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Chemical properties of Egyptian fennel honey in Upper Egypt.

Esmaeil, M.E.[1]; Hassan, M.M.M.[2]; Abdel-Rahman, M.F. [2] and Salem, M.H.A.[1]

[1]*Deptartment of Applied Entomology and Zoology, Faculty of Agriculture, Alexandria University, Egypt.*

[2]*Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt.*

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Abstract:

This study was conducted during flow season of fennel honey in the year, 2018, to assess some quality properties of the Egyptian fennel honey produced from Upper Egypt. Forty-two honey samples were obtained from different apiaries located in Assiut and Qena Governorates, Upper Egypt. Moisture content was 18.395%, with range between 17.0 and 19.5%.The total acidity was 38.61 meq. /kg. of honey, with range from 25.5 to 48.0 meq. /kg. of honey. Fructose content was 44.571%, with range between 41.1 and 49.8%. Glucose content was 31.195%, with range from 24.4 – 33.2%. Trace amounts of sucrose were detected in most of fennel honey samples with an average of 0.9%. Maltose content was 1.176%, with range between 0.6 and 1.6%. Hydroxy methyl furfural (HMF) content was 4.96 mg/ kg. of honey, with range from 1.92 to 7.68 mg/ kg. of honey. The diastase number in the tested fennel honey samples was 54.31 Goth units, with range between 8.5 and 150.0 Goth units. The invertase content in the examined fennel honey samples was 167.34 unit/kg, with range from 117.6 to 219.3 unit/kg. of honey.

Introduction

Honey is a natural sweet material all over the world and viscous liquid produced by honeybee [*Apis mellifera* L. (Hymenoptera: Apidae)] that collect the nectar from blossoms, secretions of plants and from secretions of some plant sucking insect. The three major components of honey are fructose, glucose and water. In addition, some other sugars, proteins, vitamins, enzymes, organic acids, polyphenols and inorganic compounds including trace elements necessary for vital processes (Soares *et al.,* 2008). Abou-shaara (2015) reviewed a list of the common plants in Egypt and their potential benefit to honeybee colonies, which could aid in better understanding of the suitable Egyptian flora for honeybees and guide researchers mainly during their melissopalynological studies. He showed that most potential honeybee plants are belong to first group (medicinal, aromatic and ornamental plants) with 35.2% of total plants, followed by vegetables (34.1%), fruits (21.9%) and field crops (8.8%), respectively. He also noticed that honeybees can benefit from *Foeniculum vulgare* (fennel) as a good

food source (pollen and nectar). Colour, EC, acidity, ash content and pH were the physiochemical parameters with higher discrimination power in the differentiation of nectar and honeydew honeys from central Spain. It was found that physiochemical data were not useful for distinguishing between collection places (Soria *et al.*, 2004). Solayman *et al.* (2016) described physicochemical properties, minerals, trace elements, and heavy metals in some honey samples of different origins. The higher moisture in honey content, the greater is the possibility that the yeasts will ferment and change the flavor. Namely, fermentation process results in alcohol formation and in the presence of oxygen, the alcohol will break down to acetic acid and water, which causes honey to have sour taste and to spoil. Diverse types of honey are produced in Egypt. Fennel honey is a monofloral honey produced from medical fennel plant (*Foeniculum vulgare vulgare*), which is cultivated in Egypt, especially in Assiut and Qena Governorates, Upper Egypt. This study oriented to assess the chemical properties of Egyptian fennel honey.

Materials and methods

The present investigation was carried out through flow season of fennel honey during the year, 2018. The chemical properties were conducted in Apiculture Research Department, Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza. Samples of fennel honey were collected during 2018 from Assiut and Qena, Upper Egypt where fennel honey is traditionally produced. Forty-two fennel honey samples were collected; twenty-one samples per area (three honey samples/ apiary). Each of the honey samples were acquired at 1000 g for the present investigation. Honey samples collection was conducted during May 2018. All honey samples were supplied by the professional beekeepers.

Sixteen chemical properties were studied in the obtained fennel honey samples. The chemical parameters which evaluated included: moisture, pH value, free acidity, lactone, total acidity, glucose, fructose, sucrose, maltose, reducing sugars, total sugars, glucose/ fructose ratio, glucose/ water ratio, hydroxy methyl furfural, diastase number, invertase and glucose oxidase. The refractometer was used to determination, the readings of refractive index, after correction for temperature, were converted to moisture (%), using the table of White *et al.* (1962). pH was measured by " HANNA" pH- meter, model H19321, according to (A.O. A. C., 1995). Free acidity, lactone content and total acidity were measured according to White *et al.* (1962).

The examined parameters were calculated as follows:

Free acidity= (ml Na OH to bring solution to pH 8.5- blank) × 0.05× 1000/10;

Lactone= (10- titer of Hcl) ×0.05× 1000/ 10;

And total acidity= free acidity+ lactone.

Honey acidity is a parameter which comprise pH value, free acids, Lactone content and total acidity. Collected fennel honey samples were analyzed to evaluate their sugars content. Fructose, glucose, sucrose and maltose content (%) was identification and determined using High-Performance Liquid Chromatography (HPLC), according to A.O. A. C. (1995). Reducing sugars and glucose/ fructose ratio (G/F) were also calculated.

Hydroxy methyl furfural (HMF) was determined after clarifying tested honey samples with carrez reagents (I and II) and addition of sodium bisulfate according to A.O.A.C. (1995). Absorbance was determined at 284 and 336 nm in 1cm quartz cuvette using a Labomed, inc. Spectro UV-Vis R.S. Spectrophotometer. HMF is formed in honey by the breakdown of sugars, especially fructose, when honey is stored in hot places for a long time or heated for liquification of granulation. False honey produced from

sucrose treated with weak acids contains high HMF content.

Calculation and expression of results, the transmittance is plotted against time (min) on a rectilinear paper. A straight, line is drawn through at least the three points on the graph to determine the time when the reaction mixture reaches a transmittance of 50%. Divide 300 by the time in minutes to obtain the diastase number (DN). This number expresses the diastase activity as ml 1% starch solution hydrolyzed by the enzyme in gram of honey in 1 hour at 400C. Invertase activity was spectrophotometrically measured with 4-nitrophenyl-a-D- glucopyanosode and the results are expressed in international units (IU) (Boussaid *et al.,* 2014). Data were analyzed and compared according to method of Waller and Duncan (1969). Least significant differences (LSD) values at 0.05 probabilities were calculated using MSTAT-C software program (MSTAT-C Software program, 1988), and presented as mean ± SD (standard deviation).

Results and discussion

The moisture (water) content (%) of the honey is very important parameter because of its effect upon keeping quality (White, 1978). Statistical analysis found that there were significant differences in the moisture content percentages for the studied fennel honey samples between Assiut and Qena Governorates. In general, water content (%) of all analyzed fennel honey samples ranged from 17.0 to 19.5%, with a general mean value of 18.395 ± 0.235%. and accepted by Egyptian Standards (2003) or Codex Alimentarius (2000).

The moisture content of the honey is the most important measured for the assessment of ripeness and shelf life. Moisture content depends on climatic factors, season of production and maturity of honey. Cantarelli *et al.* (2008) found that the water content of some Argentinean honey samples was 16.24± 0.19%, ranged from 14.28 – 18.6% (Table, 1). Aloisi (2010) recorded that, the water content of some Argentinean honeys was law, with a mean value of 14.67%. Essa *et al. (*2010) noticed that, the moisture of some Egyptian clover honey samples ranged between 17.5 and 19.25%, with an average of 18.76.

Table (1): Moisture content (%) in fresh fennel honey samples from Assiut and Qena Governorates.

Moisture % NO. of sample	Assiut		Qena		General Mean ± SE
	Mean	Standard Deviation	Mean	Standard Deviation	
1	19.5	0.1	17.0	0.2	
2	19.5	0.2	17.5	0.2	
3	18.0	0.1	17.5	0.1	
4	18.5	0.2	18.5	0.2	
5	19.0	0.19	17.0	0.1	
6	19.0	0.1	18.5	0.1	
7	18.5	0.29	19.5	0.3	
Total (n-7)	132.0		125.5		257.5 (n=14)
Mean ± SD	18.86± 0.556 a		17.93± 0.932b		18.395 ±0.235
Maximum	19.5		19.5		19.5
Minimum	18.0		17.0		17.0

Means not sharing a common superscript letter in row are significantly different at 5% level of probability.

Moniruzzaman *et al. (*2013) found that, the water content of some Malaysian honeys ranged between 11.59 and 19.06%. Musa *et al. (*2014) recorded that the mean value of the moisture content of some Sudanese honeys was 18.2 %. El–Metwally (2015) noticed that the moisture content of some Egyptian honeys ranged between 12.0 and 24.8%, with grand mean value of 17.26%. Valdes-Silverio *et al. (*2018) noticed that the moisture content of eucalyptus honey from the Andean region of Ecuador ranged between 11.74±1.79 and 19.42±1.81%.

The moisture content of honey depending on the botanical origin of the honey, the level of maturity achieved in the hive, processing techniques and storage conditions (Yucel and Sultanoglu, 2013). The moisture content is one of the most important characteristics influencing physical properties of honey such as crystallization and viscosity as well as other parameters: flavor, taste, specific gravity, solubility and conservation (Escuredo *et al.,* 2013).

Acidity participate not only in the flavor of honey but also to its antimicrobial specialty. In the face of the acidity of honey is eligible, when the acidity increases very rich, the honey becomes tart. The acid content in honey is characterized by the free acidity. Statistical analysis showed that, the pH and free acidity of fennel honey samples obtained from Assiut Governorate and samples collected from Qena Governorate was not significant. On the contrary, lactone and total acidity content of fennel honey samples collected from Assiut and that obtained from Qena was statistically insignificant (Table, 2). Generally. The pH values of the examined fennel honey samples ranged from 4.1 to 4.8, with a general rate value of 4.514 ± 0.054. The free acidity ranged between 19.5 and 31.5 meq. /kg., with an average value of 25.179 ± 1.120 meq. /kg. The lactone content ranged from 6.0 to 17.5 meq. /kg., with a general rate value of 13.429 ± 0.822 meq. /kg. The total acidity of analyzed fennel honey samples ranged from 25.5 to 48.0 meq/kg., with a general rate value of 38.607 ± 1.853 meq/kg.

Table (2): Statistical analysis of acidity of fennel honey samples from (Assiut and Qena), Upper Egypt.

Location	PH	Free acidity	Lactone	Total acidity
Assiut **Qane**	4.457± 0.056 a 4.587± 0.146 a	25.14 ±4.22 a 25.21±4.499 a	13.93±1.902 a 12.93±4.036 a	39.07±5.898a 38.1±8.295 a
TotalN=14	63.2	352.5	188.0	540.5
General Mean ± SE	4.514 ± 0.054	25.179± 1.120	13.429± 0.822	38.607± 1.853
Maximum	4.8	31.5	17.5	48.0
Minimum	4.1	19.5	6.0	25.5

Means not sharing a common superscript letter in column are significantly different at 5% level of probability.

It was noticed that the acidity of the studied fennel honey samples with collected from both Assiut and Qena Governorates are within the normal ranges of Egyptian Standard (2003) which states that the total acidity content of honey is ≤ 40 meq. (milliequivalents) /kg. Meanwhile, Codex Alimentarius (2000) increased the maximum amount of total acidity to be 50 meq. /kg.

Our results were in harmony with White (1978) who stated that honey was characteristically quite acidic. pH value of honey is affected somewhat by the amount of the various acids present, but mostly by the mineral contents (Codex Alimentarius, 2000). Essa *et al.* (2010) found that the pH of studied clover honey samples ranged from 3.7 to 4.15. The results of this study are also agreement with those of Hussain (1989) who found that the pH of fresh honey ranged between 3.0 and 5.0. Fatehe (2013) found that pH values ranged 3.4 – 3.78, lactone

content ranged 1.0 – 12.5 meq/kg., free acidity ranged 28.0 – 68.0 meq/kg. and total acidity content ranged 29.0 – 75.5 meq./kg.of some Egyptian honey types. Dinkov (2014) mentioned that, the mean value of pH was 4.76± 0.06 and free acidity was 25.3± 1.33 meq./kg. of Bulgarian fennel honey. El-Metwally (2015) found that, the pH values ranged 3.28 – 5.33, with a mean value of 3.91. The total acidity ranged from 16.5 to 70.75 meq/kg., with an average value of 33.56 meq/kg. of some Egyptian honey types. El Sohaimy *et al. (*2015) recorded that, the PH values of Egyptian, Yemen, Saudi and Kashmir were 4.415± 0.09, 4.114± 0.02, 4.46± 0.02 and 4.637± 0.03, respectively. Tesfaye *et al. (*2016) found that the pH values ranged 3.54 – 3.92, with an average value of 3.75, while free acidity ranged 29.55 – 36.09 meq/kg. of some honey types obtained from Ethiopia. Valdes-Silverio *et al. (*2018) reported that, the pH values ranged 3.61 – 4.2 and free acidity ranged 27.74 – 229.63 meq/kg. Of some honey samples collected from the Andean region of Ecuador.

Both active acidity pH and total acidity are properties used to characterize the quality of the honey. But pH of the honey is not directly related to the free acidity because of the buffering action of the various acids and minerals present in the honey. The pH of honey might be attributed to the content of acids, mainly gluconic acids and minerals. The pH value of honey is of great importance during storage, since the acidity can influence the texture, stability and shelf life of honey (Amril and Ladjama, 2013). It has been concluded that high free acidity values can indicate the fermentation of honey sugar by yeasts. It is well known that during fermentation, fructose and glucose are converted into alcohol and carbon dioxide. Alcohol is further hydrolyzed in the presence of oxygen and converted to acetic acids. This greatly contributes to the level of free acidity in honey (Ajlouni and Sujirapinyokul, 2010).

Honey is primarily a carbohydrate product, and their content of sugars may make up as much, as 99% of total soluble solids of honey. Sugars are also responsible for much of the physical properties of honey, such honey viscosity, granulation, energy value and hygroscopic (White, 1978 and Codex Alimentarius, 2000). Honey is a mixture of principally two reducing sugars namely glucose and fructose giving it similar properties to invert syrup. This gives it the ability to remain liquid for long times (Tewodros *et al.,* 2013).

Generally, the sugar composition of 42 Egyptian fennel honey samples was analyzed as shown in Table (3). This investigation affirms that the percentages of fructose and glucose of all the tested fennel honey samples were ranged from 41.1 – 49.8%, with a general mean value of 44.571 ± 0.708% and from 24.4 – 33.2%, with an average value of 31.195 ± 0.601%, respectively. The predominant sugar of the fennel examined honey was fructose followed by glucose. Meanwhile, sucrose and maltose were present in very low amounts in all analyzed Egyptian fennel honey samples. Obviously, a high sucrose level usually means a premature harvest of honey as sucrose has not been fully inverted to fructose and glucose by the effect of invertase. It was noticed that the sucrose percentage of all the honey samples was less than the maximum conventional limit of 5% recommended by the European Community (European Economic Community, 2002). The reducing sugars (F+G) of all examined Egyptian fennel honey samples ranged between 65.5 and 82.4%, with general mean value of 75.779 ± 1.112%.

Table (3): Statistical analysis of sugar content (%) of Egyptian fennel honey samples obtained from the studied localities (Assiut and Qena), Upper Egypt.

Sample	Fructose	Glucose	Sucrose	Maltose	F+G	F/G	G/W	G/F	F -G	(G -W)/ F
Assiut	43.286 ± 1.132 b	31.96 ± 0.690 a	0.971 ± 0.690 a	1.261 ± 0.209 a	75.243± 0.980 a	1.354± 0.053 a	1.695± 0.078 a	0.741± 0.031 a	11.33 ± 1.599 b	0.303 ± o.o30 a
Qena	45.857± 3.171 a	30.429± 3.030 a	0.829 ± 0.645 a	1.093 ± 0.259 a	76.314± 5.992 a	1.507± 0.164 a	1.697± 0.231 a	0.664± 0.036b	15.43± 1.587 a	0.27 ± 0.060 a
Total (N=14)	624	464.543	12.6	16.48	1060.543	19.96	23.744	9.814	187.3	4.018
General Mean ±SD	44.571 ±0.708	31.195 ±0.601	0.9 ± 0.173	1.176 ± 0.065	75.779 ±1.112	1.426 ±0.034	1.696 ±0.044	0.701 ±0.013	13.38 ±0.700	0.287 ± 0.013
Maximum	49.8	33.2	1.8	1.6	82.4	1.51	1.92	0.79	17.2	0.352
Minimum	41.1	24.4	0.5	0.6	65.5	1.27	1.32	0.60	8.7	0.144

Means not sharing a common superscript letter in column are significantly different at 5% level of probability

All examined fennel honey samples had fructose to glucose (F/G) ratios more than 1.0. The average value of F/G was 1.426 for honey samples obtained from Upper Egypt. Glucose to water ratios (G/W) ranged between 1.32 and 1.92, with a mean value of 1.696 ± 0.044%. Most analyzed fennel honey samples had glucose to water (G/W) ratios less than 2.0 that are not granulating honeys. Fennel honey samples collected from Upper Egypt had glucose to fructose (G/F) ratios less than 1.0 and ranged from 0.60 to 0.79. The Fructose – glucose (F – G) ranged from 8.7 to 17.2, with an average value of 13.38 ± 0.7. The (glucose – water) to fructose ratios ((G – W)/F) ranged between 0.144 and 0.352, with a mean value of 0.287 ± 0.013. The general average value of F/G ratio was 1.426 ± 0.034. Fructose to glucose ratio tells about the crystallization status of honey, when fructose is more than glucose the honey will be fluid (Venir *et al*., 2010). Also, it has been reported that the fructose to glucose ratio may also have an effect on the honey taste since fructose is much sweeter than glucose (Alvarez-Suarez *et al*., 2010).The general mean values of glucose to water (G/W), glucose to fructose (G/F), and (glucose – water)/ fructose ((G-W)/F) ratios for all analyzed Egyptian fennel honey samples were 1.696, 0.701 and 0.287, respectively. Also, the fructose – glucose (F-G) was calculated for all examined fennel honey samples. The general mean value of F-G was 13.38 ± 0.70%.

The values of sugars contents obtained in this investigation agreed particularly with those of some researchers. Nafea *et al*. (2009) concluded that fructose content ranged 34.9 – 42.3%, glucose 26.2 – 32.2% scurose1.3 - 5.3% and maltose 5.0 - 11.0% of various Libyan honey samples. Fatehe (2013) reported that fructose ranged 28.0 - 40.0%, glucose 29.9 – 42.0%, sucrose 0.46 – 3.1% and maltose 1.95 – 4.9% of different Egyptian honey types. El-Metwally (2015) noticed that the mean values of fructose, glucose and total reducing sugars were 33.33, 28.24 and 61.56%, respectively of some Egyptian honey samples. El Sohaimy *et al*., (2015) found that the total reducing sugars were 69.84 ± 0.31, 64.21 ± 0.18, 72.36 ± 0.32 and 65.11 ± 0.25% of Egyptian, Yemeni, Saudi and Kashmiri honey samples, respectively. The estimated fructose to glucose ratios for the same investigated honey samples were ranged between 0.42 and 2.35. While, the estimated glucose to water ratios were ranged from 0.72 to 1.56.

Although, all samples in this study with F/G ratio ≥1.0 indicates a tendency to granulate rapidly, it is noted that, the fennel honey is not granulated no matter how long it is stored. However, as suggested by other researchers (Manikis and Thrasivoulou, 2001), F/G ratio may not be the best indicator of granulation tendency. Glucose and fructose constituted the primary sugars in all honey. The percentage of fructose should exceed that of glucose in honey of good quality (Kaakeh and Gadelhak, 2005). Honey samples with a glucose- water to fructose ((G-W)/F) ratio higher than 0.5 predicted rapid granulation and a ratio less than 0.2 predicted slow granulation (Manikis and Thrasivoulou, 2001). The prediction accuracy of glucose, fructose and sucrose percentages are useful for the identification of the botanical origin of honey (Persano Oddo *et al*., 1995 and Persano Oddo and Piro, 2004).

The total monosaccharide content or reducing sugars (sum of glucose and fructose) is useful for the discrimination of some monofloral honeys and between honeys of nectar and honey dew origin (Persano Oddo and Piro, 2004). And to the determination of adulteration (Doner *et al*., 1979 and Low and South, 1995). Reducing and non-reducing sugars together account for 85-95% of honey's carbohydrate and their amount depend on the source of nectar (Cavian, 2002). Fructose and glucose and the ratio of their preponderance is a factor in

determining the honey suitability for diabetes management (Escuredo *et al*., 2011). Generally, the sugar spectrum of honey depends upon the sugars present in the nectar and the enzymes present in the bee and nectar (White and Doner, 1980; Zafar *et al*., 2008 and Bogdanov, 2009).

Hydroxy methyl furfural (HMF) is, actual, a good indicator of honey purity and freshness (Codex Alimentarius, 2000). High levels of HMF in honey samples indicate poor storage or overheating conditions. HMF is a broken-down product of some sugar solution, especially those containing fructose and glucose stored for long time or at high temperature. HMF contents in fennel honey samples that obtained from Upper Egypt it had a range from 1.92 to 7.68 mg/ kg., with a mean value (4.96 ± 0.591 mg/ kg). The average level of HMF was very low for all the fennel honey samples. This result attributed to freshness and good practices by beekeeper (Table, 4).

Table (4): Hydroxy methyl furfural (HMF) content of fennel honey samples from Upper Egypt.

HMF NO. of sample	Assiut		Qena		General Mean ± SE
	Mean	Standard Deviation	Mean	Standard Deviation	
1	5.76	0.009	1.92	0.02	
2	7.68	0.020	1.92	0.01	
3	3.84	0.010	7.68	0.02	
4	5.76	0.000	3.84	0.02	
5	5.76	0.010	1.92	0.01	
6	3.84	0.002	4.16	0.01	
7	7.68	0.009	7.68	0.01	
Total (n=7)	40.32		29.12		
mean ± SD	5.75± 1.568 a		4.16 ± 2.580 b		4.96± 0.591
Maximum	7.68		7.68		
Minimum	3.84		1.92		

Means not sharing a common superscript letter in row are significantly different at 5% level of probability.

The obtained results in this investigation agreed with certain previous studies and contracted with some others. According to the International Trade Guidelines European Economic Committee, 2002 and Egyptian standard, 2003.

Hassan (1985) reported that, HMF in the fresh Egyptian honeys were zero. Bogdanov (2002) concluded that HMF is generally not present in fresh honey and its content increases during conditioning and storage depending on the PH value and temperature of storage. Tharasyvoulou (1986) found that the mean HMF content of honey obtained from Greek increased from zero to 8.8 mg/ kg. After 12 months of storage. Moniruzzaman *et al.* (2013) reported that, the HMF contents in some Malaysian honeys ranged between 6.07 and 67.94 mg/ kg. Fatehe (2013) found that the HMF concentrations in certain Egyptian honey samples ranged from zero to 13.44 mg/ kg., El-Metwally (2015) recorded that the HMF content in investigated Egyptian honey samples was 15.05 mg/kg. Tesfaye *et al*. (2016) found that the HMF concentrations of some Ethiopian honey samples ranged from 27.1 to 40.8 mg/kg. with a mean value of 36.35±0.68 mg/kg. Lawal *el al*. (2017) reported that the HMF contents of certain Nigerian honey samples ranged between 12.77 and 62.6 mg/kg. Valdes-Silverio *et al*. (2018) concluded that the HMF concentrations of some honey samples

collected from Ecuador ranged from 3.46 to 172.53 mg/kg.

All analyzed fennel honey samples in this investigation were within the international limits (<40 mg/kg.). This result may be due to freshness and good practices by beekeepers. Also, these low values of HMF might be attributed to the climatic conditions of Upper Egypt region, unlike honey samples from tropical and subtropical countries which have naturally high HMF content due to the high temperature (White, 1978).

It has been demonstrated that the HMF parameter is correlated to the quality of the honey and its heat processing but not related to its origin (Anklam, 1998). Many factors influence the content of HMF such as storage conditions (especially the temperature) and floral origins (Fallico *et al*., 2004 and Meda *et al*., 2005). Also, the HMF level in honey depends on the sugar type present in honey like fructose: glucose ratio (Doner, 1979). It is well known that heating of honey results in the HMF formation, which is produced during acid-catalyzed dehydration of hexoses, such as glucose and fructose (Tosi *et al*., 2002).

HMF value of honey is quality criteria for testing and as index of heat treatment processing of honey and prolonged shelf life of honey. The HMF content is used as standard for testing honey's freshness and overheating of the honey. Diastase activity is measured as the diastase number (Hooper, 1983). The starch-digesting enzymes of honey are used as indicators of honey quality because of their heat sensitivity (Subramanian *et al*., 2007). The diastase activity of the studied Egyptian fennel honey samples ranged from 8.5 to 150.0 both units (Table,5) . With a general mean value of 54.31 units on the both scales. Invertase is a natural honey enzyme which is commonly used in Europe as a determinant of freshness. Invertase level depends on the geographic and floral origins of the honey.

Table (5): Enzymes activity of Egyptian fennel honey samples from Upper Egypt.

Sample	Assiut		Qena	
	Diastase	**Invertase**	**Diastase**	**Invertase**
1	50.0	157.4	33.3	155.8
2	50.0	190.7	150.0	219.3
3	25.0	163.7	75.0	209.8
4	25.0	124.0	60.0	160.5
5	37.5	117.6	75.0	198.7
6	100.0	143.0	8.5	122.4
7	21.4	189.1	50.0	190.7
Total (n=7)	308.9	1085.5	451.8	1257.2
Mean ± SD	44.129 ± 27.334 b	155.07 ±28.932 b	64.54 ±44.480 a	179.6 ±34.591 a
Range	21.4 – 100	117.6 -190.7	8.5 - 150	122.4 -219.3

The invertase activity of tested Egyptian fennel honey samples obtained from Upper Egypt ranged from 117.6 to 219.3 unit/kg, with a general mean value of 167.34 unit/kg honey.

The purpose of this research work is to assess the main characteristic features of Egyptian fennel honey. The obtained results aimed to proffer some advisable suggestions towards beekeepers and honey producers. The obtained results found that the chemical properties of Egyptian fennel honey are compatible with most of the international standard specifications.

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