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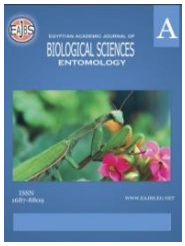

Profile Analysis of Major and Minor Honey Contents from Different African Countries

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ABSTRACT

This study was conducted with the aim of assessing the quality of some African honey types and ruling on their suitability for export. Numbers of 22 honey samples were analyzed from five African countries, namely Egypt, Libya, Algeria, Cameroon, and Zimbabwe. Results showed that the total sugar content of honey samples varies between (51.59 %, sample 10), and (75.27 %, sample 19). Honey samples from Zimbabwe had significantly the highest value of fructose (39.33±0.19 %) followed by Libyan honey (38.91±0.52 %). On the other hand, sample (1) from Egypt gave the least value of fructose sugar content represented (26.73±0.42 %). All the honey samples from Algeria, Cameroon, and Zimbabwe did not exceed the standard limit of sucrose content (5 %) indicates that the bees were not artificially fed with sugar. Samples (17 and 18) from Zimbabwe were significantly the inferior of sucrose sugar content with averages (0.58±0.04 % and 0.58±0.01 %), respectively. In addition, sample (9) from Algeria was significantly superior of all honey samples in diastase number giving (35.2±0.46 µ/g). It is clear that two honey samples from each Algeria, Cameroon, and Zimbabwe were in an acceptable range of diastase number represented (35.2, 18.2 µ/g), (26.8, 17.52 µ/g) and (14.0, 13.9 µ/g), respectively. On the other hand, diastase number DN of all honey samples from Egypt and Libya was below the proposed standard limit. Libyan honey samples had significantly the highest HMF content ranged from (418.9±5.77 to 684.0±2.30 mg/kg). On the contrary, Algerian honey samples had the least significantly HMF content of all tested samples with range (5.10±0.57 to 19.9±0.26 mg/kg). For proline amino acid, all the honey samples from Cameroon, Libya, and Algeria contain higher proline content than the standard limit. The mean flavonoid content of the African honey samples was ranged from (0.02± 0.005 g/100g, sample 1) to (0.31±0.005 g/100g, samples 4 and 16), respectively. The results suggested that measuring flavonoids levels and proline amino acid could be used to study honey's floral and geographical origins.

INTRODUCTION

Honey is a natural supersaturated sugar solution, which is mainly composed of a complex mixture of carbohydrates. In addition to carbohydrate content, it also contains approximately 20% water as well as minor but important constituents such as proteins,

enzymes (invertase, glucose oxidase, catalase, and phosphatases), amino acids, organic acids (gluconic acid, acetic acid), lipids, vitamins (ascorbic acid, niacin, pyridoxine), volatile chemicals, phenolic acids, flavonoids, carotenoid-like substances, and minerals (Blasa *et al.*, 2005 and Khalil *et al.*, 2012). In addition, the composition of honey can be variable and dependent on its floral source, geographical origin, environmental factors, and processing (Guler et al., 2007; Alvarez-Suarez et al., 2010a and El Sohaimy *et al.*, 2015).

The criteria that define the physicochemical quality of honey are specified by the EC Directive 2001/110 (Council Directive of the European Union, 2002). The major criteria of interest are moisture content, electrical conductivity (EC), ash content, reducing and non-reducing sugars, free acidity, diastase activity and hydroxymethylfurfural (HMF) content (Blasa *et al.*, 2005 and Alvarez-Suarez *et al.*, 2010b). The antioxidant properties of honey have been attributed to some of the constituents present in honey. These constituents include phenolic acids and flavonoids (Meda *et al.*, 2005), certain enzymes (glucose oxidase and catalase) (Molan, 1992 and Moniruzzaman *et al.*, 2012), ascorbic acid, proteins and carotenoids (Alvarez-Suarez *et al.*, 2010a). Other reports established a correlation between floral origin and phenolic compounds and flavonoids (Tomas-Barberan *et al.*, 2001; Gheldof and Engeseth, 2002 and Meda *et al.*, 2005). Since honey types differ from one country to another and in different regions in the same country due to floral origin, soil composition, and other factors consequently, quality criteria differ from one honey type to another (Nelly *et al.*, 2005). The reason for testing honey for quality control purposes is to verify the authenticity of the product and to reveal the possible presence of artificial components or adulterants, as well as to address processing and market needs (Krell, 1996 and Baroni et al., 2006). There are many types of honey commonly consumed in the African countries. Most of these honeys are traded without quality sign or reference to their origins and this may lead to honey adulteration and/or non-standard marketing (Alqarni *et al.*, 2012). So, comparing these honeys with quality standards is greatly required.

The main goal of this work was to characterize the physic-chemical properties of the major and minor honeys contents collected from the African countries Egypt, Libya, Algeria, Cameroon, and Zimbabwe to evaluate their suitability for export.

MATERIALS AND METHODS

The present investigation was carried out at Food Safety & Quality Control Lab, Faculty of Agriculture, Cairo University, Egypt during 2016, to study the physic-chemical properties of the honeys collected from the African countries Egypt, Libya, Algeria, Cameroon, and Zimbabwe. Twenty-two honey samples were collected and stored under refrigerator conditions until the chemical analyses were conducted. All the honey samples were collected, kept in tied glass bottles (200 gm/sample), and put directly in the refrigerator until the experimental analysis was done. For each parameter, the tests were replicated three times and the mean values were taken.

Collecting Honey Samples:

Table (1) and fig (1) illustrated the African countries, honey types, and samples number for each country.

Fig.1. Map of African countries Egypt (1), Libya (2), Algeria (3), Cameroon (4) and Zimbabwe (5)**.**

Table 1: Country, honey type, samples number and plant sources.

No.	Country	Samples Number	English name	Region	Plant sources (Scientific name)
1	Egypt	3	Citrus	Benha- Qalyubia	*Citrus spp.*
2			Clover	Manzala- Dakahlia	*Trifollium alexandrinum*
3			*(MD)*	Belbees- Sharkia	*Medical plants(MD)*
4	Libya	5	Rabeay	Al Sarag- West Tripoli	*Eucalyptus+Citrus+multi flora*
5			Sidr	Wady El Hay-South Tripoli	*Ziziphus spina-christi*
6			Thymus	Gherian- West Tripoli	*Thymus vulgaris*
7			Thymus	Tarhona- South Tripoli	*Thymus vulgaris*
8			Harmal	Commercial honeys	*Peganum harmala*
9	Algeria	3	Eucalyptus	Sona Ben Yakhlef	*Eucalyptus spp.*
10			*Multi flora*	Sona Ben Yakhlef	*Multi flora*
11			Sidr	Sona Ben Yakhlef	*Ziziphus spina-christi*
12	Cameroon	5	*Multi flora*	Commercial honeys	*Multi flora*
13			*Multi flora*	Commercial honeys	*Multi flora*
14			*Multi flora*	Commercial honeys	*Multi flora*
15			*Multi flora*	Commercial honeys	*Multi flora*
16			*Multi flora*	Commercial honeys	*Multi flora*
17	Zimbabwe	6	*Multi flora*	Commercial honeys	*Multi flora*
18			*Multi flora*	Commercial honeys	*Multi flora*
19			*Multi flora*	Commercial honeys	*Multi flora*
20			*Multi flora*	Commercial honeys	*Multi flora*
21			*Multi flora*	Commercial honeys	*Multi flora*
22			*Multi flora*	Commercial honeys	*Multi flora*

a. Determination of Sugars in Honey:

The reducing sugars (fructose and glucose) and non-reducing sugar (sucrose) were determined by HPLC Knauer Instrument, Germany. Two pumps, R1 detector, column oven, and clarity-chrom software was used to determine sugars. Instrument condition: Column: The flow rate was at adjusted at 1.5 mL/min, the column used was Luna NH_2 column for carbohydrate analysis, the column oven temperature kept constant at 40 °C, the RI detector

operated at room temperature, the mobile phase was acetonitrile: HPLC grade: water (80:20,v:v). Sample preparation: 5 g of sample dissolved in 12 mL methanol HPLC grade, Quantitatively transferred to measuring flask 50mL completed to the mark with HPLC grade water, sonicated for 20 min, Filtering through PTFE filter (0.2mm), kept at 0 °C until analysis. Standard preparation: Pipette 25mL methanol into a 100mL calibrated flask. Depending on the sugars to be analyzed, dissolve the amounts detailed below in approximately 40mL water and transfer quantitatively to the flask and fill to the mark with water. Fructose: 2.000g; glucose: 1.500g; sucrose: 0.250g; maltose: 0.150g. (Codex Alimentarius, 1993).

b. Determination of Diastase Activity:

Determination of diastase activity was evaluated spectrophotometrically based on the method of Schade et al. (1958) using the Shade method (UVA/IS Spectometer Lambda ll, Perkin Elmer, USA). The diastase activity is calculated as diastase number (DN). DN expresses units of diastase activity (Gothe unit). One unit is defined as the amount of enzyme that will convert 0.01 g of starch to the prescribed end-point in 1 h at 40 ^{o}C (Bogdanov *et al.*, 1997).

c. Determination of Hydroxymethylfurfural (HMF)

It was determined according to Winkler (1955) as following, Procedure: 1. Preparation of test sample: 5 g of honey sample weighted and dissolved without heating with distilled water and transferred to a 25 mL graduated flask and made up to volume (honey solution). The sample should be tested after preparation without delay. 2. Photometric determination: 2.0 mL of honey solution pipetted into each of two test tubes and 5.0 mL P-toluidine solution is added to each. Into one test tube, 1 mL water is pipetted and into the other 1 mL barbituric acid solution, and both mixtures are shaken. The addition of reagents should be done without pause and should be finished in about 1-2 min. The extinction of the sample is read against the blank at 550 nm using a 1-cm cell, immediately the maximum value is reached. 3. Calculation and expression of results: The method may be calibrated by using a standard of HMF standardized by dissolving commercial or laboratory prepared HMF and assaying spectrophotometrically. The equation by which results may be roughly worked out is: HMF (mg/1000g) =absorbance /thickness of layer *192. Results are expressed as mg HMF/Kg honey.

d. Determination of Proline:

Harmonized methods of International honey commission (2009) were used to determine proline content. The Instrument UV/Vis. Spectrophotometry, Jenway, England with Wave length (510 nm.) was used.

e. Total Flavonoids:

The aluminum chloride colorimetric method was used to determine flavonoid content. 1mL of sample extract was mixed with 3mL of methanol, 0.2mL of 10% aluminium chloride, 0.2mL of 1M potassium acetate, and 5.6 mL of distilled water and remains at room temperature for 30 minutes. The absorbance was measured at 420nm. Rutin was used as standard (1mg/mL). Flavonoid content was calculated from the regression equation of the standard plot (y=2937.1x-29.789, r2=0.9982) and expressed as Rutin equivalent (g/100g of the extracted compound). The UV/Vis. Spectrophotometer instrument, Jenway, England was used under 23ºc/ 40% RH (Harmonized Methods of International Honey Commission, 2009).

f. Statistical Analysis:

Data were subjected to analysis of variance program (ANOVA) (Gomez and Gomez, 1984) followed by the Multiple Range Test to compare means (Duncan, 1955).

RESULTS AND DISCUSSION

The relationships between the geographical origin of the tested honeys and physical and chemical activity were illustrated in Tables (2-3) and Figures (2-7).

Major Contents (Sugar Composition):

The range and mean levels of Fructose, Glucose, and Sucrose in Egypt, Libya, Algeria, Cameroon, and Zimbabwe honeys were analyzed (Table, 2).

Table 2: Mean values of Sugars characteristics for the African honeys analysis

Honey Country	Samples No	Sugars (g/100g)			F/G Ratio	Total tested sugars
		Fructose (F)	Glucose (G)	Sucrose		
Egyptian	1	26.73k±0.42	26.70f±0.40	8.75b±0.40	1.00	62.18
	2	34.42fg±0.57	29.16de±0.57	6.80c±0.57	1.18	70.38
	3	31.47j±0.80	26.75f±0.57	9.88a±0.57	1.17	68.10
Libyan	4	33.68gh±0.57	28.54e±0.57	4.56ef±0.57	1.18	66.78
	5	37.62bcd±0.06	22.35hi±0.20	5.16de±0.09	1.68	65.13
	6	38.06abcd±0.03	23.13h±0.65	5.75d±0.57	1.64	66.94
	7	38.91ab±0.52	28.93de±0.57	3.83fgh±0.57	1.34	71.47
	8	34.74efg±0.40	30.75bc±0.57	5.16de±0.05	1.12	70.65
Algerian	9	31.85ij±0.02	23.84gh±0.57	2.66ij±0.03	1.33	58.35
	10	27.29k±0.16	20.97i±0.57	3.33ghi±0.11	1.30	51.59
	11	38.73abc±0.57	30.77bc±0.40	4.53ef±0.57	1.25	74.03
Cameroon	12	38.36abcd±0.20	30.34bcd±0.57	4.69ef±0.05	1.26	73.39
	13	35.55ef±0.28	24.66g±0.57	2.40j±0.23	1.41	62.61
	14	35.57ef±0.57	30.74bc±0.57	4.00fg±0.28	1.15	70.31
	15	32.83hi±0.01	30.07cd±0.53	2.06j±0.03	1.09	64.96
	16	31.38j±0.57	23.08h±0.53	2.65ij±0.02	1.35	57.11
Zimbabwe	17	39.2a±0.57	32.57a±0.57	0.58k±0.04	1.20	72.35
	18	39.33a±0.19	29.84cde±0.02	0.58k±0.01	1.31	69.75
	19	39.33a±0.57	31.70ab±0.40	4.57ef±0.04	1.23	75.27
	20	37.60cd±0.34	30.81bc±0.57	2.94hig±0.02	1.22	71.35
	21	37.27d±0.57	29.90cde±0.51	3.98fg±0.04	1.24	71.15
	22	35.75e±0.57	29.54cde±0.02	2.95hig±0.02	1.21	68.22
LSD_5%		1.301	1.504	0.929		
F		66.463	42.334	48.156		
P		0.0000	0.0000	0.0000		

All results in table show the mean of triplicates ± SD

Values with different letters in each column indicate significant differences ($p < 0.05$)

The major components of honey are sugars which depend on the floral sources, geographical origins, processing, and storage conditions (Dobre *et al.*, 2012). From table (2) it can be concluded that fructose sugar content was superior of all tested sugars in honey samples. The total sugar content of honey samples varies between (51.59%, sample 10) and (75.27%, sample 19). Finola et al. (2007) mentioned that lime honey from Romanian had 42.49% of combined glucose and fructose in all the honey weight. Results showed that the monosaccharaides fructose and glucose are the main sugars in all samples which confirmed that all honey varieties are genuine (Kucuk et al., 2007). From the result in table (2), the Zimbabwe honey samples had significantly the higher value of fructose 39.33±0.19% indicating this honey is of good quality and they are less susceptible to early crystallization followed by Libyan honey 38.91±0.52% (Crane, 1990 and Kaakeh and GadelHak, 2005). On the other hand, sample (1) from Egypt gave the least percentage of fructose sugar content represented 26.73±0.42%. Moreover, samples no. 10, 5, and 6 showed the least values for glucose content with significant difference represented 20.97±0.57, 22.35±0.20, and

23.08±0.53g/100g, respectively. Furthermore, Zimbabwe honey samples (17, 19, and 20) recorded the highest glucose content (32.57±0.57, 31.70±0.40, and 30.81±0.57 g/100g) with significant differences, respectively. All the honey samples from Algeria, Cameroon, and Zimbabwe did not exceed the standard limit of sucrose content 5% as specified by Codex Alimentarius (1998) indicates that the bees were not artificially fed with sugar. On contrary, all the Egyptian honey samples exceeded the standard level of sucrose content with range (6.8 to 9.88 g/100g) but it's in the accepted range under the Egyptian standard limits not more 10% (EOSC, 2005). Samples 17 and 18 from Zimbabwe were significantly the least of sucrose sugar content with averages 0.58±0.04 and 0.58±0.01, respectively.

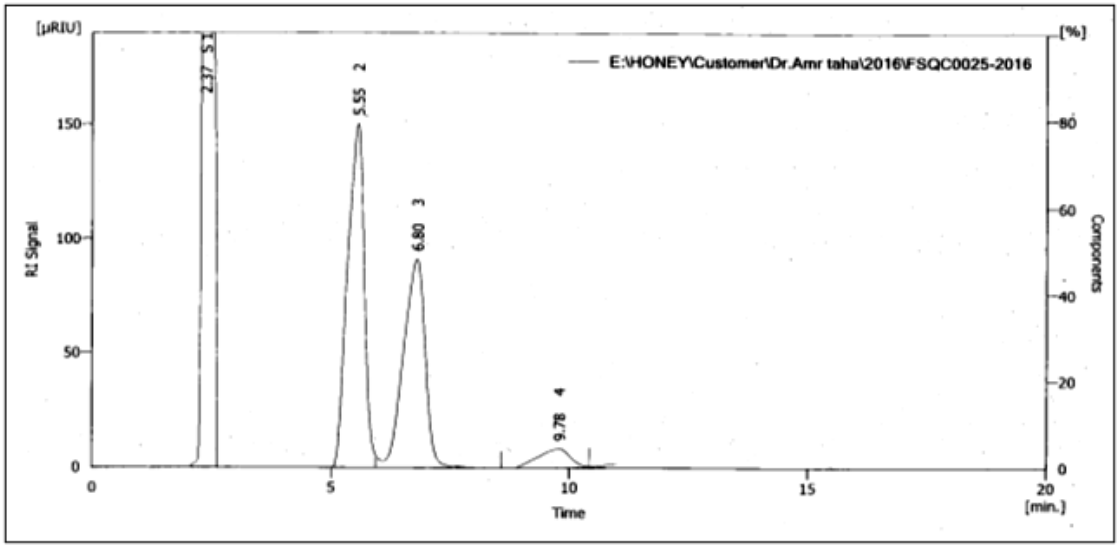

Fig 2: HPLC chromatographic profile of sugars in Egypt sample 1 (2: Fructose, 3: Glucose, 4: Sucrose).

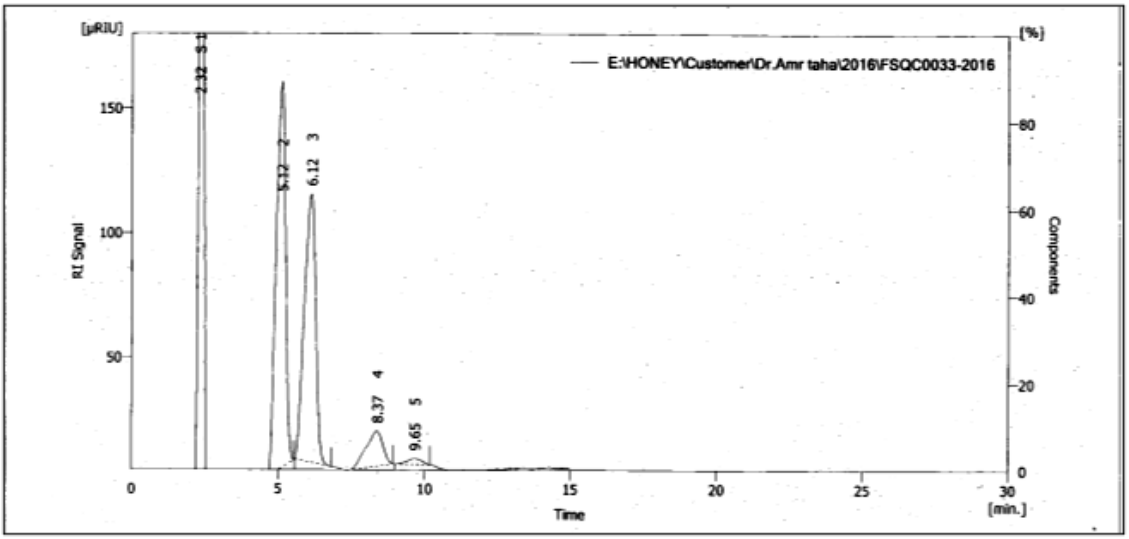

Fig 3: HPLC chromatographic profile of sugars in Libya sample 4 (2:Fructose, 3:Glucose, 4:Sucrose).

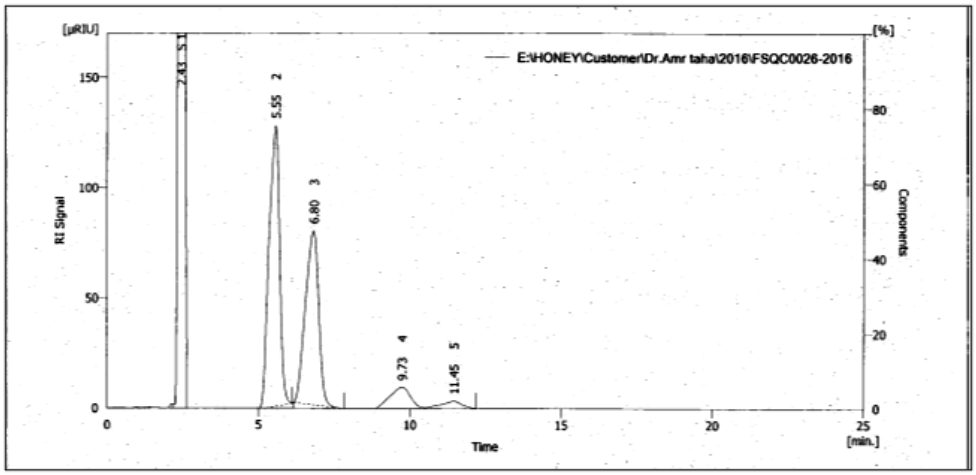

Fig. 4: HPLC chromatographic profile of sugars in Algeria sample 10 (2: Fructose, 3: Glucose, 4: Sucrose).

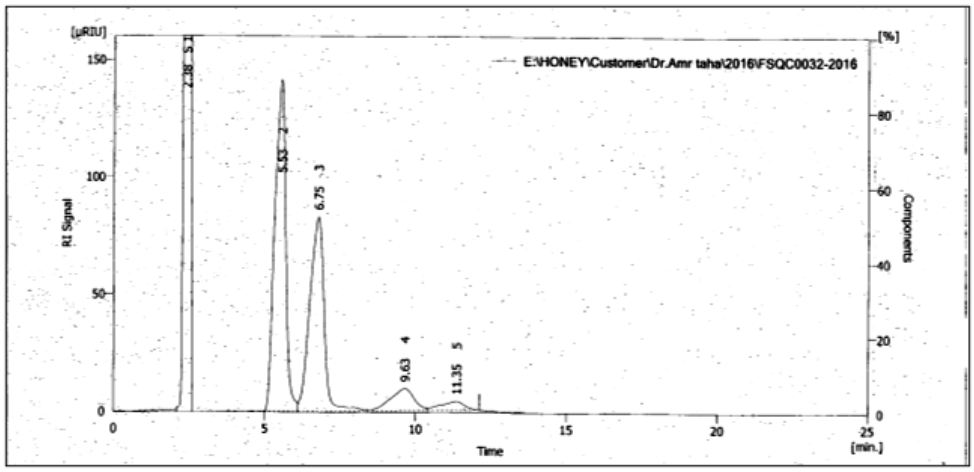

Fig.5: HPLC chromatographic profile of sugars in Cameroon sample 16 (2: Fructose, 3: Glucose, 4: Sucrose).

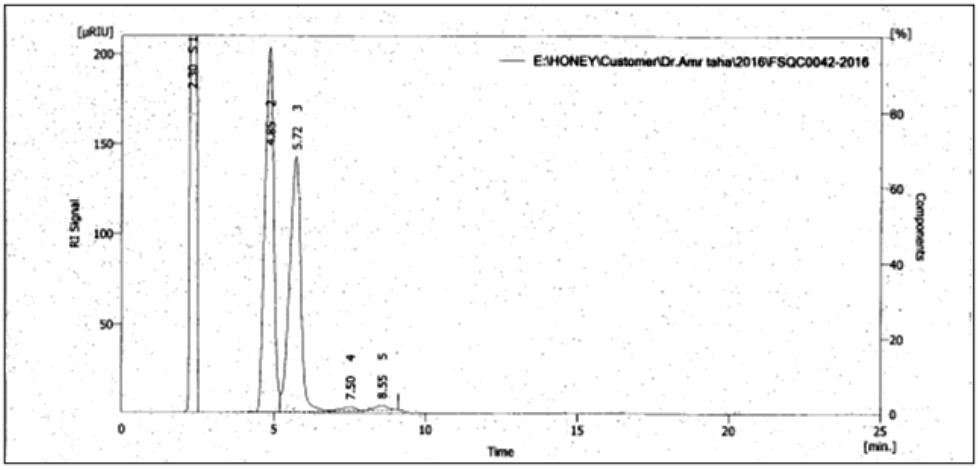

Fig.6: HPLC chromatographic profile of sugars in Zimbabwe sample 18 (2: Fructose, 3: Glucose, 4: Sucrose).

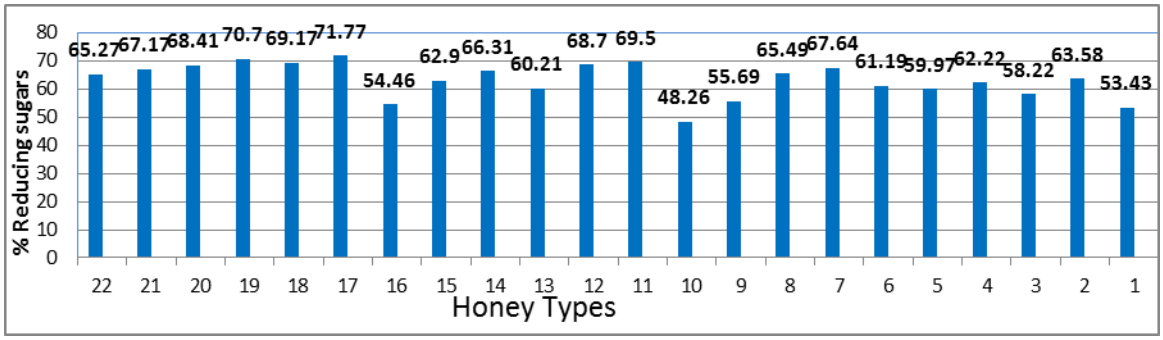

Fig. 7: Reducing sugars percentages of honey samples from Egypt, Libya, Algeria, Cameroon and Zimbabwe

It is clear that samples 1, 15, and 8 showed the least Fructose/Glucose ratio (F/G) (1.00, 1.09, and 1.12), respectively. On contract, the highest Fructose/Glucose ratio was observed for samples 5, 6, and 7 from Libya represented 1.68, 1.64, and 1.34, consequently. Crane (1990) reported that glucose and fructose which are the two major and primary sugars in honey are the main factors in determining the tendency of honey to crystallize. Generally, the higher the glucose, the faster honey crystallizes, and the higher the fructose, the slower it crystallizes. Bogdanov (1993) and Buba *et al.* (2013) mentioned that if glucose content of 30% or more the tendency to granulate is ready.

Minor Contents:

Diastase Number in Honey Samples:

Table (3) showed the diastase activity values for twenty-two honey samples from different African countries. In addition, sample (9) from Algeria was significantly superior of all honey samples in diastase number giving (35.2±0.46 DN). Moreover, sample no (13) from Cameroon coming at the second level with significant difference of the other samples represented (26.8±0.28 DN). It is clear that two honey samples from each Algeria, Cameroon and Zimbabwe were in an acceptable range of diastase number not less than 8 on Goth standard represented (35.2, 18.2µ/g), (26.8, 17.52 µ/g) and (14.0, 13.9 µ/g), respectively. On the other hand, diastase number DN of all honey samples from Egypt and Libya was below the standard proposed by Codex Alimentarius, 1993. This may refer to non-freshness or heating damage of honey. The activity of diastase (α-, β-, γ-amylase) is the important quality parameter of honey and the diastase number must not be less than or equal to 8 DN. Results support the theory that enzymes can serve as a sensitive indicator and has strong impacts on the quality and nutritional value of honey (Bogdanov et al., 1987; Codex Alimentarius, 1993; Rossano *et al.,* 2012 and Taha *et al.,* 2019).

Hydroxymethylefurfural (HMF):

From the result in table (3), the Libyan honey samples had very high HMF content as it is significantly exceeded the maximum standard of 40 mg/kg specified by Codex Alimentarius (2001). The HMF content of the Libyan honey samples ranged from (418.9±5.77 to 684.0±2.30 mg/kg). However, the value of HMF in sample (16) from Cameroon cam at the second level represented (248.5±2.88 mg/kg) after the Libyan honeys. In addition, Tosi et al. (2002) reported that thermal treatment can increase HMF content of honey. Moreover, overheating honey during processing or storage for long period could leads to the conversion of sugars to HMF (Saxena *et al.,* 2010). Therefore, honey treatment temperature and time must be limited when pasteurizing and stabilizing. According to Fallico *et al.* (2004), HMF concentration in honey is also related to honey composition (pH, acidity), particularly at low heating temperatures. Alqarni *et al.* (2012) indicated that four Saudi honeys had very high HMF content ranged from 101.80 mg/kg to 258.72 mg/kg, respectively. If the honey stored for more than one year, the HMF level will be very high

ranging from 128.19-1131.76 mg/kg (Khalil *et al.,* 2010). On the contrary, Algerian honey samples had significantly the least HMF content of all tested samples with range (5.10±0.57 to 19.9±0.26 mg/kg) and lower than the limit (40 mg/kg) recommended by the Codex Alimentarius (2015). HMF content is an important parameter widely used as an indicator of purity and freshness of honey. The freshness of honey, the HMF contents the less (Martinez *et al.,* 2018).

Table 3: Mean values of diastase, HMF, proline and total flavonoids of African honeys

Honey Country	Samples No	Diastase D.N. µ/g	HMF mg/kg	Proline mg/kg	Total Flavonoids g/100g
Egyptian	1	1.30L±0.115	130.1O±0.005	62.86q±0.46	0.02k±0.005
	2	2.20jk±0.115	67.3i±0.57	415.17j±2.88	0.08h±0.005
	3	4.65g±0.101	32.8L±0.57	122.80p±1.15	0.03jk±0.005
Libyan	4	4.09ghi±0.051	546.2c±0.46	575.13g±2.88	0.31a±0.005
	5	5.75f±0.288	470.3d±0.88	358.90k±4.61	0.23c±0.005
	6	4.68gh±o.577	587.9b±1.15	312.21L±5.77	0.27b±0.014
	7	1.50kL±0.115	684.0a±2.30	441.18i±5.77	0.23c±0.017
	8	2.45j±0.028	418.9e±5.77	263.54m±1.73	0.16de±0.017
Algerian	9	35.20a±0.461	19.9n±0.26	898.37c±4.61	0.15ef±0.011
	10	5.90f±0.230	5.10p±0.57	195.89 O±2.88	0.03jk±0.005
	11	18.20c±0.115	12.4 O±0.23	491.18h±28.48	0.15ef±0.005
Cameroon	12	7.30e±0.173	80.1h±2.88	624.21f±2.30	0.16de±0.011
	13	26.80b±0.288	104.6g±2.30	960.44b±5.77	0.18d±0.011
	14	5.86f±0.173	29.7Lm±0.40	659.30e±2.30	0.13fg±0.005
	15	17.52c±0.277	48.1jk±0.05	1143.81a±5.77	0.26b±0.011
	16	2.30j±0.115	248.5f±2.88	803.87d±1.73	0.31a±0.005
Zimbabwe	17	4.00hi±0.115	53.3j±1.90	67.11q±1.154	0.04jk±0.005
	18	4.00hi±0.066	25.2mn±0.11	58.36q±1.73	0.05ij±0.005
	19	7.04e±0.023	4.20p±0.11	242.18n±1.15	0.03jk±0.005
	20	14.00d±0.577	25.8mn±0.46	119.87p±3.33	0.09h±0.011
	21	7.00e±0.288	23.6n±0.34	354.52k±2.30	0.07hg±0.011
	22	13.90d±0.288	45.3k±2.88	497.96h±4.04	0.12g±0.011
LSD $_5$%		0.744	5.94	19.86	0.028
F		1123.15	1131.49	1965.75	92.35
P		0.0000	0.0000	0.0000	0.0000

All results in table show the mean of triplicates ± SD.
Values with different letters in each column indicate significant differences ($p < 0.05$)

Proline Amino Acid:

Data tabulated in table (3) illustrated proline amino acid existing in honey samples from different African countries. Honey sample (No., 15) from Cameroon was significantly superior of proline amino acid represented (1143.81±5.77 mg/Kg). Meanwhile, honey sample (No., 18) from Zimbabwe represented the least (58.36±1.73 mg/Kg). The proline content values were significantly different among all the honey samples ($p<0.05$). A minimum value of (180 mg/Kg) for genuine honey has been accepted in codex standards. All the honey samples from Cameroon, Libya, and Algeria contain higher proline content than the standard limit and thus can be considered as maturity and unadulterated honeys (Bogdanov *et al.,* 1999). The low value of proline content was observed from two honey samples of Egypt represented (62.86 and 122.8 mg/Kg) and three samples of Zimbabwe honeys (58.36, 67.11, and 119.87 mg/Kg), respectively. These results are in agreement with Mouhoubi-Tafinine *et al.* (2018) they stated that the proline levels ranged 551.88-890 mg/Kg. Our findings were supported by El-Sohaimy *et al.* (2015) found that the lowest value of protein content was

registered in Egyptian honey (1.69±0.015 gm/g). Amino acids profiles could be used as chemical markers for botanical and geographical origin of honey as it's originated from pollen existing in honey (Goodall *et al.,* 1995 and Schafer et al., 2006). Taha and Asmaa (2011) mentioned that proline is the most important from a quantitative point of view of amino acids.

Total Flavonoid Content:

Flavonoids are low-molecular-weight phenolic compounds that affect the aroma and antioxidant properties of honey. The mean flavonoid content of the African honey samples was ranged from (0.02± 0.005g/100g, sample 1) to (0.31±0.005 g/100g, samples 4 and 16) (Table 3), respectively. It is clear that honey samples differ significantly in total flavonoids content. Libyan honey samples represented significantly the highest total flavonoids content of all tested samples ranged from (0.16±0.017g/100g to 0.31±0.005g/100g), respectively. Honey samples from Cameroon were at the second level with an average range from (0.13 to 0.31 g/100g). On the other hand, Egyptian honey samples were significantly the least of flavonoid content represented (0.02±0.005g/100g) followed by Zimbabwe honey sample represented (0.03±0.005g/100g). The flavonoid content has been studied for Burkina Fasan acacia honey (61.4 mg/kg) (Meda et al., 2005); Algerian honeys (71 mg/kg) (Khalil *et al.,* 2012); eucalyptus honey (20–25 mg/kg); sunflower and rape honey (15–20 mg/kg); lavender, and acacia honey (5–10 mg/kg), as previously reported (Meda *et al.,* 2005 and Ferreira *et al.,* 2009). The variations of total flavonoids content prolonged to the difference between honey types and floral sources. The results suggested that measuring flavonoids levels could be used to study honey's floral and geographical origins (Tomas-Barberan *et al.,* 2001).

Conclusion, African honeys can occupy a global position in the international trade by conducting further studies to assess the floral origin and vital characteristics of each honey. In addition, restricted application of quality standards during colony management, honey production, and marketing are required.

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ARABIC SUMMARY

تحليل مكونات العسل الكبرى و الصغرى فى البلدان الإفريقية المختلفة

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أجريت هذه الدراسة بهدف تقييم جودة بعض أنواع العسل الإفريقي والحكم على ملاءمتها للتصدير. تم تحليل ٢٢ عينة عسل من خمس دول أفريقية هي مصر، ليبيا، الجزائر، الكاميرون وزيمبابوي. أظهرت النتائج أن المحتوى الكلى للسكر لعينات العسل يتراوح بين (٥١,٥٩٪، عينة ١٠) و (٧٥,٢٧٪، عينة ١٩). كانت عينات العسل من زيمبابوي ذات قيمة أعلى من الفركتوز (٣٩,٣٣ ±٠,١٩٪) يليها العسل الليبي (٣٨,٩١±٠,٥٢٪). من ناحية أخرى، أعطت العينة (١) من مصر أقل قيمة لمحتوى سكر الفركتوز معطيه (٢٦,٧٣±٠,٤٢٪). جميع عينات العسل من الجزائر والكاميرون وزيمبابوي لم تتجاوز المستوى القياسي لمحتوى السكروز (٥ ٪). كانت العينات (١٧ و١٨) من زيمبابوي الأدنى بشكل ملحوظ فى محتواها من سكر السكروز بمتوسطات (٪ ٠,٥٨±٠,٠٤ و٠,٥٨±٠,٠١٪)، على التوالى. بالإضافة إلى ذلك، كانت العينة (٩) من الجزائر الأعلى في رقم إنزيم الدياستيز عن جميع عينات العسل معطيه (٣٥,٢±٠,٤٦ µg/g). يتضح أن، عينتين من العسل من كل من الجزائر والكاميرون وزيمبابوي كانت في الحدود المسموح بها بالنسبة لرقم الدياستيز معطية (٣٥,٢، ١٨,٢ µg/g) ، (٢٦,٨ ، ١٧,٥٢ µg/g) و (١٤,٠ ، ١٣,٩ µg/g)، على التوالي. من ناحية أخرى، كانت قيمة رقم الدياستيز DN لجميع عينات العسل من مصر وليبيا أقل من الحد القياسي الموصى به. كانت عينات العسل الليبي الأعلى فى قيمة هيدروكسى ميثايل فورفورال HMF بصورة معنوية وتراوحت بين (٤١٨,٩±٥,٧٧ ملليجرام/كجم) إلى (٦٨٤,٠±٢,٣٠ ملليجرام / كجم). على العكس، إحتوت عينات العسل الجزائري على أقل قيمة بصورة معنوية من HMF مقارنة بجميع العينات المختبرة بمدى (٥,١٠±٠,٥٧ ملليجرام/كجم) إلى (١٩,٩±٠,٢٦ملليجرام/كجم). بالنسبة للحمض الأميني البرولين، إحتوت جميع عينات العسل من الكاميرون، ليبيا والجزائر على محتوى برولين أعلى من الحد القياسي. تراوح متوسط محتوى الفلافونويد في عينات العسل الأفريقي من (٠,٠٠٥ ±٠,٠٢ جم/١٠٠جم، عينة ١) إلى (٠,٣١±٠,٠٠٥ جم/١٠٠جم، عينات ٤ و ١٦)، على التوالي. أشارت النتائج إلى أن قياس مستويات الفلافونويدات والحمض الأميني البرولين يمكن إستخدامها لدراسة الأصل الزهرى والجغرافي للعسل.