The Effects of Heating Treatment and Storage Temperature on Some Physico-chemical Properties of Some Egyptian Honey Types after one Year Storage

Youssef, M. K. E.; El-Rify, M. N. A.; Ramadan, E. A. and Saleh, A. S. M.
Food Science and Technology Departement, Faculty of Agriculture, Assiut University.

ABSTRACT: This investigation was carried out on seven honey types produced in different regions in upper Egypt (El-Minia, Assiut and Qena governorates) namely; Alfalfa, Cotton, Sunflower (two samples, (I) from Assiut and (II) from El-Minia), Sesame, Eucalyptus, Lemon and Orange honey (citrus honeys). All honey samples were collected during summer 2003 season (July-September), except lemon and orange honey samples which were collected during winter 2004 season (April). A comparison between the effects of cold storage (4-7°C) and room temperature storage (14-32°C) with or without heating on quality of honey types after 1 year storage time was made. Honey stored at cold temperature granulated rapidly compared with honey stored at room temperature .However, heated honey at 60°C for 30 min remained liquid during the entire storage period. Colour density, reducing sugar, hydroxymethyl furfural and total acidity were significantly increased, whereas sucrose, diastase activity were decreased and insignificant changes in pH values were observed at the end storage period. Heating treatment significantly ($p<0.05$) increased colour intensity and total acidity at the end of storage period. Generaly, storage at room temperature had signiicant ($p<0.05$) effect on quality of studied honeys compared with cold storage.

INTRODUCTION

Honey is cited in all holly books. Its virtues as a remedy for man and as a food in paradise are stressed in the Moslems' holly book 'The Koran' honey was royal prerogative in ancient Egypt, and mentioned exclusively in ancient Egyptian religious texts (Mesallam and El-Shaarawy, 1987).

Honey is subjected to thermal treatments for two different reasons: (1) to modify its tendency to crystallization or delay its appearance and (2) to destroy the contaminating micro-organisms .Honey crystallization and size of crystals are a function of water content, fructose/ glucose ratio and thermal history. Crystallization can contribute to the difficulty in handling, pouring, filling, packaging, and product presentation (Tosi et al., 2002).

Honey is generally evaluated by a physico- chemical analysis of its constituents which are of great importance to the honey industry as they influence the storage quality, granulation, texture, flavour and nutritional and medicinal quality of honey. The International Honey Commission (IHC) had therefore proposed certain constituents as quality criteria for honey. Such criteria include moisture content, electrical conductivity, specific rotation, reducing sugars, amount of fructose and glucose, sucrose content, individual sugars, minerals, free acidity, diastase, HMF, invertase, and proline (Joshi et al., 2000).

HMF (5-hydroxymethylfurfuraldehyde) is essential to evaluate the conformity of honey to the current legislation. Elevated concentrations of HMF in honey provide an indication of overheating, poor storage conditions or age of the honey. According to both the Codex Alimentarius Commission (alinorm 01/25, 2000) and the European Union (directive 110/2001) the concentration of HMF in honey usually should not exceed 80 or 40 mg/kg, respectively (Zappala et al., 2005).

Youssef and El-Gadawy (1973) studied the effect of storage at room temperature and refrigerated storage during four months on the physicochemical characteristics of Egyptian citrus honey and found no significant change in the specific gravity, refractive index, colour and total soluble solids. No statistical variations between the two storage temperatures in both moisture and ash contents were detected. However, the differences in pH (from 4.50 to 3.80 and from 4.50-4.0), ascorbic acid content (from 6.00 to 3.20 and from 6.00 to 2.00 mg/100g), acidity (increase from 0.06-0.09 and from 0.06-0.08 %) and sucrose content (fell from 1.80 to 0.91 and from 1.80-1.19 %) after the four months storage at room temperature and refrigeration were significant. Honey was granulated during the first 24 hour of cold storage.

Han et al. (1985) determined the effect of storage temperature (4, 20 and 50°C) and time on diastase activity and HMF concentration of various honeys from Korea and other countries. The diastase activity was lost and HMF concentration increased during storage with increasing temperature.

Gupta et al. (1992) studied the influence of different treatments, storage temperature and time on some physicochemical characteristics and sensory qualities of Indian honey. The colour darkening of honey was significant. Honey started granulating after 30 days at room temperature and granulation can be prevented for two more months by heat treatment (at 60°C for 90 min) and subsequent storage at 5°C.

Cosentino et al. (1996) measured the physicochemical characteristics of asphodel honey samples which were stored at 4°C, at room temperature (18-27°C) in the light, and at room temperature in the dark (15-22°C) for 12 and 24 months. The sucrose disappeared, diastase index decreased, while total acidity and HMF content increased. The pH and moisture content were unchanged.

Kubis and Ingr (1998) investigated the effect of storage time on HMF content in honey sample (Locust and summer honey). The HMF content did not increase during 12 months for samples stored in a cooler at 6°C, whereas, the increase was significant during storage at 18°C. The HMF content did not exceed the maximum limit after 1 year of storage.

Abd El-Aleem (2002) studied the effect of storage at room temperature on some physico-chemical of Egyptian honeys. The pH values decreased; colour intensity increased from 0.223 to 0.269; reducing sugars content increased; sucrose content decreased from 3.46 to 0.948 %; HMF increased from 2.215 to 9.863; total acidity slightly increased from 38.911to 41.344 meq/kg.

Cavia et al. (2002) evaluated the fructose and glucose over one year in 30 honey samples from purges (N. Spain). Both fructose and glucose increased in most samples. Induced-crystallized samples did not show any significant difference in both sugars in comparison with directly stored samples. Linear correlations were found, for both fructose and glucose, between samples directly stored and honeys in which granulation was induced.

The aim of this research was to investigate the effects of cold storage, room temperature storage and heating treatment on granulation or crystallization phenomenon and quality of several honey types after one year storage.

MATERIAL AND METHODS

Honey samples:

The present study was carried out on seven honey types produced in different regions in upper Egypt (El-Minia, Assiut and Qena governorates) namely; Alfalfa, Cotton, Sunflower (two samples, (I) from Assiut and (II) from El-Minia), Sesame, Eucalyptus, Lemon and Orange honey (citrus honeys). All samples were obtained directly from beekeepers. Honey samples were collected from the farm, which located in the ariea where above mentioned crops constituted the major flora, for the collection of nectar. All honey samples were collected during summer 2003 season, except lemon and orange honey samples which were collected during winter 2004 season. All the data of interest; place, date, extraction procedure, heat treatment if any, temperature and storage location as well as the botanical and climatic data of the locations of the hives were recorded. The samples were stored at room temperature (14-32°C) till the analysis.

Preparation and treatment of honey samples:

Samples of 3 kg from each studied honey type were taken and mixed well. All samples free from granulation or crystallization, were divided into 250g portions and packed in airtight clean colourless glass jars. Fresh honeys were analyzed for physico-chemical parameters. Then three 250g. Portions from each studied honey types were taken and treated as follows:

- One 250g portion from each studied honey type (unheated) was stored at room temperature (14-32°C) for one year and then taken for analysis.
- One 250g portion from each studied honey type (unheated) were stored at 4-7°C in refrigerator for one year and then taken for analysis.
- One 250g portion from each studied honey was heated at 60±2°C for 30 minutes (a moderate temperature, which is not able to sensibly modify the honey characteristics). The applied thermal treatment was made in a water bath with controlled temperature, directly measuring the honey temperature. The heated honey samples were shaken well and immediately cooled to room temperature and stored at the room temperature (14-32°C) for one year and then taken for analysis.
- Note: all studed honey samples not had been heat treated before collection.

The effect of different storage conditions and heating on some physico-chemical properties of studied honey types after one year storage was assessed.

Physical methods:

Granulation or crystallization phenomena:

Different formations of crystallization of studied honey types were observed during one year at cold and room temperature storage.

pH value was determined using a pH-meter in a solution containing 10g honey in 75 ml of distilled water (AOAC, 1995).

Colour intensity was determined as optical density at 560 nm by a shimadzu UV-240 double-beam spectrophotometer According to United States Standards for Grades of Extracted Honey (1985), whereas per cent transmittance was determined for honey

(without dilution) versus an equal cell containing glycerin at 560 nm and calculated as follows:

$$\text{Optical density (Absorbance)} = \log_{10} (100/ \text{ per cent transmittance})$$

Chemical methods:

Reducing sugars and apparent sucrose content:

The reducing sugars (mainly fructose and glucose), as well as the apparent sucrose content were measured by the Fehling method, involving the reduction of soxhelt's modification of fehlings solution by titration at boiling point against a solution of reducing sugars in honey using methylene blue as an internal indicator. The difference in concentrations of invert sugar was multiplied by 0.95 to give the apparent sucrose content. As described in Harmonised methods of the international honey commission (Bogdanov et al., 1997). Results expressed as percentages.

Hydroxy methyl furfural content (HMF) was determined after clarifying samples with carrez reagents (I and II) and the addition of sodium bisulphite. The absorbance was determined at 284 nm and 336 nm in a 1-cm quartz cuvette in a shimadzu UV-240 double-beam spectrophotometer (AOAC, 1995). Results were expressed as mg/kg.

Diastase activity was measured photometrically according to AOAC, (1995). Results were calculated as schade unit as ml of 1 % starch hydrolyzed by an enzyme in 1 g honey in 1 h.

Total acidity was determined by the titrimetric methods according to AOAC, (1995).

Statistical Analysis:

Data were subjected to analysis of variance and the least significant difference (LSD) at 5% probability using the Statistical Package for the Social Sciences (SPSS) software for windows. All determinations carried out in tri-replicates.

RESULTS AND DISCUSSION

Granulation or crystallization phenomena:

Different formations of crystallization of studied honey types were observed during one year at cold and room temperature storage. There were many factors influenced the crystallization of studied honey types, the most important considered to be storage temperature, cleanness of honey and heating process.

(A) Effect of storage temperature on crystallization:

Studied honey types crystallized most rapidly under cold storage (4-7°C) compared with at room temperature (14-32°C). Likewise, differences in the rate of crystallization were observed between studied honeys at the same storage conditions where the crystallization begins within a few hours in sunflower (II) honey under cold storage, and within one month at room temperature. However, eucalyptus honey crystallized within three months under cold storage, and within eight months at room temperature. These differences in rate of crystallization between studied honeys may be attributed to difference

in composition or in processing methods during harvesting (as exposed honey to sunlight to complete ripening or liquefaction by heating for extracting wax which retards the crystallization). On the other hand, there were differences in rate of crystallization of studied honeys stored at room temperature during different seasons where rate of formation crystals was most rapidly during winter months (low temperature) than that during summer months (high temperature).

Crane (1975) reported that the rate of crystal growth in honey is affected by supersaturation and diffusion (which is related to viscosity), both of which are strongly temperature dependent. Glucose crystals are unable to grow unless there is molecular diffusion within the honey. When the temperature is reduced, supersaturation will be increased, favouring crystals grows, but viscosity is also increased, and this hinders the movement of glucose monohydrate. The effects of supersaturation and viscosity balance out at an optimum temperature at which crystallization will progress most rapidly. Each honey will have a distinct temperature at which crystal grows is a maximum.

Crystallization is an important characteristic for honey marketing, though not for price determination. In temperate climates most honeys crystallize at normal storage temperatures. This is due to the fact that honey is a supersaturated sugar solution, i.e. it contains more sugar than can remain in solution. Many consumers still think that if honey has crystallized it has gone bad or has been adulterated with sugar.

The crystallization results from the formation of monohydrate glucose crystals, which vary in number, shape, dimension and quality with the honey composition and storage conditions. The lower the water and the higher the glucose content of honey, the faster the crystallization. Temperature is important, since above 25°C and below 5°C virtually no crystallization occurs. Around 14°C is the optimum temperature for fast crystallization, but also presence of solid particles (e.g pollen grains) and slow stirring result in quicker crystallization. Usually, slow crystallization produces bigger and more irregular crystals (Krell, 1996).

(B) Effect of heating on crystallization:

No crystallization occurred in studied honey types heated at 60±2°C for 30 min. during one year storage at room temperature. The effect of heating under this conditions may be to dissolve most small crystals of dextrose that are capable of acting as nuclei for further crystallization, or to form decomposition products which themselves act as retarding factor of granulation.

C) Effect of the cleanness on crystallization:

The orange honey in this study contained air bubbles, small particles-dust, bee parts and bits of wax. Such impurities can act as seeds or nuclei for initiation of crystallization. Sesame honey also contained higher amounts of pollen and higher residual centrifugation sediment, leading to crystallization formation. Furthermore, incomplete crystallization was observed in sesame honey where the crystalline layer was overlaid by a layer of liquid higher in water than that of the original honey, where it became more susceptible to fermentation.

Colour intensity (O.D.):

Data in table (1) reveal that honeys stored in the refrigerator (4-7°C) for 1 year and heated honeys stored at room temperature (14-32°C) significantly ($p<0.05$) increased in colour intensity value. There was statistical variation between storage at room temperature (unheated and heated honeys) and the cold storage**.** Lynn et al. (1936) indicated that the main causes of darkening in honey could be: (a) reaction amino acid aldol (maillard reaction): (b) combination of tannates and other oxydated polyphenols with ferrum salts: (c) instability of fructose (caramelization reaction). These results are in agreement with those obtained by Youssef and El-Gadawy (1973) and Cervantes et al. (2000).

Table (1): Effect of heating and storage temperatures in colour intensity (O.D.) of honey after one year storage.

Honey Types	Storage temperature			
	Initial value	Cold storage (4-7 °C)	Room temperature (14-32°C)	
			Unheated	Heated (60±2°C for 30 min)
Alfalfa	0.183±0.07[a]	0.193±0.08[b]	0.231±0.06[c]	0.254±0.08[d]
Cotton	0.391±0.09[a]	0.401±0.06[b]	0.445±0.08[c]	0.466±0.07[d]
Sunflower(I)	0.259±0.06[a]	0.269±0.05[b]	0.351±0.07[c]	0.401±0.04[d]
Sesame	0.587±0.11[a]	0.619±0.13[b]	0.735±0.09[c]	0.775±0.14[d]
Eucalyptus	0.461±0.07[a]	0.571±0.09[b]	0.724±0.12[c]	0.769±0.08[d]
Sunflower(II)	0.264±0.08[a]	0.276±0.06[b]	0.329±0.05[c]	0.369±0.06[d]
Lemon	0.164±0.05[a]	0.175±0.07[b]	0.213±0.03[c]	0.235±0.08[d]
Orange	0.160±0.04[a]	0.170±0.02[b]	0.208±0.03[c]	0.233±0.05[d]

-Any two means within a row having the same superscript letters are not significantly different at ($p \leq 0.05$).
-Reported values are means±SD (n=3).

pH value:

Data presented in table (2) show that there was insignificant changes in pH value of the most studied honeys after one year storage at room temperature and cold storage. The pH of honey is not directly related to the free acidity because of the buffering action of the various acids and minerals (Abu-Tarboush et al., 1993). These results are in agreement with those reported by Youssef and El-Gadawy (1973) and Cosentino (1996).

Table (2): Effect of heating and storage temperatures on pH value of honey after one year storage.

Honey Types	Storage temperature			
	Initial value	Cold storage (4-7 °C)	Room temperature (14-32°C)	
			Unheated	Heated (60±2°C for 30min)
Alfalfa	3.85±0.02^{b}	3.85±0.02^{b}	3.84±0.03^{ab}	3.83±0.02^{a}
Cotton	4.15±0.04^{a}	4.15±0.03^{a}	4.14±0.02^{a}	4.13±0.02^{a}
Sunflower(I)	4.00±0.02^{a}	4.00±0.02^{a}	3.98±0.01^{a}	3.96±0.02^{a}
Sesame	4.11±0.03^{c}	4.11±0.04^{c}	4.07±0.03^{a}	4.10±0.02^{bc}
Eucalyptus	4.45±0.05^{a}	4.45±0.0^{a}	4.44±0.03^{a}	4.46±0.04^{a}
Sunflower(II)	4.13±0.02^{a}	4.13±0.03^{a}	4.12±0.02^{a}	4.13±0.03^{a}
Lemon	4.12±0.02^{b}	4.12±0.01^{b}	4.10±0.03^{ab}	4.08±0.02^{a}
Orange	4.04±0.01^{b}	4.04±0.03^{b}	4.00±0.02^{a}	4.03±0.02^{ab}

-Any two means within a row having the same superscript letters are not significantly different at ($p \leq 0.05$).
-Reported values are means±SD (n=3).

Reducing sugars content (%):

The data given in Table (3) revealed that slight increase was observed in reducing sugars content of honey types stored at 4-7°C after 1 year. On the other hand, this increment in reducing sugars contents was higher in unheated honeys than heated ones after storage at room temperature (14-32°C). Statistical analysis showed that there were significant differences between the cold storage and storage at room temperature as well as there were significant variations between reducing sugars contents of unheated and heated honeys after storage period at room temperature.

The enzymes that are added by the bees are responsible for the variability of the spectra of honey sugars, so different nectars can yield very similar sugar spectra. Further more, this composition varies with time after extraction and during the whole shelf-life, with some sugars increasing and others diminishing (Barez et al., 2000).

Table (3): Effect of heating and storage temperatures on reducing sugars content (%) of honey after one year storage.

Honey Types	Storage temperature			
	Initial value	Cold storage (4-7 °C)	Room temperature (14-32°C)	
			Unheated	Heated (60±2°C for 30 min)
Alfalfa	71.28±0.32^{a}	71.46±0.35^{b}	74.70±0.31^{d}	73.19±0.24^{c}
Cotton	70.12±0.27^{a}	70.27±0.23^{a}	71.87±0.33^{c}	70.48±0.29^{b}
Sunflower(I)	73.41±0.41^{a}	73.53±0.38^{a}	75.39±0.52^{c}	74.24±0.43^{b}
Sesame	73.60±0.47^{a}	73.83±0.35^{b}	75.36±0.61^{d}	74.14±0.49^{c}
Eucalyptus	72.48±0.36^{a}	72.63±0.32^{a}	74.61±0.26^{c}	73.54±0.34^{b}
Sunflower(II)	74.17±0.53^{a}	74.27±0.47^{a}	76.24±0.57^{c}	75.17±0.51^{b}
Lemon	67.43±0.23^{a}	67.64±0.24^{b}	73.87±0.37^{d}	71.32±0.25^{c}
Orange	62.96±0.25^{a}	63.15±0.22^{a}	72.93±0.34^{c}	67.75±0.24^{b}

-Any two means within a row having the same superscript letters are not significantly different at ($p \leq 0.05$).
-Reported values are means±SD (n=3).

Sucrose content (%):

Sucrose content of studied honeys (Table 4) recorded lower decreases when stored under cool conditions (4-7°C) for 1 year. A considerable decrease in sucrose contents was shown when unheated honeys were stored at room temperature (14-32°C). Sucrose contents of heated honeys stored at room temperature were higher compared with unheated honeys. There were statistical variations between unheated and heated honeys stored at room temperature. On the other hand, there were statistical variations between cold and room temperature stored honeys. These results are in-agree with those reported by Youssef and El-Gadawy (1973) and Cosentino et al. (1996).

Sucrose decrement could be attributed to the invertase conversion of the sucrose to glucose and fructose. Consequently an increase in the reducing sugars content took place (Ibrahim et al., 1977).

Table (4): Effect of heating and storage temperatures on sucrose content (%) of honey after one year storage.

Honey Types	Storage temperature			
	Initial value	Cold storage (4-7 °C)	Room temperature (14-32°C)	
			Unheated	Heated (60±2°C for 30 min.)
Alfalfa	4.60±0.24^{d}	4.16±0.11^{c}	1.86±0.15^{a}	2.91±0.18^{b}
Cotton	1.60±0.16^{c}	1.53±0.21^{c}	0.00^{a}	1.12±0.14^{b}
Sunflower(I)	3.19±0.21^{d}	2.90±0.24^{c}	1.40±0.20^{a}	1.78±0.17^{b}
Sesame	1.80±0.20^{d}	1.41±0.25^{c}	0.00^{a}	0.45±0.12^{b}
Eucalyptus	1.92±0.15^{d}	1.49±0.13^{c}	0.00^{a}	0.56±0.11^{b}
Sunflower(II)	2.33±0.27^{c}	2.07±0.18^{b}	1.40±0.20^{a}	1.32±0.21^{a}
Lemon	8.86±0.31^{d}	8.11±0.37^{c}	2.60±0.22^{a}	5.57±0.28^{b}
Orange	13.74±0.43^{d}	12.87±0.35^{c}	4.18±0.17^{a}	8.26±0.22^{b}

-Any two means within a row having the same superscript letters are not significantly different at ($p \leq 0.05$).
-Reported values are means±SD (n=3).

HMF content (mg/kg):

As indicated in Table (5) HMF of studied honey types stored in the refrigerator at 4-7 °C for 1 year, decreased and the consider decrease was found in unheated and heated honeys stored at room temperature (14-32 °C) for 1 year. The variations were significantly high between cold and room temperature storage and likewise, low significant variations between unheated and heated honeys stored at room temperature for 1 year were detected. The data revealed that some heated honey types had higher HMF content than unheated honeys after storage period at room temperature and vice versa in other honeys was observed. This might be attributed to effect of heating on initial value or to effect of granulation during storage for unheated honeys, where the honeys rapidly completely granulated showed lower HMF values than liquid honeys after storage period. These results are in agreement with those reported by Cosentino et al. (1996) and Kubis and Ingr (1998).

Increase in HMF at high temperatures storage might be due to the decomposition of labile fructose particularly in the presence of acid (Rodgers, 1975).

Table (5): Effect of heating and storage temperature on HMF content (mg/kg) of honey after one year storage.

Honey Types	Storage temperature			
	Initial value	Cold storage (4-7 °C)	Room temperature (14-32°C)	
			Unheated	Heated (60±2°C for 30 min.)
Alfalfa	23.40±1.80^{a}	25.34±1.50^{b}	103.22±3.20^{d}	98.62±2.40^{c}
Cotton	6.88±0.70^{a}	8.34±1.30^{b}	67.33±2.10^{c}	70.46±2.60^{d}
Sunflower(I)	14.15±1.40^{a}	19.42±1.60^{b}	131.25±4.50^{d}	124.79±3.70^{c}
Sesame	20.78±1.60^{a}	22.51±1.50^{b}	196.62±5.28^{d}	191.30±5.13^{c}
Eucalyptus	25.77±1.90^{a}	27.48±1.18^{b}	105.63±3.36^{c}	108.24±3.27^{d}
Sunflower(II)	11.51±1.24^{a}	13.10±1.15^{b}	112.68±4.12^{c}	119.39±4.82^{d}
Lemon	3.89±0.60^{a}	5.23±0.71^{b}	39.25±1.90^{c}	45.36±2.14^{d}
Orange	2.50±0.42^{a}	4.18±0.70^{b}	27.12±1.46^{c}	29.48±1.52^{d}

-Any two means within a row having the same superscript letters are not significantly different at ($p \leq 0.05$).
-Reported values are means±SD (n=3).

Diastase activity (schade unit):

Studied honey types (Table 6) had higher values of diastase activity (lower decrease) in samples stored at 4-7°C in the refrigerator for 1 year compared with heated honeys stored at room temperature (14- 32°C) having the lowest values (higher decrease). However, unheated honey types stored at room temperature had more diastase activity values than heated honeys. There were significant variations between storage at room temperature and cold storage. On the other hand significant differences among values of diastase activity of heated and unheated honeys stored at room temperature after 1 year were noted.

It is note-worthy that the level of diastase is dependent upon the source of honey. Since honey from citrus as well as honeys produced in tropical climates contain naturally low levels of diastase (La Grange & Sanders, 1988). Moreover, variation in diastase activity from honey type to other has been shown to occur for a variety of reasons, including the amount of sucrose in food sources, rat of nectar flow and even age of the bees (White, 1994).

Table (6): Effect of heating and storage temperature on diastase activity (schade unit) of honey after one year storage.

Honey types	Storage temperature			
	Initial value	Cold storage (4-7 °C)	Room temperature (14-32°C)	
			Unheated	Heated (60±2°C for 30 min.)
Alfalfa	18.00±1.48^{d}	15.57±1.63^{c}	12.35±2.30^{b}	7.08±0.63^{a}
Cotton	11.43±1.23^{d}	9.16±0.78^{c}	8.35±0.46^{b}	4.99±0.61^{a}
Sunflower(I)	19.58±1.92^{d}	17.35±0.84^{c}	12.62±1.13^{b}	7.25±0.53^{a}
Sesame	23.71±1.40^{d}	19.43±1.35^{c}	14.50±1.20^{b}	10.47±1.30^{a}
Eucalyptus	18.52±1.25^{d}	15.87±1.02^{c}	11.81±0.92^{b}	8.31±0.67^{a}
Sunflower(II)	22.34±1.75^{d}	18.23±1.18^{c}	13.41±0.76^{b}	9.07±0.58^{a}
Lemon	14.73±1.27^{d}	12.64±1.16^{c}	10.35±0.83^{b}	6.58±0.49^{a}
Orange	17.43±1.54^{d}	15.76±1.30^{c}	12.32±1.17^{b}	10.36±0.86^{a}

-Any two means within a row having the same superscript letters are not significantly different at ($p \leq 0.05$).
-Reported values are means±SD (n=3).

Total acidity:

Total acidity is the sum of free and lactone acidities .Data given in Table (7) revealed insignificant increase in total acidity values of studied honeys stored in the cooler at 4-7°C was recorded. Heated honeys stored at room temperature had higher total acidity values than unheated honeys, except unheated sesame, eucalyptus, sunflower (II) and orange honeys which had lower values. This might be attributed to different formulations of granulation during storage. On the other hand there were significant variations between cold and room temperature storage. These results are in-agree with those reported by Youssef and El-Gadawy (1973) Cosentino et al. (1996) and Cervantes et al. (2000).

The increase in acidity of honey during storage might be due to the microbial action on sugars and consequent production of acids. The changes in acidity of honey during storage were dependent on the type of honey (Kauashik et al., 1993). White (1961) found a significant relationship between the rate of increase of acidity and enzyme activity in honey. This is further evidence that honey contains an enzyme that slowly produces in honey.

Table (7): Effect of heating and storage temperature on total acidity (meq/kg) of studied honey types after one year storage.

Honey Types	Storage temperature			
	Initial value	Cold storage (4-7 °C)	Room temperature(14-32°C)	
			Unheated	Heated (60±2°C for 30 min.)
Alfalfa	27.12±0.90[a]	27.55±0.68[a]	29.69±1.20[b]	30.58±0.95[c]
Cotton	26.55±0.70[a]	26.63±0.60[a]	29.98±1.50[b]	30.18±1.13[b]
Sunflower(I)	39.97±1.70[a]	40.20±1.00[a]	42.02±1.06[b]	43.46±1.24[c]
Sesame	58.18±2.13[a]	58.36±1.78[a]	63.33±2.24[c]	62.63±2.18[b]
Eucalyptus	36.57±0.70[a]	37.03±0.52[a]	39.15±0.90[c]	38.36±1.12[b]
Sunflower(II)	39.60±1.14[a]	40.00±0.83[a]	41.85±1.05[c]	40.97±1.32[b]
Lemon	14.52±0.60[a]	14.71±0.45[a]	16.46±071[b]	17.41±0.58[c]
Orange	22.45±1.15[a]	22.55±1.03[a]	24.26±036[c]	23.33±0.80[b]

-Any two means within a row having the same superscript letters are not significantly different at ($p \leq 0.05$).
-Reported values are means±SD (n=3).

CONCLUSSION

In the light of the present investigation, it could be concluded that granulation or crystallization of honey during storage was natural phenomenon and not an indicator for adulteration with sugar syrup whereas; honey is supersaturated solution of sugars, which have a tendency to crystallize spontaneously at room temperature, especially at low temperature (during winter or under cold storage in refrigerator). Colour density, reducing sugar, hydroxymethyl furfural and total acidity were significantly increased; whereas, sucrose, diastase activity were decreased and insignificant changes in pH values were observed at the end storage. Heating treatment significantly ($p<0.05$) influence only on the development of colour intensity value and total acidity at the end of one year storage. Generally, storage at room temperature had significant ($p<0.05$) effect on quality of studied honeys compared with cold storage.

REFERENCES

Abd El-Aleem, W. M. (2002). Quality evaluation for some kinds of honey produced in Egypt. M.Sc. Agric., Thesis in Food Science, Fac. of Agric. El-Minia University.

Abu-Tarboush, H. M.; Al-Kahtani, H. A., and El-Sarrage, M. S. (1993). Floral-type identification and quality evaluation of some honey types.Food Chem. 46: 13-17.

AOAC (1995). Official methods of analysis (16th ed., vol.II). Washington, DC, USA; Association of Official. Analytical Chemists.

Barez, J. A. G.; Garcia-Villanova, R. J.; Garcia, E. S.; Pala, R.T.; Paramas, G. A. M., and Sanchez, S. J. (2000). Geographical discrimination of honeys through the employment of sugar patterns and common chemical quality parameters. Eur. Food Res. Technol. 210(6):437–444.

Bogdanov, S.; Martin, P.; Lcullmann, C.; Borneck, R.; Flamini, C.; Morlot, M.; Heretier, J.; Vorwohl, G.; Russmann, H.; Persano-Oddo, L.; Sabatini, A. G.; Marcazzan, G. L.; Marioleas, P.; Tsigouri, K.; Kerkvliet, J.; Ortiz, A., and Ivanov, T. (1997). Harmonised Methods of the European honey commission. Apidologie, 1–59 (extra issue).

Cavia, M. M.; Fernandez-Muino, M. A.; Gomez-Alenso, E.; Montes-perez, M. J.; Huidorbo, J. F., and Sancho, M. T. (2002). Evolution of fructose and glucose in honey over one year: influence of induced granulation. Food Chem. 78:157-161.

Cervantes, M. A.; Novelo, S. A., and Duch , E. (2000). Effect of the temporary thermic treatment of honey on variation of the quality of the same during storage Apiacta. 35(4):162-170.

Cosentino, S.; Tuberoso, C. I. G.; Pisano, B.; Cherchi, A.; Spanedal, L., and Palmas, F. (1996). Influence of different storage conditions on honey quality.Rivista di Scienza dell' Alimentazione. 25(3):253-260.

Crane, E., (1975). Honey: a comprehensive survey. Heinemann, London: International Bee Research Association.

Gupta, J. K.; Kaushik, R., and Joshi, V. K. (1992). Influence of different treatments, storage temperature and period on some physico-chemical characteristics and sensory qualities of Indian honey. J. Food Sci. Technol. 29 (2): 84–87.

Han, J. G.; Kim, K.; Kim, D. Y., and Lee, S. K. (1985). The aggregation state of melittin in lipid bilayers: an energy transfer study. Korean J. Food Sci.Technol. 17(3):155-162.

Ibrahim S. H.; Soliman N. Z., and Wissa H. (1977). Studies on the properties of the major Egyptian honey types and on honey ripening. Agric. Res.Rev. 55:125-128.

Joshi, S. R.; Pechhacker, H.; Willam, A., and Ohe, W. (2000). Physico-chemical characteristics of *Apis dorsata , A. cerana* and *A. mellifera* honey from Chitwan district, central Nepal. Apidologie. 31:367-375.

Kaushik, R.; Joshi, V. K., and Gupta, J. K. (1993). Total soluble solids, acidity, pH and standard plate counts in the Indian honey as affected by different treatments and storage condition. J. Food Sc. Technol. 30(6):442–443.

Krell, R., (1996). Value-added products from beekeeping. FAO Agricultural services Bulletin No. 124. M-24.

Kubis, I., and Ingr, I. (1998). Effects inducing changes in hydroxymethylfurfural content in honey. Czech J. Animal Sci. 42:379–383.

LaGrange, V., and Sanders, S. W. (1988). Honey in cereal-based new food products. Cereal Food World. 33:833–838.

Lynn, E. G.; Englis, D. T., and Milum, V. G. (1936). Effect of processing and storage on composition and colour of honey. Food Research, 1,23-27. c.f. Gonzalles, A. P., Burin, L., and Buera, M. P.(1999). Colour changes during storage of honeys in relation to their composition and initial colour. Food Res. Int. 32:185-191.

Mesallam, A. S., and El-Shaarawy, M. I. (1987). Quality attributes of honey in Saudi Arabia. Food Chem. 25:1-11.

Rodgers, P. E. W., (1975). Honey quality control. In "Honey: A comprehensive survey " E. Crane (Ed.), pp. 314. Heinemann : London. c.f. Moussa, M. M. (1995). Effect of storage temperature on the physical and chemical properties of citrus honey.J. Agric. Sci. Mansoura Univ. 20(4):1667-1675.

Statistical Package for the Social Sciences (SPSS) software for windows.

Tosi, E.; Ciappini, M., and Lucero, E. H. (2002). Honey thermal treatment effects on hydroxymethylfurfural content. Food Chem. 77:71-74

United States Departement of Agriculture (USDA). Standards for grades of extracted honey. Effective date May 23,1985.

White, J. W. Jr. (1961). A survey of American honeys. 7. relation of colour to composition. Cleaning in bee culture, 89,292-293. c. f. Abu-Jdayil, B., Ghzawi, A., Al-Malah, K. I. M., and Zaitoun, S.(2002):Heat effect on rheology of light- and dark-coloured honey..J. of Food Engineering. 51:33-38.

White, J. W. (1994). The role of HMF and diastase assays in honey quality evolution. Bee World. 75(3):104-117.

Youssef, K. E., and El-Gadawy, E. H. (1973). Influence of prolonged storage on certain physical and chemical quality characteristics of Egyptian citrus honey. Confructa. 18: 263-266.

Zappala, A.; Fallico, B.; Arena, E., and Verzera, A. (2005). Methods of the determination of HMF in honey: a comparison. Food Control. 16(3):273-277.

تأثير المعاملة الحرارية ودرجات حرارة التخزين على بعض الصفات الطبيعية والكيميائية لبعض أنواع عسل النحل المصري بعد عام من التخزين

محمد كمال السيد يوسف؛ محمد نجيب أحمد الريفي؛ السيد عبد النبي رمضان؛ أحمد صلاح موسى صالح
قسم علوم وتكنولوجيا الأغذية, كلية الزراعة, جامعة أسيوط، مصر.

الملخص: أجريت هذه الدراسة على سبعة أنواع من عسل النحل المنتجة في بعض محافظات صعيد مصر وهي على وجه التحديد المنيا, أسيوط وقنا، وتمثل عسل البرسيم, القطن, عباد الشمس (عينتان, عينة I من أسيوط وعينة II من المنيا) السمسم, الكافور, الليمون والبرتقال (عسل الموالح). تم الحصول على العينات مباشرة من النحالين. تم جمع عينات العسل موضع الدراسة من مناحل منتشرة في الحقول حيث تشكل المحاصيل المذكورة أعلاه النباتات الرئيسية لجمع الرحيق. وقد تم جمع العينات خلال موسم صيف عام ٢٠٠٣ (يوليو – سبتمبر) فيما عدا عسل الليمون والبرتقال حيث تم جمعها خلال موسم شتاء ٢٠٠٤ (شهر أبريل).

تم عمل مقارنة بين تأثيرات التخزين البارد (٤–٧°م), التخزين على درجة حرارة الغرفة (١٤–٣٢°م) والتسخين (على ٦٠±٢°م لمدة ٣٠ دقيقة) على ظاهرة تبلور أو تحبب العسل وجودته بعد التخزين لمدة عام حيث أوضحت النتائج أن العسل الذي خزن تحت ظروف التبريد كان أسرع في تحببه من العسل الذي خزن تحت درجة حرارة الغرفة بينما ظل العسل المسخن سائلا بدون تحبب طوال فترة التخزين.

من ناحية أخرى أوضحت النتائج المتحصل عليها إن الزيادة في الكثافة اللونية, السكريات المختزلة, مركب الهيدروكسى ميثيل فور فيورال, والحموضة الحرة واللاكتونية والكلية لأنواع العسل المدروسة تحت ظروف التخزين البارد كانت غير معنوية واقل بكثير عنها تحت ظروف التخزين على درجة حرارة الغرفة, كذلك بالنسبة لتناقص كل من البرولين والسكروز وإنزيم الدياستيز، بينما لم يسجل رقم الـ pH تغيرا ملحوظا في نهاية فترة التخزين. أما بالنسبة لتأثير التسخين فلم يتضح فقط إلا على زيادة الكثافة اللونية والحموضة الكلية في العسل المسخن عنها في العسل غير المسخن والمخزن تحت نفس الظروف (حرارة الغرفة) وذلك بعد عام من التخزين. بوجه عام كان للتخزين على درجة حرارة الغرفة تأثير معنوي على جودة أنواع العسل المدروسة مقارنة بالتخزين المبرد في الثلاجة.