37	58.91	85.05	Almost 60%	5
Sucrose (%)	4.96	2.91	1.34	11.88	Almost 5%	8
pH	4.03	0.25	3.65	4.81	At least 3.5	-
Ash (%)	0.33	0.07	0.2	0.5	Almost 0.6	-
Electrical conductivity(mS/cm)*	0.07	0.03	0.03	0.19	Almost 0.8	-
Diastase activity(°Gothe)	-	-	-	-	At least 8	3
HMF(mg/kg)	8.04	2.12	1.54	42.21	Almost 80	1
Commercial glucose	-	-	-	-	Should not be found	4

* the amount of moisture and electrical conductivity in honey samples in various seasons showed statistically significant differences.

2005) results were detected in previous studies.

Reducing sugars and sucrose

These results are more than those Olugbemi *et al.*(2013), Rodriguez *et al.* (2004) and Cantarelli *et al.* (2008) obtained, but in agreement of Mahmoudi *et al.* (2012). Also the results of this study agreement with EL Sohaimi *et al*. (2016) research, Based on their findings the value of reducing sugars of Saudi, Egyptian and Yemeni honey samples were 72.36± 0.32 g/100 g, 69.84 ±0.31 and 64.21± 0.18 g/100 g respectively, and this rate in our study was 71. 24%. Reducing sugars value of 169 (95.89%) samples was accepted by Codex Alimentations (2001).

pH

The results are completely similar to the findings of Ouchemoukh *et al.* (2007), Azeredo *et al*. (2003), Kayacier and Karama (2003) and Mahmoudi *et al.* (2012). The pH of honey is low enough to slow down or prevent the growth of many species of bacteria, but this acidity may be neutralized in the body by the buffering liquid fluids. The results of this study are also in agreement with those of Adenekan *et al.* (2010) and White (1975), who reported the pH of 3.0 to 5.0 in pure honey,. These pH ranges are mainly due to the variation of different acid and minerals present in the honey.

Ash

These results are in agreement with those of White (1975) who worked on different varieties of honey and obtained ash content in the range of 0.020 to 1.028%. Adenekan *et al*. (2010) (0.18% - 0.5%), Olugbemi (0.33% - 0.37%) (2013), Adebiyi *et al.* (2004), Jeffery and Echazarreta (1996) and Malika

Table 3. Microbial results (bacterial, fungal and yeast)

	Number of contaminated samples	Mean (Log_{10} cfu.g^{-1})
Bacterial contamination	10	2.6
Fungal contamination	8	2.3
Yeast contamination	5	2.3
Total coliforms	Not found	-

et al. (2005) also obtained such results. The variation may be due to many factors such as soil conditions, atmospheric conditions and physiology of each plant.

Electrical conductivity

Electrical conductivity, closely related to the concentration of mineral and organic acids, shows great variability according to the floral origin. This results in this study was within the values found in Algerian (mean ranged between 0.02 and 0.16 mScm^{-1}) (Ouchemoukh *et al.*, 2007) and Northwest Moroccan honeys (between 0.02 and 0.17 mScm^{-1}) (Terrab *et al.*, 2004). The results of this study are less than results of Pavelková *et al.* (2013) in Liptov region (between 0.17 and 0.39 mScm^{-1}), Adenekan *et al.* (2010) in Ibadan (between 0.25 –0.64 mScm-^{1}). Electrical conductivity very often used in routine honey control instead of the ash content. The amounts of Electrical conductivity during various seasons show statistically significant differences ($P \leq 0.05$).

Diastase activity

Diastase is a natural enzyme of honey. Its level depends upon geographic and floral origins of the product, as well as on its freshness. As with HMF, diastase activity can be used as indicative of aging and temperature abuse, but with precaution, since its variability has been higher, confirmed in several honeys. These results are in agreement with those of Chakir *et al.* (2011) that work on seventy- three Moroccan honey samples. But all of the honey samples diastase activity was more than 8˚ Goethe (Gomes *et al*., 2010).

HMF

HMF is formed during acid-catalysed dehydration of hexoses and, it is connected to the chemical properties of honey, like pH, total acidity, mineral content (Bertoncelj *et al*., 2007; Saxena *et al.,* 2010; Chakir *et al*., 2011; Olugbemi *et al*., 2013). The HMF content is widely recognized as a parameter of honey samples freshness, because it is absent in fresh honeys and tends to increase during processing and/or aging of the product. Several factors influence the levels of HMF, such as temperature and time of heating, storage conditions, pH and floral source, thus it provides an indication of overheating and storage in poor conditions (Fallico *et al*., 2006).

Table 4. *Bacillus* spp. detected from contaminated samples

Bacillus spp.	Contaminated samples (N)
B.mycoides	3
B.cereus	6
B.circulans	1

Commercial glucose

Commercial glucose is an important factor in assessing the quality of honey. According to European Commission Regulation (EU) (2002), the presence of commercial glucose is not acceptable. Our result is in agreement of Mahmoudi *et al*. (2012) studies. But in disagreement of (Kayacier *et al*., 2003).

Microbial analyze

Based on this study, the numbers of the average total bacteria count was found to be 2.6 Log_{10} cfu.g^{-1}, These results are in agreement with Malika *et al.* (2005) but less than results obtained by Omafuvbe (2009) and Erkan *et al*. (2015). The result of *Bacilluss* spp that detected is presented in Table 4. The

Contamination rate of vegetative form of *Bacillus* spp. was found to be 5.55%, the study was carried out on honey samples in Turkey the rate of spor form bacteria was 4%, and the observed difference is minimal (Erkan *et al.*, 2015). The Total coliforms were not detected in any of the honey sample, similar as in study Adenekan *et al.* (2010) and Malika *et al.* (2005). The mold and yeast contamination levels in the honey samples analyzed were found in 13 honey samples (7. 22 %), While most fungal infections have been reported in many studies (Gomes *et al.*, 2010; Erkan *et al*., 2015).The low number of moulds in this study would be most probably related to the environmental conditions during honey processing. Such results are shown in Malika *et al*. (2005) researches.

Conclusion

The results showed that the physicochemical and microbial properties of the samples of honey samples

produced in the Ardabil province during the year 2012 were acceptable. The low microbial and fungal contamination of honeis, affect their quality. High pH and low moisture are one of the reasons for this.

Acknowledgments

This paper has been performed to present the results of a D.V.M (thesis) in Department of Food Hygiene and Aquatics, Faculty of Veterinary Medicine, University of Tabriz, Tabriz. We thank all who helped us to perform it, as well.

References

Adebiyil, F.M., Akpan, I., Obianjuwa, E.I. and Olaniyi, H.B. 2004. Chemical/ Physical characterization of Nigerian honey. Pakistan Journal Nutrition 3 (5): 278 – 81.

Adenekan, M.O., Amusa, N.A., Lawa, A.O. and Okpeze, V.E. 2010. Physicochemical and microbiological properties of honey samples obtained from Ibadan. Journal of Microbiology and Antimicrobials 2(8): 100-104.

Akhtar, S., Ali, J., Javed, B., Hassan, S., Abbas, S., Siddique, M. 2014. Comparative physiochemical analysis of imported and locally produced Khyber Pakhtunkhwa honey. Global Journal of Biotechnology Biochemistry 9 (3): 55–59.

Association of Analytical Communities .2000. Official methods of analysis.17th ed. Washington, DC: Association of Official Analytical Chemists.

Association of Official Analytical Chemists 1990. Official Methods of Analysis, 15th ed. Arlington, DC: Association of Official Analytical Chemists.

Aureli, P., Franciosa. G. and Fencila, L. 2002. Infant botulism and honey in Europe: a commentary. The Pediatric Infectious Disease Journal 21 (9): 866-868.

Azeredo, L.D.C., Azeredo, M.A.A., De Souza, S.R. and Dutra, V.M.L. 2003. Protein content and physicochemical properties in honey samples of Apis Mellifera of different floral origins. Food Chemistry 80 (1): 249–254.

Bansal, V., Medhi, B. and Pandhi, P. 2005. Honey-A remedy rediscovered and its therapeutic utility. Kathmandu University Medical Journal 3 (2): 305-309.

Bertoncelj ,J., Dobersek, U., Jamnik, M. and Golob, T. 2007. Evaluation of the phenolic content, antioxidant activity and colour of Slovenian honey. Food Chemistry 105 (1): 822–828.

Blasa, M., Candracci, M., Accorsi, A., Piacentini, M.P., Albertini, M.C. and Piatti, E. 2006. Raw millefiori honey is packed full of antioxidants. Food Chemistry 97 (1): 217-222.

Bogdanov, S., Rouff K. and Persani – odd, O.L. 2004. Physico-chemical methods for the characterisation of unifloral honeys: a review. Apidologie 35 (1): S4- S17.

Bogdanove, S., Martin, P., Lullmann, C., Borneck, R., Flamini, C.H. and Morlot, M.1997. Harmonised methods of the European honey commission. Apidologie (extra issue): 1–59.

Cantarelli, M.A., Pellerano, R.G., Marchevsky, E.J. and Camiña, J.M. 2008. Quality of honey from argentina: study of chemical composition and trace elements. Journal Argentina Chemistry Society 96(1-2): 33-41.

Chakir, A., Romane, A., Marcazzan, G.L. and Ferrazzi P. 2011. Physicochemical properties of some honeys produced from different plants in Morocco. Arabian Journal Chemistry 4(3): 427-430.

Codex Alimentarius Commission.1969. Standard for honey (CAC/RS 12 1969). Rome (Italy).

Da Silva, P. M., Gauche, C., Gonzaga, L.V., Costa, A.C.O and Fett, R. 2016. Honey: Chemical composition, stability and authenticity Priscila. Food Chemistry 196: 309–323.

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

Erkan M.E., Vural A., Guran H.S. and Durmusoglu H. 2015 Microbiological investigation of honey collected from Şırnak province of Turkey. Journal of the Hellenic Veterinary Medical Society – Current 66(1): 22-26

Fallico, B., Arena, E., Verzera, A. and Zappala, M. 2006. The European Food Legislation and its impact on honey sector. Accreditation and Quality Assurance 11: 49-54.

Fenicila, L. and Anniballi, F. 2009. Infant botulism. Ann Ist Super Sanita 45 (2): 134-146.

Gomes, S., Dias, G.L., Moreira, L.L. and Rodrigues, P.2010. Estevinho L. Physicochemical, microbiological and antimicrobial properties of commercial honeys from Portugal. Food Chemistry Toxicology 48 (1): 544-548.

Gomes, S., Dias, L., Moreira, L., Rodrigues, P. and Estevinho, L.M. (2010). Physicochemical, microbiological and antimicrobial properties of commercial honeys from Portugal. Food and Chemical Toxicology 48: 544–548.

Guler, A., Bakan, A., Nisbet, C. and Yavuz, O. 2007. Determination of important biochemical properties of honey to discriminate pure and adulterated honey with sucrose (*Saccharum officinarum* L.) syrup. Food Chemistry 105(111): 9–1125.

Guler, Z. 2005. The Chemical and sensory properties of honey produced in the east blacksea regions. Gıda 30 (6), 379–384.

Jeffrey, A.E. and Echazarreta, C.M. 1996. Medical uses of honey. Review Biomedical 7: 43 – 49.

Kayacier, A. and Karama, S. 2003. Rheological and some physicochemical characteristics of selected Turkish honeys. Journal Texture Study 39 (1): 17-27

Mahmoudi, R., Zare P., Tajik, H., Shadfar, S. and Nyiazpour, F. 2012. Biochemical properties and microbial analysis of honey from North-Western regions of Iran: Seasonal effects on physicochemical properties of honey. African Journal of Biotechnology 11(44): 10227-10231.

Malika, N., Mohamed, F. and Chakib, E. 2005.

Microbiological and physico - chemical properties of Moroccan honey. International Journal of Agriculture and Biology 7 (5): 773- 76

Migdal, W., Owczarczyk, H.B, Kediza, B., Holderna-Kedzia, E. and Madajczyk, D. 2000. Microbiological decontamination of natural honey by irradiation. In Radiation Physics and Chemistry 57: 285-288.

Moghadamnia, H.A. 2012. Province of Ardabil. Textbook publishing companies in Iran, p. 131-133. [in Persian]

Nanda, V., Sarkara, B.C., Sharma, H.K. and Bawa, A.S.V. 2003. Physicochemical properties and estimation of mineral content in honey produced from different plants in Northern India. Journal Food Composition Analaysis 16 (5): 613–619.

Olugbemi, O., Ikeme, C.H. and Dioha, I.J. 2013. Physcochemical analysis of honey from Umuahia, Abia satate, Nigeria Research Journal Engineering Applied Science 2(3): 199-202.

Omafuvbe, B.O. and Akanbi, O.O. 2009. Microbiological and physico-chemical properties of some commercial Nigerian honey. African Journal of Microbiology Research 3(12): 891-896.

Ouchemoukh, S., Louaileche, H. and Schweizer, P. 2007. Physicochemical characteristics and pollen spectrum of some Algerian honey. Food Control 18 (1): 52–58

Pavelkova, A., Kacaniova, M., Cubon, J., Svecova, Z., Knazovicka, V. and Felsociova, S. 2013. Physicochemical and microbiological quality of honey from Liptov region. Journal Microbiology Biotechnology Food Science 2 (Special issue 1): 1185-1193.

Przybylowsky, P. and Wilczynska, A. 2001. Honey as an environmental marker. Food Chemistry 74 (3): 289–291.

Rodriguez, G.O., Ferrer, B.S., Ferrer, A. and Rodriguez, B. 2004. Characterization of honey produced in Venezuela. Food Chemistry 84 (4): 499-502.

Saxena, S., Gautam, S. and Sharma, A. 2010. Physical, biochemical and antioxidant properties of some Indian honeys. Food Chemistry 118: 391-397.

Singh, N. and Bath, P.K. 1998. Relationship between heating and hydroxymethylfurfural formation in different honey types. Journal Food Science Technology 35: 54–156.

Terrab, A., Recamales, A.F., Hernanz, D. and Heredia, F.J. 2004. Characterisation of Spanish thyme honeys by their physicochemical characteristics and mineral contents. Food Chemistry 88 (4): 537–542.

White, J.W. 1975. Physical characteristics of honey. In Crane (ed.) Honey: A comprehensive survey, p. 207–229. Heinemann, London.