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PHYSICOCHEMICAL CHARACTERISTICS OF LIBYAN, EGYPTIAN AND IMPORTED HONEYS FROM SAUDIA AND TURKEYA

BY

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ABSTRACT

Four honey samples from different regions of Libya, two samples of Egyptian honey and two samples imported from Saudia and Turkeya were analysed for refractive index (R.I), specific gravity (Sp. Gr), moisture, total solids (T.S.), total soluble solids (T.S.S.), insoluble solids (Ins.S), total sugars (T. Sug.), reducing sugars (R. Sug.), glucose, fructose, total ash, protein, acidity, pH, hydroxymethylfurfural (HMF), vitamin C and minerals content. El Marj honey (H1) has significantly higher values from Sp.Gr., T.S., T.S.S., T. Sug., R. Sug. and fructose (1.4918 gm/cm^3, 86.40, 86.22, 82.24, 77.56 and 42.19%, respectively). El Koffra honey (H3) had significantly higher amounts from glucose, HMF and Vit. C (36.26%, 43.42 mg/kg and 17.28 mg/100g, respectively). The significant higher sucrose content was found in Sabha honey (H4) and Egyptain clover honey (H6) (5.50% and 5.15%, respectively). While the significantly higher ash content was found in Sabha (H4), Egyptian clover (H6) and Saudi (H7) honeys. Sabha honey (H4) and Saudia honey (H7) have significantly higher values from free acidity, total acidity and pH (31.12 and 33.24 meq/kg, 41.28 and 45.32 meq/kg and 3.74 and3.76, respectively). Turkish honey (H8) has significantly higher amount from moisture and protein (17.80 and 0.92%, respectively.

With respect to minerals content of honey samples, it could be noticed that Subrata honey (H2) contained significantly higher concentrations from Mg, Zn, Cu, Cd and Hg (44.18, 1.56, 0.42, 0.35 and 0.32 ppm, respectively) than the other samples. Sabha honey (H4) contained significantly higher concentration from K, Mn and Pb (460.11, 5.17 and 0.78 ppm, respectively). Egyptian clover honey (H6) and Saudi honey (H7) contained significantly higher concentrations from Fe (16.88 and 19.26 ppm, respectively). The Turkish honey (H8) contained significantly higher concentrations from Ca and Ni (134.01 and 4.75 ppm, respectively).

INTRODUCTION

Honey is a natural food by honeybees from a nectar of different plants, as well as from honeydew. This latter is a sugar containing substance extracted by some plant sucking insects. Honey contains at least 181 substances (Azeredo *et al.*, 2003; Sato and Miyata, 2000; Terrab *el al.*, 2003a and b). Chemically, honey comprise sugar (70-80%), water (10-20%) and other minor constitutes such as organic acids, minerals, vitamins and protein. The monosaccharides, fructose and glucose are the

main sugars found in honey (Nagai *et al.*, 2002; Terrab *et al.*, 2001 and 2003c; Ahmed *et al.*,2007 and Kücük *et al.*, 2007).

The quality and biochemical properties of honey are related to honey maturity, production methods, climatic conditions, processing and storage conditions, as well as the nectar source of the honey (Bogdanov, 1999; Khan *et al.*, 2006 and Oddo and Bogdanov. 2004). However, quality and composition of honey are negatively affected by the other factors such as overfeeding with sucrose and other sucrose variants, harvesting prior to maturity, unhealthy storage conditions and overused veterinary drugs (Bakan, 2002; Bogdanov *et al.*,2000 Moreira *et al.*, 2007 and Sahinler *et al.*, 2004).

A number of studies reported a regional variation in the physicochemical properties of the honey sample such as the moisture content, the ash content, the spectrum of saccharides, hydroxymethylfurfural, pH, acidity and mineral contents (Ahmed *et al.*, 2007; Dag *et al.*,2006; Golob and Plestenjak, 1999; Guler *et al.*,2007; Kücük *et al.*,2007; Finola *et al.*, 2007; Khan *et al.*,2006; Ouchemoukh *et al.*, 2007; Moreira *et al.*,2007; Terrab *et al.*, 2003, 2003a, b and c).

Currently, characterization of honey by means of chemical, rheological and sensory characteristics has received several attentions (Anklam and Radovic, 2001; Cordella *et al.*, 2003 and Iglesias *et al.*, 2004). Plenty of literature were available on physico-chemical, rheological and quality aspects of honey produced in different countries which is evident from publication in a single year on the tropic (Corbella and Cozzolino, 2006; Juszczak and Fortuna, 2006; Ouchemoukh *et al.*, 2007 and Yanniotis *et al.*, 2006).

Despite the fact that the mineral content of honey is very low when compared with other components, great variability has been reported in honey content of sodium, calcium, magnesium, potassium, phosphorous, iron, copper, zinc, manganese, aluminum, lead, mercury, nicl, chromium, cadmium and selenium. Metals such as chromium, cobalt, copper, iron, manganese and zinc (among others) are essential for human, and they may play an important role in a number of biochemical processes (Falco *et al.*, 2003; Garcia *et al.*, 2005; Dag *et al.*, 2006 and Kücük *et al.*,2007). However, these elements can also be toxic to humans when ingested in high doses. In contrast, elements such as Cadmium, Lead and Mercury are well known toxic elements for humans. The presence of heavy metals can pose humans health risks and their presence in honey has not been much studied in contrast to other hazardous compounds, such as pesticides and antibiotics (Domingo, 1994; Fredes and Montenegro, 2006; Khan *et al.*, 2006; Tuzen *et al.*, 2007 and Yilmaz and Yavuz, 1999).

MATERIALS AND METHODS

Materials:

Honey samples:

A collection of eight samples of honey were analyzed. Four samples of honey produced in various regions of Libya, were taken directly from the containers that the beekeepers use for the storage of honey in 2006. The regions

from which the sample of Libyan honey were as follow: east region El-Marj, (H1), west region Subrata (H2), south east region El-koffra (H3) and south west Sabha, (H4). Two samples of honey produced in Egypt comprise citrus honey (H5) and clover honey (H6) were obtained in 2006 from Agricultural Research Center Faculty of Agriculture, Moshtohor, Benha Univ. Egypt. The remaining two samples of honey were imported from Saudia Arabia (H7) and Turkeya (H8) were obtained from the local market in Sabha.

After removal of superficial layer, about 400g of every honey were analyzed. All the samples were examined in triplicates for several physico-chemical characteristics and minerals content.

Methods of analysis:

Phisco-chemical parameters:

Moisture content, Specific gravity, total soluble solids (T.S.S) and insoluble solids were determined by using Abbe refractmeter to record total soluble solids (T.S.S) and refractive index value. After correction for temperature, the reading was converted to moisture content (%) using the table given by White *et al.*, (1962).

Total sugar, reducing sugar, fructose, glucose, non reducing sugar (sucrose), ascorbic acid (V.C), ash, protein contents and The pH value were determined according to the methodology described in A.O.A.C. (1990).

Free acidity, lactonic acidity and total acidity were determined according to the method described by Bogdanov *et al.* (1997).

Hydroxymethylfurfural (HMF) was determined spectrophotometrically as outlined by Harmonization method of International Honey Commission (IHC) Bogdanov *et al.* (2000).

Minerals content:

The Na and K contents were determined according to the method described in A.O.A.C. (1990) using Flame Emission Spectrophotometer 410; Ca, Mg, Fe, Mn, Zn, Cu, Pb, Cd, Hg and Ni were determined by the method described by Willard *et al.*, (1981) using Atomic Absorption Spectrophotometer (AAS) at the Central Lab., Libyan Petroleum Oil Guardionship.

Statistical analysis: of the results was calculated as described by Gomez and Gomez (1984)

RESULTS AND DISCUSSION

Physical properties:

The results of physical properties of honey from different sources are presented in Table (1). Moisture content, a parameter related to the maturity degree, ranged from 13.60 to 17.80%, corresponding to refractive index between 1.4920 to 1.5033. Turkish honey (H8) has highest significant moisture content as

compared to other samples. Statistical analysis did not appear any significant differences in moisture content between Egyptian clover honey (H6) and El-koffra honey (H3) there is a variation in moisture content among the investigated samples of honey. Nanda *et al.*, (2003), Terrab *et al.*, (2003c) and Ouchemoukh *et al.*, (2007) stated that moisture content is affected by climate, season and moisture content of original plant. The values obtained of all samples are below 20% the maximum allowed by the European Community Directive (Council of the European Union, 2002). The quality of the investigated honey is good because honey with high moisture content is more likely to ferment (Bogdanov *et al.*, 1999). Moisture content is highly important for the shelf-life of the honey during storage (Terrab *et al.*, 2003b).

The physical parameter specific gravity ranged from 1.4203 to 1.4918 g/cm^3. El-Marj honey (H1) has significantly higher specific gravity as compared to other samples except Sabha honey (H4). While the Turkish honey (H8) has significantly lower specific gravity. Statistical analysis also did not appear any significant differences in specific gravity between Egyptian clover honey (H6), Saudi honey (H7) and El-Koffra honey (H3) and also between Egyptian citrus honey (H5), Subratr honey (H2) and Sabha honey (H4).

Table (1): Physical parameters of Libyan, Egyptian, Saudi and Turky honeys.

Samples	Refractive index	Specific gravity	Moisture (%)	Total solids (%)	Total soluble solid (%)	Insoluble solids (%)
H1	1.5033	1.4918^{a}	13.60^{de}	86.40^{a}	86.22^{a}	0.18^{cd}
H2	1.5007	1.4762^{b}	14.40^{cd}	85.60^{c}	85.38^{b}	0.22^{c}
H3	1.4961	1.4489^{c}	16.20^{b}	83.80^{e}	83.48^{d}	0.32^{b}
H4	1.5018	1.4863^{ab}	14.00^{d}	86.00^{b}	85.35^{b}	0.65^{a}
H5	1.4997	1.4726^{b}	14.80^{c}	85.20^{d}	85.05^{c}	0.15^{d}
H6	1.4951	1.4430^{c}	16.60^{b}	83.40^{f}	83.08^{f}	0.32^{b}
H7	1.4956	1.4481^{c}	16.40^{b}	83.60^{ef}	83.26^{e}	0.34^{b}
H8	1.4920	1.4203^{d}	17.80^{a}	82.20^{g}	82.12^{g}	0.08^{e}
LSD	N.S	0.0116	0.69	0.34	0.13	0.07

Data calculated from triplicates.

(a-g) There is no significant differences between any two means have the same letter within certain property.

Total solids and total soluble solids ranged from 82.20 to 86.40% and from 82.12 to 86.22%. El-Marj honey (H1) also has significantly higher total solids and total soluble solids as compared to other samples, while the Turkish honey (H8) had significantly lower total solids and total soluble solids. The insoluble solids ranged from 0.08 to 0.65%. Sabha honey (H4) had very significantly higher insoluble solids as compared to other samples, while the Turkish honey (H8) has very significantly lower insoluble solids. The lower amount of insoluble solids indicate the cleanness of the products such as wax, which is not determined by the Codex Alimentarius Method (2001) is a major source of water insoluble contamination (Bogdanov *et al.*, 1999). Generally, the

honey samples having a low moisture content had the highest total solids and total soluble solids. The variation in total solids, total soluble solids and insoluble solids are found to be dependent on climate, floral source and some other factors (Juszczak and Fortuna, 2006; Ohchemoukh *et al.*, 2007 and Ahmed *et al.*, 2007).

Chemical parameters:

As shown in Table (2) the major sugar present in different honeys are fructose and glucose. Total sugars and reducing sugars ranged from 72.60 to 82.24% and from 69.90 to 77.56%, respectively. El-Marj honey (H1) have significantly higher content of total and reducing sugars, while the Egyptian citrus honey (H5) has significantly lower amount of total sugars. The significantly lower of reducing sugars were found in Saudi honey (H7). These results confirm that sugars represent the major constituents of honey.

Fructose is always the most important sugar quality quantitatively followed by glucose. Fructose ranged from 37.48 to 42.19%, which was significantly higher in El-Marj honey (H1), while it was significantly lower in Sabha honey (H4). Glucose ranged from 28.58 to 36.26%. which was significantly higher in El-Koffra honey (H3), while it was significantly lower in Saudi honey (H7). These obtained results are in agreement with those obtained by Diez *et al.*, (2004), Finalo *et al.*, (2007), Guler *et al.*, (2007), Ohchemoukh *et al.*, (2007) and Terrab *et al.*, (2003a and b). Total sugars ranged from 71.25 to 74.25, reducing sugar ranged from 67.83 to 80.24, fructose ranged from 38.97 to 43.07 and glucose ranged from 27.25 to 36.15%, respectively.

Sucrose content ranged from 0.80 to 5.51%. Only the honey samples of Sabha (H4) and clover Egyptian (H6) has significantly higher amount of sucrose, while the Turkish honey (H8) has significantly lower content from sucrose. Statistical analysis did not appear any significant differences in sucrose content among El-Marj honey (H1), Subrata honey (H2) and Saudi honey (H7). Generally, sucrose content in all samples was lower than the limit (is $\leq$ 10%) of The Council of the European Union, (2002). The sucrose level can be increased if the beekeeper has over-fed the bees with sugar during the spring (Anklam. 1998). Moreover, a high concentration of this sugar in early harvest of the honey (Azerdo *et al.*, 2003). The obtained results are in agreement with those of (Terrab *et al.*, 2003b; Kücük *et al.*, 2007 and Ohchemoukh *et al.*, 2007).

Ash content of the honey samples differed and ranged from 0.09 to 0.36%. The significantly higher ash content was found in Egyptian clover honey (H6), Sabha honey (H4) and Saudi honey (H7), where as samples El-Koffra honey (H3) and Egyptian citrus honey (H5) possessed the significantly lower ash content 0.09 and 0.11%, respectively. These differences in ash content are depended on the type of soil in which the original nectar bearing plant was located (Anklam. 1998). Ash content is a quality criterion for honey botanical origin. These results are in agreement with those of {Ohchemoukh *et al.*, 2007 (0.06–0.54), very comparable to Terrab *et al.*, 2003c (0.08–0.37%) and almost similar to Ahmed *et al.*, 2007 (0.08–0.39%)}.

Table (2): Some chemical parameters of Libyan, Egyptian, Saudi and Turky honeys (on wet weight basis).

Sample	Total sugars (%)	Reducing. Sugars (%)	Fructose (%)	Glucose (%)	Sucrose (%)	Total ash (%)	Protein (%)
H1	82.24^{a}	77.56^{a}	42.19^{a}	35.37^{a}	4.45^{b}	0.15^{cd}	0.21^{d}
H2	80.93^{a}	76.38^{ab}	40.74^{bc}	35.64^{a}	4.32^{b}	0.18^{c}	0.14^{de}
H3	76.67^{bc}	74.40^{b}	38.14^{e}	36.26^{a}	2.16^{c}	0.09^{d}	0.11^{e}
H4	77.58^{bc}	71.79^{cd}	37.48^{f}	34.31^{b}	5.50^{a}	0.35^{a}	0.18^{de}
H5	72.60^{d}	70.64^{d}	38.21^{e}	32.43^{c}	1.86^{d}	0.11^{d}	0.22^{d}
H6	79.85^{ab}	74.05^{bc}	39.85^{d}	34.20^{b}	5.51^{a}	0.36^{a}	0.71^{b}
H7	74.54^{cd}	69.90^{d}	41.32^{b}	28.58^{d}	4.41^{b}	0.33^{a}	0.38^{c}
H8	75.50^{cd}	74.66^{b}	40.59^{c}	34.07^{b}	0.80^{e}	0.23^{b}	0.92^{a}
LSD	3.36	2.61	0.63	1.25	0.53	0.04	0.09

Data calculated from triplicates.

(a-e) There is no significant differences between any two means have the same letter within component.

Protein content of honey is normally less than 5 mg/g (0.5%) Anklam (1998). The protein content of honey samples ranged from 0.11 to 0.92%, which was significantly higher in Turkish honey (H8), while it was significantly lower in El-Koffra honey (H3). Statistical analysis did not appear any significant differences in protein content among El-Marj (H1), Subrata (H2), Sabha (H4) and Egyptian citrus (H5) honeys and also between Subrata honey (H2), El-Koffra honey (H3) and Sabha honey (H4). This variation may be due to the type of flora. Honey contains about 0.20% protein as α- amylose, invertase, catalase, glucose oxidase and phosphatase, which is related to plant origin, pollens and nectar (Anklam. 1998). The results of (H1), (H4) and (H5) are approximate to obtained by {Azerdo *et al.*, 2003 (0.223%)} while the results of H6, H7 and H8 are in agreement with those obtained by Ohchemoukh *et al.* (2007) for Algerian honey (0.37-0.86%). The results of H2 and H3 are in agreement with those obtained by Kücük *et al.* (2007) for Turkish honey (0.065-0.17%).

Data in Table (3) shows the free acidity, lactonic acidity, total acidity, pH value, hydroxymethylefurfural (HMF) and vitamin C. The acidity of honey was presence of organic acids, particularly gluconic, pyruvic, malic and citric acids which is in equilibrium with corresponding lactones or internal esters and some inorganic ions such as phosphate, sulfite and chloride (Anklam. 1998 and Terrab *et al.*, 2003b). The values of free acidity ranged from 17.37 to 33.24 meq/kg, while the lactone acidity ranged from 5.13 to 12.08 meq/kg and the total acidity ranged from 22.50 to 45.32 meq/kg. The significantly higher values of free, lactone and total acidity were found in Saudi honey (H7), while the significantly lower values were found in Egyptian clover honey (H6). The total acidity in all honey samples was likewise within limits (below 50 meq/kg) indicated absence of undesirable fermentation. These results are in agreement with those obtained by Terrab *et al.* (2003c) and Kücük *et al.* (2007) with the range obtained by Khan *et al.* (2006) and higher than those obtained by Finola *et al.* (2007) and Owayes (2006).

The pH values, which are of great importance during the extraction and storage of honey as they influence the texture, stability and shelf-life. Most honeys are acidic with a pH ranged from 3.18 to 3.76. These results are in agreement with those obtained by Terrab *et al.* (2003a, c) and Khan *et al.* (2006), but these results are lower than those obtained by Ahmed *et al.* (2007).

Table (3): Free acidity, Lactonic acidity, total acidity (meqv./100g), pH value, 5-hydroxymethylfurfural (ppm) and ascorbic acid (Vit.C.) mg/100g of Libyan, Egyptian, Saudi and Turky honeys (on wet weight basis).

Samples	Free acidity	Lactonic acidity	Total acidity	pH value	HMF	Vit.C
H1	23.48^{b}	8.96^{cd}	32.44^{cd}	3.34^{d}	22.84^{b}	14.35^{b}
H2	22.69^{b}	6.39^{f}	29.08^{de}	3.45^{c}	19.07^{b}	7.46^{d}
H3	18.73^{c}	8.41^{d}	27.14^{e}	3.61^{b}	43.42^{a}	17.28^{a}
H4	31.12^{a}	10.16^{b}	41.28^{b}	3.74^{a}	19.87^{b}	2.67^{f}
H5	18.24^{c}	7.32^{e}	25.56^{ef}	3.29^{d}	12.84^{c}	5.15^{e}
H6	17.37^{c}	5.13^{g}	22.50^{f}	3.18^{e}	6.97^{d}	3.29^{ef}
H7	33.24^{a}	12.08^{a}	45.32^{a}	3.76^{a}	13.02^{c}	11.05^{c}
H8	24.56^{b}	9.61^{bc}	34.17^{c}	3.63^{b}	3.69^{e}	9.52^{cd}
LSD	2.21	1.08	3.39	0.06	3.04	2.17

Data calculated from triplicates.
(a-f) There is no significant differences between any two means have the same letter within certain component.

Hydroxymethylfurfural (HMF) content are widely used as an indicator of honey freshness. HMF can be formed by hexose dehydration in acid media or by maillard reaction. Heating and storage temperatures and duration cause an increase in HMF (Tosi *et al.*, 2002; Terrab *et al.*, 2002 and Moreira *et al.*, 2007). HMF ranged from 3.69 to 43.42 mg/kg, which was significantly higher in El-koffra honey (H3), while it was significantly lower in Turkish honey (H8). One only honey sample (H3) had HMF over the local regulations limit of 40 mg/kg (The Council of the European Union, 2002). The obtained results were lower than those obtained by Khan *et al.* (2006) 13.6-509.8 mg/kg and Küçük *et al.* (2007) 19.2-28.6 mg/kg and are in agreement with those obtained by Finola *et al.* (2007) 1.10-44.80 mg/kg, Terrab *et al.* (2003b) 5.05-43.30 mg/kg and Moreira *et al.* (2007) 2.80-41.50 mg/kg.

Vitamin C ranged from 2.67 to 17.28 mg/100g, which was significantly higher in El-Koffra honey (H3), while it was significantly lower in Sabha honey (H4). Statistical analysis did not appear any significant differences in vitamin C between (H7 and H8), (H8 and H2), (H5 and H6) and (H4 and H6). These results were lower than the obtained by Guler *et al.* (2007).

Minerals content:

The minerals content (ppm on wet weight basis) of honeys are shown in Table (4). The minerals can be ranked in the following descending order: K, Na, Mg, Ca, Fe, Mn, Ni, Zn, Cu, Pb, Hg and Cd.

Na and K ranged respectively from 72.61 to 301.05 ppm and from 103.04 to 460.11 ppm, which were significantly higher in Sabha honey (H4), while were lower in Saudi honey (H7). Mg ranged from 17.20 to 44.18 ppm, which was significantly higher in Subrata honey (H2), while it was lower in Egyptian citrus honey (H5). Ca ranged from 8.74 to 134.01 ppm, which was significantly significantly higher in Turkish honey (H8). Statistical analysis did not appear any significant differences in Ca content among H1, H2, H3, H4, H5, H6, and H7. These results are in agreement with those obtained by Dag *et al.* (2006), Terrab *et al.* (2003b) and lower than the obtained by Kücük *et al.* (2007). Fe content ranged from 2.09 to 19.26 ppm, which was significantly higher in Saudi honey (H7), while it was lower in Turhish honey (H7). Statistical analysis did not appear any significant differences in Fe content between (H6) and (H7), also between (H1) and (H2) and finally between (H1), (H3), (H5) and (H8)). These results are higher than those obtained by Tuzen *et al.* (2007), Terrab *et al.* (2003b) and Kücük *et al.* (2007), while these results are in agreement with those obtained by Terrab *et al.* (2003c) and Khan *et al.* (2006).

Mn content ranged from 0.28 to 5.17 ppm, which was significantly higher in Sabha honey (H4), while it was significantly lower in Egyptian citrus honey (H5). Statistical analysis did not appear any significant differences in Mn content between (H1) and (H2) also between (H1) and (H3) and finally between (H5), (H6), (H7) and (H8). These results are in agreement with those obtained by Conti (2000), Tuzen and Soylk (2005) and Tuzen *et al.*, (2007), but these results were lower than the obtained by Khan *et al.* (2006) and Lachman *et al.* (2007).

Table (4): Minerals content of Libyan, Egyptian, Saudi and Turky honeys (ppm on wet weight basis).

Samples	Na	K	Ca	Mg	Fe	Mn	Zn	Cu	Pb	Cd	Hg	Ni
H1	241.04^{b}	401.13^{b}	15.87^{b}	30.51^{b}	6.18^{cd}	2.45^{bc}	1.34^{ab}	0.18^{b}	0.38^{bc}	0.12^{bc}	0.12^{cd}	1.78^{c}
H2	298.30^{a}	320.11^{c}	19.29^{b}	44.18^{a}	7.41^{c}	3.23^{b}	1.56^{a}	0.42^{a}	0.46^{b}	0.35^{a}	0.32^{a}	2.43^{b}
H3	116.70^{e}	215.60^{d}	8.74^{b}	18.01^{c}	4.28^{d}	2.13^{c}	1.09^{b}	0.21^{b}	0.28^{bc}	0.07^{c}	0.14^{c}	1.29^{cd}
H4	301.05^{a}	460.11^{a}	10.24^{b}	37.61^{ab}	11.26^{b}	5.17^{a}	1.26^{ab}	0.20^{b}	0.78^{a}	0.18^{b}	0.20^{b}	2.58^{b}
H5	83.45^{f}	115.04^{e}	15.03^{b}	17.20^{c}	5.41^{d}	0.28^{d}	0.29^{c}	0.35^{ab}	0.19^{c}	0.09^{bc}	0.10^{d}	1.07^{d}
H6	78.84^{f}	110.80^{e}	12.14^{b}	21.94^{bc}	16.88^{a}	0.34^{d}	0.84^{b}	0.26^{b}	0.16^{c}	0.11^{bc}	0.16^{bc}	0.88^{cd}
H7	72.61^{f}	103.04^{e}	14.25^{b}	19.03^{c}	19.26^{a}	0.30^{d}	0.72^{b}	0.22^{b}	0.15^{c}	0.16^{bc}	0.19^{bc}	1.13^{c}
H8	121.14^{e}	213.42^{d}	134.01^{a}	26.34^{b}	2.09^{d}	1.14^{d}	0.61^{c}	0.24^{b}	0.17^{c}	0.13^{bc}	0.15^{c}	4.75^{a}
LSD	21.15	26.65	18.83	10.84	2.86	0.95	0.41	0.15	0.28	0.11	0.05	0.61

Data calculated from triplicates.

$^{(a-d)}$ There is no significant differences between any two means have the same letter within certain element.

Zn and Cu ranged respectively from 0.29 to 1.56 and from 0.18 to 0.42 ppm, which were significantly higher in Subrata honey (H2), while Zn content was significantly lower in Egyptian clover honey (H5) and Cu was significantly lower in El-Marj honey (H1). Statistical analysis did not appear any significant differences in Zn content between (H1), (H2) and (H4), also between (H1), (H3) and (H4) and finally between (H5), (H6), (H7) and (H8), while the statistical analysis did not appear

any significant differences in Cu content between (H2) and (H5) and between (H1), (H3), (H4), (H5), (H6), (H7) and (H8). These results are lower than the obtained by Tuzen *et al.,* (2007) (Zn ranged from 1.10 to 12.70 and Cu ranged from 0.23 to 2.41 ppm) and are in agreement with those obtained by Khan *et al.* (2006) and Lachman *et al.* (2007).

Pb ranged from 0.15 to 0.78 ppm, which was significantly higher in Sabha honey (H4), while it was lower in Saudi honey (H7). Statistical analysis did not appear any significant differences in Pb content between (H1), (H2) and (H3) and also between (H1), (H3), (H5), (H6), (H7) and (H8).

Cd content ranged from 0.07 to 0.35 ppm, which was significantly higher in Subrata honey (H2), while it was lower in El-Koffra honey (H3). Statistical analysis did not appear any significant differences in Cd content between (H1), (H4), (H5), (H6), (H7) and (H8) and between (H1), (H3), (H5), (H6), (H7) and (H8). These results are in agreement with those obtained by Owayes (2006), but were higher than those obtained by Khan *et al.* (2006) and Tuzen *et al.* (2007).

Hg content ranged from 0.10 to 0.32 ppm, which was significantly higher in Subrata honey (H2), while it was lower in Egyptian citrus honey (H5). Statistical analysis did not appear any significant differences in Hg content between (H4), (H6) and (H7), also between (H1), (H3), (H6), (H7) and (H8) and finally between (H1) and (H5). These results are within the range reported by Khan *et al.* (2006) who mentioned that (Hg ranged from 0.06 to 1.35 ppm).

Ni content ranged from 0.88 to 4.75 ppm, which was significantly higher in Turkish honey (H8), while it was significantly lower in Egyptian clover honey (H6). Statistical analysis did not appear any significant differences in Ni content between (H2) and (H4), also between (H1) and (H3) and finally between (H3), (H5), (H6) and (H7). These results are in agreement with those obtained by Khan *et al.* (2006), Lachman *et al.* (2007) and lower than obtaind by Owayes (2006).

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الخصائص الفيزيوكيميائية للعسل الليبي، المصري والمستورد من السعودية وتركيا

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إستهدف هذا البحث دراسة الخواص الفيزيوكيميائية لأربعة أنواع من العسل من مواقع مختلفة بالجماهيرية الليبية {المرج (H1)، صبراته (H2)، الكفرا (H3) وسبها (H4)}، نوعين من العسل المصرى {الموالح (H5) والبرسيم (H6) }ونوعين من العسل المستورد {السعودى (H7) والتركى (H8).

إحتوى عسل المرج (H1) على قيم عالية معنويا لكل من الكثافة النوعية، المواد الصلبة الكلية، المواد الصلبة الذائبة، السكريات الكلية، السكريات المختزلة (١,٤٩١٨جم/سم٣، ٨٦,٤٠، ٨٦,٢٢، ٨٢,٢٤، ٤٢,١٩% على التوالى). إحتوى عسل الكفرا (H3) على قيم عالية معنويا لكل من الجلوكوز، هيدروكس ميثيل فورفورال، وفيتامين (C) (٣٦,٢٦%، ٤٣,٤٢ ملج/كجم و١٧,٢٨ ملج/١٠٠جم على التوالى). التركيزات العالية معنويا من السكروز وجدت فى عسل سبها (H4) وعسل البرسيم المصرى (H6) (٥,٥٠ و٥,٥١%، على التوالى). محتوى الرماد العالى معنويا وجد فى عسل سبها (H4)، عسل البرسيم المصرى (H6) والعسل السعودى (H7). إحتوى عسل سبها (H4) والعسل السعودى (H7) على قيم عالية معنويا لكل من الحموضة الحرة، الحموضة الكلية والـ pH (٣١,١٢ و٣٣,٢٤ ملى/كجم ٤١,٢٨ و٤٥,٣٢ ملى/كجم و٣,٧٤ و٣,٧٦، على التوالى). إحتوى العسل التركى (H8) كميات عالية معنويا من الرطوبة والبروتين (١٧,٨٠ و٠,٩٢%، على التوالى).

بالنسبة لمحتوى العسل من العناصر المعدنية إتضح أن عسل صبراته (H2) إحتوى على تركيزات عالية معنويا من عناصر الماغنسيوم، الزنك، النخاس، الكادميوم والزئبق (٤٤,١٨، ١,٥٦، ٠,٤٢، ٠,٣٥، و٠,٣٢ جزء فى المليون على التوالى). إحتوى عسل سبها (H4) على تركيزات عالية معنويا من عناصر البوتاسيوم، المنجنيز والرصاص (٤٦٠,١١، ٥,١٧ و٠,٧٨ جزء فى المليون، على التوالى). إحتوى العسل السعودى (H7) على تركيز عالي معنويا من عنصر الحديد (١٦,٨٨ و١٩,٢٦ جزء فى المليون على التوالى). إحتوى العسل التركى (H8) على تركيزات عالية معنويا من عنصرى الكالسيوم والنيكل (١٣٤,٠١ و٤,٧٥ جزء فى المليون، على التوالى).