Biological Forum – An International Journal **9**(2): 185-193(2017)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Evaluation of Changes in some Physical and Chemical Properties of Syrian Honey, Affecting Honey Crystallization due to the Different Geographical Sites

Ebraheem Al-Jouri*, Nouraldin Daher-Hjaij*, Raghdan Alkattea**, Kassem alsayed Mahmoud and Al-Muthanna Saffan*******

**Insects Research Department, Plant Protection Research Administration, General Commission for Scientific Agricultural Research (GCSAR), Al-Halbouni, Damascus, Syria.*
***State Institute of Apiculture, University of Hohenheim, Stuttgart, Germany.*
****Bio-BioTech, Université Libre de Bruxelles, Brussels, Belgium.*
*****Laboratory of the Internal Trade and Consumerism Directorate in Deir Ezzor, Syria.*

(Corresponding author: Ebraheem Al-Jouri)
(Received 09 September 2017, Accepted 04 October, 2017)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: This paper aimed to evaluate some physical and chemical properties of Syrian honey that affect honey crystallization. 44 Samples of honey were collected after harvesting from different Syrian regions. All were produced by the local honey bee colonies *Apis mellifera syriaca* L. The results proved that all samples were in the range of the Syrian and European Codex Standards. The lowest moisture content was found in the eastern region samples where it reached around 12.43%. pH value ranged between 3.74 and 5.74 in all samples. Sucrose did not exceed 3.85%. The average of glucose to fructose reached 0.96% in the eastern region honey, whereas it reached 1.21% and 1.1% in the southern and middle regions respectively. This refers that honey of the eastern region has the highest trend to crystallization. As a result, Syrian honey in general is susceptible to crystallization with differences according to geographical sites and nectar sources.

Key words: Syrian honey, physical and chemical properties, crystallization

INTRODUCTION

Syrian honey is characterized by its wide varieties due to the wide botanical variation in Syria. The nectar sources for honeybee foragers differ according to the geographical sites. This includes forest and orchard trees such as Eucalyptus-Citrus trees- stone fruit trees, crops like cotton - sunflower - anise- black seeds *Nigella sativa*, besides a number of medical plants such as Thyme-caper *Capparis spinose*-Artemisia, and wild thorn plants like camelthorn *Alhagi maurorum* and the yellow star-thistle *Centaurea solstitialis*. What can be considered as a good factor for the quality of Syrian honey is its very low content of pesticides residues due to the high prices of pesticides that most of the farmers cannot afford applying them on their crops (Fert, 2004). The honey production in Syria reached 2900 tons (AOAD, 2015)).

Natural honey is one of the most sought products due to its unique nutritional and medical properties resulting from the different substances composing the honey (Buba *et al.,* 2013). Honey is defined as a sweet natural sugar compound, has a viscous structure and a special aroma, produced by the workers of honeybees either from flowers nectar, secretions of flowering buds, or secretions of plant lice (Buba *et al.*, 2013; Hernândez *et al.,* 2005). This definition was mentioned in the publication of the Codex Alimentarius Commission, 2001 and the Council of European Union, 2002). All types of honey have common features: water content (moisture) less than 20%, reduced sugars 60-65%, sucrose 5-10% (Hernândez *et al.*, 2005).

Honey consists of essential components, which include monosaccharides like glucose and fructose, and low-concentration components like amino acids, enzymes, vitamins and minerals (Manzanares *et al.,* 2011).

The flavor and components of honey depend on a big number of variables; the most important one is the plant species, which supplies the honeybee workers with nectar, then, the climatic conditions during production and the following production procedures like harvesting, storage condition, and beekeepers' procedures to extract honey (Kayode and Oyeyemi, 2014).

Sugars in honey are responsible for many physical and chemical properties such as viscosity, ability of honey to absorb air moisture and crystallization like most of the honey with saturated glucose solution. Glucose tends to crystallize automatically in room temperature when it is bound with water. This phenomenon is known as crystallization of honey (Cavia *et al.*, 2002). Temperature plays an important role in honey crystallization. For instance, mild temperature between 10-21ºC encourages crystallization; whereas, the warm temperature between 21 - 27º C prevents the occurrence of this phenomenon (Joseph *et al.* 2007).

This work was carried out to evaluate the changes in some physical and chemical properties of Syrian honey produced from varied nectar sources in different geographical sites and the influence of these changes on honey crystallization.

MATERIALS AND METHODS

A. Collecting honey samples

44 honey samples were immediately collected from beekeepers after harvesting. Honey was produced by local honeybee colonies *Apis mellifera syriaca* L. during the season of 2012. The samples covered all geographical regions in Syria (Fig. 1) as following: 11 samples from the eastern region (Deir Ezzor, Al-Hassakeh and Ar-Raqqa), 7 samples from the northern region (Aleppo and Edleb), 11 samples from the coastal region (Latakia and Tartous), 12 samples from the central region (Homs and Hama), and 3 samples from the southern region (Damascus, Damascus Countryside, Daraa, As-Suwaydaa and Al-Qunietreh). Honey was named after its region of origin due to the Syrian standards' labelling. The Item 1/2/8 from paragraph 8/1 mentioned, concerning the product's name, that honey can be named by the geographical or topographical name of the region (Syrian Arab Standards and Metrology Organization, 2004).

B. Physical and Chemical Analyses

All required analyses were carried out at the laboratory of the Directorate of Food Supply in Deir Ezzor. Moisture content, pH and solid materials content were calculated besides the estimating of different sugars such as fructose, glucose and sucrose and total sugars according to the AOAC official method of analysis (AOAC, 1990):

1. Calculating the average of water content ratio by using a drying oven (Kottermann Model: D3165).
2. Measuring pH average in honeybee samples by using the pH-meter (Model: G103).
3. Calculating the average of total solid materials ratio:

% of total solid materials = 100 - % of water content

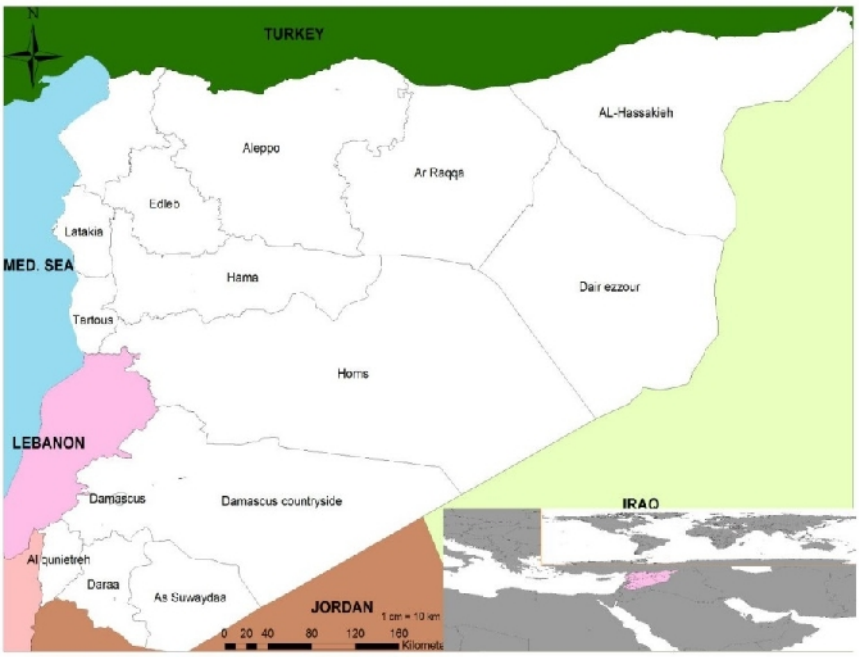

Fig. 1. A map of Syria illustrates its location and administrative provinces (Ministry of defense, 1977).

4. Estimating the average of sugars ratio (fructose, glucose, sucrose) by using an HPLC (Shimadzu LC-10ADVP) equipped with a manual injector and RID detector, using a 25 cm long NH2 separation column, with 0.32 mm internal diameter and filling thickness to 0.5 µm.
5. Estimating the average of total sugars ratio: by using the J57 HA refractometer at 25°C.
6. Estimating the average of crystallization indicators: fructose/glucose ratio, the difference of fructose-glucose, glucose/water content ratio, (glucose-water content)/fructose ratio.

C. Statistical analysis

The results were statistically analyzed by distributing the honey samples according to the region of origin. The data were analyzed by using Fischer test F at probability level 0.01 and LSD test at the same level of significance. The results were compared with the Syrian standards (Syrian Arab Standardization and Metrology Organization, 2004), European Standards (The Council of European Union, 2002) and the Codex (Codex Alimentarius Commission, 2001).

RESULTS AND DISCUSSION

A. Physical and Chemical Properties of Samples

Water Content (Moisture): Water content is an important indicator affecting honey quality. It refers to the exact amount of water exists in honey (Ahmed *et al.* 2014). The results (Table 1) showed that the lowest mean of moisture was in the honey of the eastern region where it reached 12.43% ±1.09, whereas it increased in the honey of the coastal region to 16.60% ±0.80. The difference was significant at 0.01 level between the honey of the coastal region from one hand and the honey of the eastern, northern, and southern regions on the other hand. The difference in honey water content is due to the nectar sources and the difference of air humidity at the different regions of collected samples. For instance, the eastern region has a higher temperature and lower air humidity than other regions, especially the coastal region (Fig. 2). In general, moisture content for all honey samples was within the range allowed by the Syrian standards, European standards and Codex where it should not exceed 20%, 20% and 21% respectively. The water content ratio in all samples was very low. This indicates to the complete ripening of honey at harvesting, which gives the honey a better flavor and texture. Former studies proved that water content is an important factor contributing to the stability of honey depending on the climatic conditions, honey ripening grade, and how beekeepers deal with honey during harvesting. This can differ from year to year (Karimov *et al.,* 2014; Ahmed *et al.,* 2014; Terrab *et al.,* 2004; Ayari *et al.,* 2013). High moisture content in honey leads to undesired fermentation of honey during storage, so beside the effects of water content on honey quality, viscosity, fermentation and taste, it is important to protect honey from microbes (Abramovic *et al.,* 2008; Kayode and Oyeyemi, 2014).

Table 1: Some Physical and Chemical Properties of the Syrian Honey and the Codex.

Property		Region					F	LSD 0.01
		Eastern	**Northern**	**Coastal**	**Central**	**Southern**		
Water Content %	**Max**	14.37	14.37	17.31	17.8	14.82	**37.76*** **	**1.90**
	Min	10.84	13.49	14.52	14.97	13.72		
	Mean±SD	**12.43**±0.57d	**14.04**±0.44c	**16.6**0±0.80a	**15.81**±0.88ab	**14.35**±0.46ab		
	Syrian Standards for water content that does not exceed 21%							
	European Standards for water content that does not exceed 20%							
pH	**Max**	5.55	5.45	4.81	5.74	4.86	**3.86***	**1.09**
	Min	4.21	3.84	3.74	3.79	4.06		
	Mean±SD	**4.92**±0.36a	**4.41**±0.54ab	**4.13**±0.42b	**4.65**±0.61ab	**4.33**±0.46ab		
Total Solid Materials %	**Max**	89.15	86.05	85.47	85. 02	86.27	**37.76*** **	**1.90**
	Min	85.62	85.40	82.68	82.19	85.17		
	Mean±SD	**87.65**±1.09a	**85.95**±0.44b	**83.4**0±0.80d	**84.17**±0.88cd	**85.64**±0.57bc		

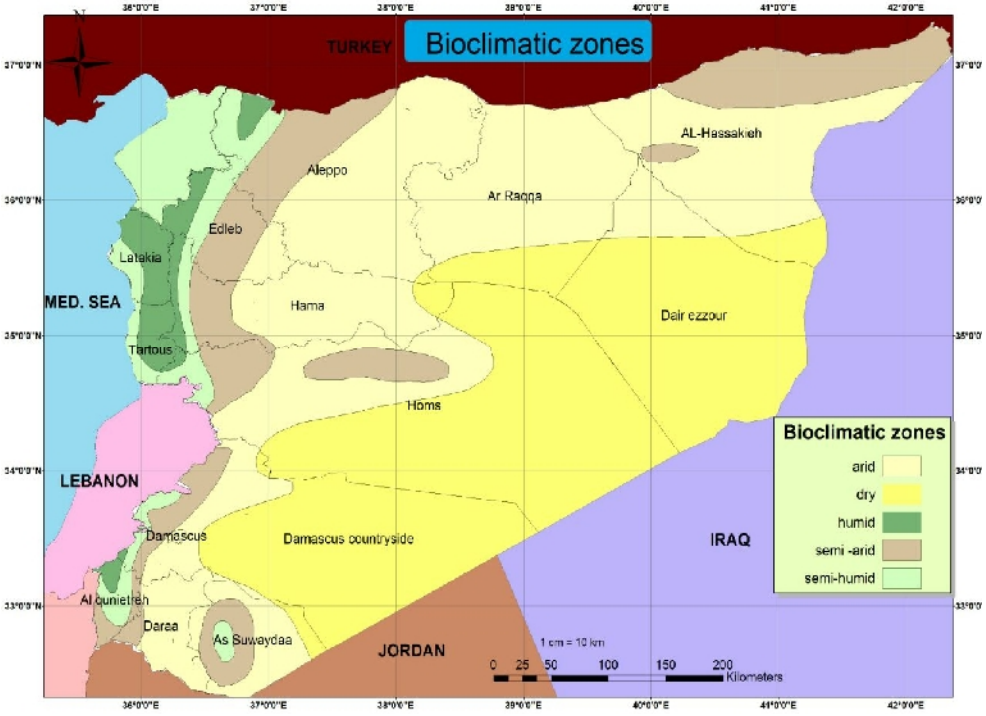

Fig. 2. A map of Syria illustrates the different bioclimatic zones (Ministry of defense, 1977).

Therefore, keeping moisture ratio under 21% was emphasized in all over the world. For instance the water content ratio ranged between 14 -16.9% in Saudi honey, 13.8-17.8% in Spanish honey and 15.4-18.1% in Polish honey (Lazaridou *et al*., 2004), and it ranged between 15.87-18.05% in Moroccan honey, 10.09-20.37% in South-African honey and 14.86 -17.53% in Malaysian honey (Ahmed *et al.*, 2004). Depending on the obtained results of moisture ratio, we can confirm the good storage potential of the Syrian honey which enables to keep it as an important medical and nutritional material for the longest period.

pH of Honey: The pH value is one of the important and required properties to keep the honey and protect it from fermentation. The obtained results showed that the pH values were close to each other in all honey samples. It ranged between 3.74 and 4.81 in the honey of the coastal region with an average of 4.13± 0.42, and between 4.32 and 5.55 in the honey of the eastern region with an average of 4.92 ±0.36. All these values make the honey an acidic medium (Table 1). These results come in accordance with many studies which emphasized that honey coming from flowers nectar is an acidic medium. Bogdanov *et al*. (2004) proved that all honeys are acidic with values ranging between 3.5 and 5.5.

Organic acids give flavor and stability against microbial corruption. Terrab *et al.* (2004) mentioned that the average of pH in Spanish mint honey was about 4.2, which was of great importance during honey extraction and storing by keeping the texture and stability of honey and keeping the honey valid for consumption for longer periods. It ranged between 3.55 and 4.79. These values are optimal in flowers honey. In general, honey is an acidic medium, regardless its geographical origin. Previous studies demonstrated that the pH values varied between 3.7-4.4 in Indian honey, 3.91-4.93 in Moroccan honey, 3.25-3.32 in Argentinian honey and 3.48 - 6.06 in Saudi honey (Azeredo *et al.*, 2003; Ouchemoukh *et al.*, 2007). All the values obtained in this study are similar to former reports for honey samples from India, Brazil, Spain and Turkey were pH values recorded between 3.4- 4.7. (Azeredo *et al.*, 2003; Saxena *et al.*, 2010).

Solid Materials: Solid materials refer to the content of both organic and non-organic materials (Kayode and Oyeyemi, 2014). Solid materials ratio ranged between 82.65 and 85.47% in the coastal region's honey samples with an average of 83.4% ±0.8, where the ratio ranged between 85.62 and 89.15% in the eastern region's honey samples with an average of 87.56% ±1.09 (Table 1).

The values of solid materials were ignored at the reports of Codex and European standards with time (Codex Alimentarius Commission, 2001; The Council of European Union, 2002).

B. Sugars

Fructose: The results (Table 2) showed that fructose ratio ranged between 32.77 and 38.45% in the eastern region's honey samples with an average of 35.66 % ±1.8.

Table 2: Sugar types in Syrian honey.

Sugar Type		Region					F	LSD $_{0.01}$
		Eastern	Northern	Coastal	Central	Southern		
Fructose (F) %	Max	38.45	39.62	42.85	43.03	45.22	**22.37*****	**3.50**
	Min	32.77	36.66	36.69	37.35	42.49		
	Mean±SD	**35.66**±1.80c	**38.34**±1.11b	**39.89**±1.82b	**40.27**±1.41b	**43.87**±1.37a		
Glucose (G) %	Max	39.54	40.23	39.44	39.11	37.77	**0.06**^{ns}	**2.78**
	Min	35.11	36.87	35.41	35.37	35.37		
	Mean±SD	**37.13**±1.31a	**38.44**±1.30a	**37.39**±1.27a	**36.71**±1.18a	**36.42**±1.23a		
F + G %	Max	76.11	79.34	79.36	78.82	81.34	**19.91*** **	**3.50**
	Min	69.26	74.44	75.86	74.63	79.26		
	Mean±SD	**72.79**±2.34b	**76.78**±1.49a	**77.28**±1.04a	**76.98**±1.17a	**80.29**±1.04a		
	Syrian standards, European standards and codex Alimentarius forF + G that do not less than60%							
Sucrose(S) %	Max	2.45	3.42	2.77	3.85	2.354	**0.15**^{ns}	**2.06**
	Min	0.89	1.59	0.38	0.51	0.74		
	Mean±SD	**1.81**±0.50a	**2.43**±0.63a	**1.50**±0.79a	**1.60**±0.93a	**1.55**±1.14a		
	Syrian standards, European standards andcodex Alimentarius for sucrose that do not exceed 5%							
Total Sugars%	Max	85.79	84.09	82.44	82.41	84.98	**11.97*** **	**2.80**
	Min	80.12	82.77	78.5	79.28	83.9		
	Mean±SD	**82.91**±1.98a	**83.54**±0.56b	**80.69**±1.12b	**80.88**±0.84a	**84.48**±0.54a		
(F + G)/Total Sugars	Max	0.94	0.95	0.99	0.98	0.96	**16.87*** **	**0.05**
	Min	0.82	0.90	0.93	0.92	0.93		
	Mean±SD	**0.88**±0.04b	**0.92**±0.02a	**0.96**±0.02a	**0.95**±0.02a	**0.95**±0.02a		
Total Sugars/ Solid Material	Max	0.96	0.98	1.00	0.98	0.99	**7.58*** **	**0.03**
	Min	0.93	0.97	0.95	0.93	0.97		
	Mean±SD	**0.95**±0.01b	**0.97**±0.01a	**0.97**±0.02a	**0.96**±0.01ab	**0.99**±0.01a		

Whereas the range was between 42.49 and 45.22% in the southern region's honey samples with an average of 39.87% ±1.37, with a significant difference at 0.01 level. While the average of fructose ratio was 38.34% ±1.11, 39.89% ±1.82, and 40.27% ± 1.41 in the honey samples of the northern region, coastal region and the central region respectively.

The higher fructose ratio in the central region's and southern region's honey samples is due to the dominant nectar sources in these two regions such as thorn plants in the southern region and anise and black seed in central region, while cotton, sunflower and forest trees prevail in the eastern region.

Glucose: Glucose ratio ranged between 36.42% ±1.32 in the southern region's honey samples and 38.44% ±1.30 in the northern region's honey samples. The results showed similarity in glucose ratio among all honey samples. No significant differences were detected.

Sum of fructose and glucose: It is an important property to distinguish between pure flowers' nectar honey and faked honey (Manzanares *et al.* 2011). The results mentioned in Table 2 referred that the sum of fructose and glucose ranged between 69.26 and 76.11% in the eastern region's honey samples with an average of 72.79% ±2.34. And it ranged between 79.26 and 81.34% in the southern region's honey with an average of 80.29% ±1.04. There was a significance difference at 0.01 level between the honey samples of the eastern region and the other regions. However, in all honey samples, the sum of fructose and glucose matched with the Syrian standards, European standards, and the Codex which require that the sum of fructose and glucose should not be less than 60%.

Sucrose: The analyses showed that the sucrose ratio in all honey samples were conforming to the Syrian standards, European standards and Codex which require that sucrose should not exceed 5% in most types of honey.

In the examined samples, sucrose ranged between 0.38 and 2.77% in coastal region's honey samples with an average of 1.5% ±0.79, while it ranged between 1.59 and 3.42% in northern region's honey samples with an average of 2.43% ±0.63. No significant differences were found among the honey samples from the different regions.

Total sugars: total sugars ratio ranged between 79.28 and 82.41% in the Central region's honey samples with an average of 80.88% ±0.84. While it ranged between 83.9 and 84.98% in the southern region's honey samples with an average of 84.48% ±0.54. The average of the sum of fructose and glucose constitutes the highest amount of total sugars which ranged between 88% ±0.04 in the eastern region's honey samples and 95% ±0.02 in the southern and central regions' honey samples. Whereas the total sugars constitutes the largest part of the solid materials with an average of 95% ±0.01 in the eastern region's honey samples and 99% ±0.01 in the southern region's honey samples (Table 2). Earlier studies confirmed that total sugars are the major component of honey and constitute 95% of the dry weight of honey (Buba *et al*. 2013, Shafiq *et al.* 2014).

C. Chemical properties of the Syrian honey and its influence on crystallization

Crystallization, or what is also known as granulation of honey, is a natural phenomenon. It is influenced by many factors such as moisture, the ratio of both fructose and glucose and climatic conditions. Moistureis considered as an important factor largely contributing to honey stability against fermentation and granulation during storage (Karimov *et al.*, 2014).

The international criteria for determining the susceptibility of honey to crystallization are:

Glucose ratio: Glucose in honey is the main factor responsible for honey crystallization. When honey has a high glucose content, it is much more susceptible to crystallization. In this study, the average of glucose ratio in honey samples was relatively low (between 36.42 and 38.44%, Table 2) and this is not enough to accelerate honey crystallization. The same result was also found in a study conducted by Gariola et al., 2013 where glucose ratio ranged between 35.37 and 38.04%. This range is low; therefore, the honey is less tending to be crystallized. So the crystallization in the honey samples of this study was slow according to this criterion.

The difference between fructose and glucose in honey (F-G): The results mentioned in table 3 showed an increasing of fructose ratio comparing to the glucose ratio in the honey samples of the central, southern and coastal regions with a significant difference at 0.01level, where there were no significant differences at the honey samples from the eastern and northern regions. The bigger the difference between fructose ratio and glucose ratio, the lower is the tendency of crystallization (Finola *et al.,* 2007). The value of (F-G) in the examined samples ranged between -1.47 ±2.1 and 7.45 ±2.38 in the eastern region's and southern region's honey samples respectively.

Table 3: Comparison between fructose and glucose ratio in Syrian honey for each region.

Region		Sugar type		F	$LSD_{0.01}$
		Fructose (F) %	Glucose (G) %		
Eastern	**Max**	38.45	39.54	**0.040***	**1.90**
	Min	32.77	35.11		
	Mean±SD	**35.66**±1.80a	**37.13**±1.31a		
Northern	**Max**	39.62	40.23	**0.869**^{ns}	**1.97**
	Min	36.66	36.87		
	Mean±SD	**38.34**±1.11a	**38.44**±1.30a		
Coastal	**Max**	42.85	39.44	**0.002****	**2.02**
	Min	36.69	35.41		
	Mean±SD	**39.89**±1.82a	**37.39**±1.27b		
Central	**Max**	43.03	39.11	**0.001****	**1.49**
	Min	37.35	35.37		
	Mean±SD	**40.27**±1.41a	**36.71**±1.18b		
Southern	**Max**	45.22	37.77	**0.003****	**4.88**
	Min	42.49	35.37		
	Mean±SD	**43.87**±1.37a	**36.42**±1.23b		

The negative value refers to increasing the glucose ratio from the fructose ratio. The analyses proved that in most of the eastern region's honey samples, glucose ratio was more than fructose ratio. The difference was significant for this indicator between the honey samples from the southern region and the honey samples of other regions. This index indicates that the honey of the eastern and northern regions is much more susceptible to crystallization than the honey of the southern and central region.

Fructose to glucose ratio (F/G): This ratio is a factor influencing the honey flavor (Finola *et al.,* 2007) and its susceptibly of crystallization (Buba *et al.,* 2013). It depends on the nectar source (Finola *et al.,* 2007; Chua and Adnan, 2014). Honey with a higher fructose ratio can stay as a liquid for a longer period. It is the sweetest compared to glucose. Glucose is considered the main cause for honey granulation (Finola *et al.,* 2007). The F/G ratio in the examined honey samples ranged between 0.9 and 1.08 for the eastern region's samples with an average of 0.96 ±0.06, while it ranged between 1.12 and 1.25 in the southern region's honey samples with an average of 1.21 ±0.07 (Table 4). The obtained data agree with what Buba *et al.,* 2013 found, where the ratio ranged between 1 and 1.45 with an average of 1.24 ±0.10, and confirmed that crystallization of honey is slower when the value F/G is more than 1.3. And it is faster in crystallization when the ratio is lower than 1.0. Ahmed *et al.* (2014) defined this ratio between 1.7 and 1.17. It was important to explain the composition of honey and its crystallization and he recommended it as an important indicator to evaluate granulation of honey. That's due to glucose which is less soluble in water than fructose. From all above mentioned data, it is obvious that the honey of the southern and central region has the lowest tendency for crystallization compared to the honey of the northern and eastern regions.

Glucose/Water content Ratio (G/W): This ratio is more specific than the F/G ratio in predicting honey crystallization tendency (Buba *et al.,* 2013). It ranged between 2.10 and 2.62 with an average of 2.26± 0.17 in the honey of the coastal region, and between 2.49 and 3.54 with an average of 3.01± 0.32 in the honey samples of the eastern region (Table 4). These values reflect the tendency of honey crystallization in Syrian honey in general and the honey of the eastern region in particular. These results come in accordance with what Amir et al., 2010 mentioned that honey crystallization is too slow or even doesn't occur when the G/W ratio is less than 1.3 and it becomes complete and fast when the G/W ratio is more than 2.0. Buba *et al.,* 2013 advised that glucose is the main sugar in honey, so when the ratio is less than 1.7, the honey tends to crystallize and the prediction of fast crystallization is possible when the G/W ratio is more than or equal to 2.1.

(G-W)/F Ratio: it ranged between 0.47-0.57 with an average of 0.50±0.05 in the southern region honey, while it ranged between 0.56 and 0.78 with an average of 0.69±0.07 in the honey of the eastern region (Table 4).

Table 4: Crystallization index for Syrian honey samples.

Property		Region					F	LSD $_{0.01}$
		Eastern	Northern	Coastal	Central	Southern		
F - G	Max	2.74	2.24	6.34	7.58	9.1	**12.39*** **	**5.26**
	Min	-3.72	-2.51	-2.75	-1.76	4.72		
	Mean±SD	**-1.47**±2.1d	**-0.11**±1.9cd	**2.49**±2.95bc	**3.56**±2.32ab	**7.45**±2.38a		
F / G	Max	1.08	1.06	1.17	1.21	1.25	**12.10*** **	**0.15**
	Min	0.90	0.94	0.93	0.95	1.12		
	Mean±SD	**0.96**±0.06d	**1**±0.05cd	**1.07**±0.08bc	**1.1**±0.06ab	**1.21**±0.07a		
G / W	Max	3.54	2.98	2.62	2.48	2.75	**22.58*** **	**0.47**
	Min	2.49	2.56	2.10	1.99	2.44		
	Mean±SD	**3.01**±0.32a	**2.74**±0.15ab	**2.26**±0.17c	**2.33**±0.15c	**2.54**±0.18bc		
(G - W) / F	Max	0.78	0.69	0.63	0.62	0.57	**18.46*** **	**0.130**
	Min	0.56	0.58	0.45	0.42	0.47		
	Mean±SD	**0.69**±0.07a	**0.64**±0.05ab	**0.52**±0.07b	**0.52**±0.05b	**0.50**±0.05b		
F / W	Max	3.30	2.90	2.67	2.80	3.10	**16.35*** **	**0.37**
	Min	2.56	2.57	2.25	2.33	3.02		
	Mean±SD	**2.88**±0.24a	**2.73**±0.13ab	**2.41**±0.12c	**2.55**±0.16bc	**3.06**±0.04a		

These values refer to the tendency of all kinds of honey to crystallization, in particular, for the honey of the eastern region according to the findings of Gairola *et al*. (2013) who confirmed that when the ratio of (glucose-water)/fructose is less than 0.50, the crystallization of honey is accelerated, while it tends to be slow when the ratio is less than 0.20.

Fructose/Water content (F/W) ratio: It ranged between 2.25 and 2.67 with an average of 2.41± 0.12 in the honey samples of the coastal region, and between 3.02 and 3.10 with an average of 3.06± 0.04 in the honey samples of the southern region.

CONCLUSION

The results of this paper demonstrate that the geographical site has a significant effect on the chemical and physical properties of the Syrian honey, especially for the ratio of fructose and water content.

This is due to the differences of the environmental conditions and the dominated nectar plants in each region, with the emphasis that all physical and chemical properties are conforming to the Syrian and European Standards and the Codex, which can reflect the high quality of the Syrian honey. Crystallization is a natural property for all types of the Syrian honey and at all geographical sites, in particular for the honey of the eastern region, which is the most tending to crystallize. Crystallization of the honey coming from the southern and central region is often delayed due to the higher fructose/glucose ratio.

ACKNOWLEDGMENT

We would like to thank all beekeepers for their cooperation in offering us the honey samples needed for the analyses.

REFERENCES

Abramovic H., Jamnik M., Burkan L and Kac M (2008). Water activity and water content in Slovenian honeys. Food Control. **19**: 1086-1090.

Ahmed M., Khiati B., Meslem A., Aissat S and Djebli N (2014). Evaluation of physicochemical and antioxidant properties of raw honey from Algeria. *J Microb Biochem Technol* **S4**: 006. doi:10.4172/1948-5948.S4-006.

Amir Y., Yesli A., Bengana M., Sadoudi R and Amrouche T (2010). Physico-chemical and microbiological assessment of honey from Algeria. *Electronic Journal of Environmental, Agricultural and Food Chemistry*, **9**: 1485-1494.

AOAC (1990). Food composition, additives and natural contaminants. In: Official Methods of Analysis. Helrich, K. (ed). Association of Official Analytical Chemists International 2, 15th Edition, Arlington, VA, USA.

AOAD (2015). Arab gric. statistics yearbook - *Khartoum* - Vol. **35**: 107.

Ayari B., Feten A., Mohamed A. H and Ahmed L (2013). Physicochemical and antimicrobial properties of Tunisian honeys: Honey inhibited the motility of bacteria. *African Journal of Microbiology Research*. **7**(32): 4138-4145.

Azeredo LC, Azeredo MAA, Souza SR, Dutra VML (2003). Protein contents and physicochemical properties in honey samples of *Apis mellifera* of different floral origins. *Food. Chem*. **80**: 249-254.

Bogdanov S., Ruoff K and Oddo L.P (2004). Physico-chemical methods for the characterization of unifloral honeys: a review. *Apidologie* **35**: S4-S17.

Buba F., Gidado A and Shugaba A (2013). Analysis of biochemical composition of honey samples from north-east Nigeria. *Biochem Anal Biochem* **2**: 139. doi: 10.4172/2161-1009.1000139.

Cavia M.M., Fernandez-Muino M.A., Gömez-Alonso E., Montes-Pérez M.J., Huidobro J.F. and Sancho M.T (2002). Evolution of fructose and glucose in honey over one year influence of induced granulation. *Food Chemistry*, **78**: 157-161.

Chua L.S and Adnan N.A. (2014). Biochemical and nutritional components of selected honey samples. *Acta Sci. Pol., Technol. Aliment*. **13**(2): 169-179.

Codex Alimentarius Commission (2001). Codex Standard for Honey, FAO, *Rome. Alinorm* **1**: 19-26.

Fert, G. (2004). Zoom in to Syria. *Bees for Development Journal* **71**, 6-7.

Finola M.S., Lasagne M.C and Marioli J.M (2007). Microbiological and chemical characterization of honeys from central Argentina. *Food Chemistry* **100**:1649-1653.

Gairola A., Tiwari P and Tiwari J.K. (2013). Physic-chemical properties of *Apis cerana-Indica* F. honey from Uttarkashi District of Uttarkhand, India. *Journal of Global Biosciences*. **2**(1): 20-25.

Hernândez O.M., Fraga J.M.G., Jiménez A.I., Jiménez F and Arias J.J. (2005). Characterization of honey from the Canary Islands: determination of the mineral content by atomic absorption spectrophotometry. *Food Chemistry* **93**: 449-458.

Joseph T., Julius A.N., Florence F.A., Delphine D.N., Jonnas P and Antoine M.Z (2007). Physico-chemical and microbiological characteristics of honey from the sudano-guinean zone of West Cameroon. *African Journal of Biotechnology*. **6**(7): 908-913.

Kayode J and Oyeyemi S.D (2014). Physico-chemical investigation of honey samples from bee farmers in Ekiti State, *Southwest Nigeria*. **2**(5): 246-249.

Karimov E., Zohre X., Paniz H and Jamil A (2014). Quality evaluation of honey from the different region of Azerbaijan. *Journal of Food Chemistry and Nutrition*. **2**(02): 71-79.

Lazaridou A., Biliaderis C.G., Bacandritsos N and Sabatini A.G (2004). Composition, thermal and rheological behavior of selected Greek honeys. *Journal of Food Engineering*. **64**: 9-21.

Manzanares A.B., García Z.H., Galdón B.R., Rodríguez E.R and Romero C.D. (2011). Differentiation of blossom and honeydew honeys using multivariate analysis on the physicochemical parameters and sugar composition. *Food Chemistry*. **126**: 664-672.

Ministry of Defense, (1977). Meteorological department. Agro-climatological reference book for the Syrian Arab republic.

Nedji N and Loucif-Ayad W. (2014). Antimicrobial effects of Algerian honey on pathogenic food-related bacteria. *Advance Journal of Food Science and Technology*. **6**(11): 1194-1200.

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

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

Shafiq H., Iftikhar F., Ahmad A., Kaleem M and Sair A.T (2014). Effect of Crystallization the water activity of honey. *International journal of food and nutritional sciences.* **3**(3): 1-6.

Syrian Arab Standardization and Metrology Organization, 2004. Syrian Honey bees standard, Ministry of industry, Syria. 412.

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

The Council of European Union. 2002. Council Directive 2001/110/EC of 20 December 2001 relating to honey. *Offic. J. the Europ. Comm.* **L10**: 47-52.