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Quality Evaluation of Some Honey from the Central Region of Algeria

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Abstract

The quality of sixteen samples of *Apis mellifera* L. honey, from the center of Algeria, was evaluated by determining the physico-chemical characteristics. The following determinations were carried out: water content, total sugar, electrical conductivity, ash, pH, acidity (free, lactone, and total), hydroxylmethylfurfural (HMF) and color. The physicochemical parameters found are within acceptable ranges: water 13.36–17.93%, total sugar 80.17-84.73%, pH 3.58–4.72, total acidity 17.97-49.1 meq/kg, electrical conductivity 2.75×10^{-4} –7.19×10^{-4} S/cm, ash 0.075–0.33%, and color 4.1–9.2 Pfund index. The analysis of HMF showed that the majority of samples were exposed to a high temperature during processing or storage.

Keywords: Honey, quality, physicochemical parameters, Algeria.

1. Introduction

Honey is the natural sweet substance produced by *Apis mellifera* from the nectar of plants or from secretions of living parts of plants or excretions of plant-sucking insects on the living parts of plants, which the bees collect, transform by combining with specific substances of their own, deposit, dehydrate, store and leave in honeycombs to ripen and mature (Council Directive of the European Union, 2002).

The composition of honey depends on the plant species visited by the honeybees and the environmental processing and storage conditions (Bertoncelj *et al*., 2007; Guler *et al*., 2007; Sanz *et al*., 2004).

The carbohydrates are the major components of honey. The monosaccharides as fructose and glucose are the dominant fraction and occur for 85-95% of honey sugars. Honey also contains water and certain minor constituents such as proteins, enzymes, amino and organic acids, lipids, vitamins, volatile chemicals, phenolic acids, flavonoids, and carotenoid-like substances and minerals (Ball, 2007; Blasa *et al*., 2006). Blossom or nectar honey is derived from the nectaries of flowers and honeydew honey comes from the sugary excretion of some hemipterous insects on the host plant or from the exudates of the plants (Saxena *et al*., 2010).

Honey is generally evaluated by physico-chemical analysis of its constituents. The manipulation of honey and its possible adulteration is reflected in many of its physico-chemical properties such as HMF and sugar. Therefore, to ensure the authenticity, it is necessary to analyze honey samples in detail**.**

The studies of the physico-chemical properties of honey are important for the certification process that determines honey quality. The aim of this study was to evaluate and compare the quality of some honey samples from the central region of Algeria to the international standards.

2. Materials and Methods

2.1. Honey samples

Sixteen honey samples supplied by local producers from two geographical regions of center Algeria (Laghouat and Djelfa regions) have been studied. The samples were collected between 2009 and 2010, and stored at 4–6°C. Botanical classification was achieved when the pollen spectrum contained more than 45% of the corresponding dominant pollen (Louveaux *et al*., 1978). Pollen types were identified by comparing them with a reference collection of the Laboratory of analysis of the honey (Baba Ali, Algeria) (Table 1).

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Table 1. Honey samples and their botanical origin.

Samples	location	Botanical origin	Harvested period
L02	Kabegue	*Peganum harmala*	July 2009
L03	Khat alouad	Polyfloral	June 2009
L05	Hamda	Polyfloral	June 2009
L08	Tadjmout	*Trifolium sp.*	June 2009
L10	Taouyala	*Trifolium sp.*	June 2009
L11	Sidi makhlouf	Polyfloral	June 2009
L12	Gueltat sidi saad	Polyfloral	July 2010
L13	Kabegue	*Peganum harmala*	July 2010
D01	Megusem	Polyfloral	May 2009
D02	Megusem	*Ziziphus lotus*	July 2009
D05	Messad	Polyfloral	July 2009
D06	Messad	Polyfloral	July 2009
D07	Messad	Polyfloral	July 2009
D09	Ain oussara	Polyfloral	July 2010
D11	Medjbara	Polyfloral	July 2009
D12	Djalfa	Polyfloral	July 2009

(L: Laghouat region, D: Djelfa region).

2.2. Physico-chemical determinations

2.2.1. Sugar and water content

Sugar and water values were determined using a special refractometer reading at 20 °C (Carl-Zeiss Jena refractometer), with two direct reading displays, for the measurement of sugar content and moisture percent, respectively (AOAC, 1990). Sugar content was expressed as brix degrees.

2.2.2. Electrical conductivity

The Electrical Conductivity (EC) of a honey solution at 20% (dry matter basis) in CO_2-free deionized distilled water was measured at 20°C (AOAC, 1990) in a EUTECH instrument conductimeter (Con.520).

2.2.3. Ash content

The ash content was indirectly determined using the measured electrical conductivity and applying the following equation: X1= (X2 − 0.143)/1.743. Where: X1= ash value; X2= electrical conductivity in mS/cm at 20 °C (Piazza *et al*., 1991, Bogdanov *et al*., 1999).

2.2.4. pH, free, lactonic and total acidity

The pH was measured by pH-meter (WTW inoLab pH 750) in a solution containing 10g of honey in 75 mL of distilled water (AOAC, 1990).

The free, lactonic and total acidity were determined by the titrimetric method: the addition of 0.05 N NaOH, is stopped at pH 8.50 (free acidity), immediately a volume of 10 mL 0.05 N NaOH is added, and without delay, back-titrated with 0.05 M HCl from 10 mL to pH 8.30 (Lactonic acidity). Total acidity was obtained by adding free plus lactone acidities. Results were expressed as meq/kg **(**AOAC, 1990**)**.

2.2.5. Color measurement

The color was measured by the technique of visual Lovibond comparator (Series 2000, USA) (Aubert and Gonnet, 1983). The liquid honey (about 20g) was loaded into the measuring tube and the color compared with standards and the results obtained were expressed as "Pfund index".

2.2.6. Hydroxymethylfurfural analysis

Hydroxymethylfurfural (HMF) was determined by HPLC method (Fallico *et al*., 2004), Aliquots of honey samples were diluted to 50 ml with distilled water, filtered on 0.45 mm filter and injected into an HPLC (Varian 9012Q) equipped with a diode array detector (Varian, Star 330). The HPLC column was a Merck Lichrospher, RP-18, 5 mm, 125_4 mm, fitted with a guard cartridge packed with the same stationary phase (Merck, Milan). The HPLC conditions were the following: isocratic mobile phase, 90% water at 1% of acetic acid and 10% methanol; flow rate, 0.7 ml/min; injection volume, 20 ml. All the solvents were of HPLC grade (Merck, Milan). The wavelength range was 220–660 nm and the chromatograms were monitorated at 285 nm. HMF was identified from the peak in honey with a standard HMF (P>98% Sigma-Aldrich, Milan), and by comparison of the spectra of the HMF standard with that of one honey samples. The amount of HMF was determined using an external calibration curve, measuring the signal at λ=285 nm.

2.2.7. Statistical analysis

All results were statistically analyzed by one-way analysis of variance (ANOVA). Differences were considered significant for $p < 0.05$.

3. Results

Significantly, all parameters were very highly different among the samples ($p<0.001$). The results of physico-chemical parameters of honey samples from the two regions were presented in Table 2. The highest value for water content was found in the sample L10 (17,93%), this sample showed the lowest quantity of sugar. The total sugar contents ranged from 80.17 to 84.73%.

All studied honey samples were acidic in nature and the pH values varied between 3.58 and 4.72. Free, lactone and total acidity of

analyzed honey samples were between: 14.9-40.33, 3.06-8.98 and 17.97- 49.1 meq/kg, respectively.

The electrical conductivity was less than 8×10^{-4} S/cm. Medjbara honey (D11) has the highest conductivity (Table 2). The EC found in all the samples was typical for floral honey. The HMF content in five honey samples was lower than the allowed maximum limit of 40 mg/kg recommended by Codex Alimentarius (2001).

According to the method used by Aubert and Gonnet (1983), seven of our samples were light (≤ 6.2 Pfund index) and the remaining nine samples were dark (>6.2 Pfund index). L12 (9.2 Pfund index) is the darkest samples, followed by L05 and L10 with (8.3 Pfund index), the samples D11 (4.1 Pfund index) is the lightest samples, followed by L03 (5.1 Pfund index)

Table 2. Analysis of some physico-chemical parameters of *Apis mellifera* L. honey samples.

Samples code	Water content (%)	pH	Free acidity (meq/kg)	Lactone acidity (meq/kg)	Total Acidity (meq/kg)	HMF (mg/kg)	Electrical conductivity (10^{-4} S/cm)	Ash content (%)	Total sugar (%)	Color (Pfund index)
L02	14.3± 00	4.16±0.01	23.33±0.57	5.83±0.57	29.16±1.15	36.63±2.03	4.21±0.04	0.159±0.002	83.8±0.02	7.1
L03	17.36±0.25	3.58±00	40.33±0.28	8.76±0.25	49.1±0.52	49.41±0.54	3.91±0.02	0.142±0.001	80.95±0.22	5.1
L05	14.43±0.20	3.89±0.01	29.14±0.30	6.78±0.28	35.93±0.29	104.12±0.71	4.56±0.04	0.179±0.002	83.75±0.21	8.3
L08	13.96±0.20	4.08±0.02	23.98±0.49	5.16±0.37	29.15±0.14	116.61±3.67	3.72±0.02	0.131±0.001	84.15±0.13	7.1
L10	17.93±0.23	3.90±0.02	27.60±0.42	7.04±0.38	34.65±0.51	29.74±2.42	333±0.03	0.108±0.001	80±0.17	8.3
L11	16.53±0.05	3.69±0.03	25±0.62	5.64±0.57	30.65±0.25	72.86±1.84	4.65±0.02	0.184±0.001	81.76±0.05	6.2
L12	14.36±0.55	4.02±0.01	24.82±0.57	4.99±00	29.81±0.57	62.97±1.21	3.95±0.05	0.144±0.003	83.43±0,23	9.2
L13	14.16±0.11	4.43±0.01	17.22±0.25	6.82±0.28	24.04±0.38	18.21±0.52	5.22±0.01	0.217±0.001	83.93±0,11	8.3
D01	15.03±0.15	3.97±0.01	22.47±0.5	5.49±0.5	27.96±0.5	38.37±0.65	3.78±0.01	0.134±0.001	83.16±0.18	5.5
D02	16.33±0.15	4.29±0.00	19.72±0.25	5.13±0.31	24.85±0.15	85.07±1.64	5.30±0.04	0.222±0.002	81.95±0.13	7.1
D05	13.36±0.05	4.72±0.01	14.91±00	3.06±0.14	17.97±0.14	8.90±0.29	5.21±0.02	0.216±0.001	84.73±0.05	7.1
D06	14.13±0.05	3.91±0.02	25.42±0.49	7.06±0.37	32.48±0.51	100.29±2.04	3.66±0.02	0.127±0.001	84.01±0.05	8.3
D07	14.5±0.2	4.11±0.03	20.85±00	7.44±00	28.29±00	63.67±1.58	3.78±0.01	0.134±0.001	83.7±0.15	6.2
D09	17.53±0.11	3.6±0.01	40.08±0.28	8.98±0.25	49.06±0.14	205.04±3.9	3.93±0.02	0.143±0.001	80.76±0.11	5.5
D11	14±0.1	3.79±00	19.39±00	4.97±00	24.36±00	82.79±0.29	7.19±0.08	0.330±0.004	84.18±0.1	4.1
D12	15.16±0.11	3.91±0.02	16.33±0.85	4.37±0.51	20.70±0.86	138.77±2.61	2.75±0.03	0.075±0.001	83.05±13	5.5

4. Discussion

4.1. Water and sugar content

The water and sugar contents of honey are strictly correlated (Conti, 2000); the water content depends on various factors such as harvesting season, degree of maturity reached in the hive and climatic factors (Finola *et al*., 2007). All the values obtained were below 18% (Table 2) indicating a good degree of maturity are included in the water range limits approved by the European Commission (Council Directive of the European Union, 2002) and the Codex Alimentarius (Codex Alimentarius, 2001). Higher water content could lead to undesirable honey fermentation during storage (Saxena *et al*., 2010; Al *et al*., 2009). According to this result, lower water content is highly important for the shelf-life of the honey during storage. The honey samples having higher moisture content had lower total sugar and vice versa.

4.2. Electrical conductivity and ash content

The electrical conductivity of the honey is closely related to the concentration of mineral salts, organic acids and proteins; it is a parameter that shows great variability according to the floral origin and is considered one of the best parameters for differentiating between blossom honeys and honeydews (Mateo and Bosch-Reig, 1998; Terrab *et al*., 2002). The electrical conductivity of the samples varied between 2.75×10^{-4} –7.19×10^{-4} S/cm. According to Codex Alimentarius (Codex Alimentarius, 2001) and European Commission (Council Directive of the European Union, 2002) value for the nectar honey should be less than 8×10^{-4} S/cm (with few exceptions). Moreover, the values of EC of our samples are typical of blossom honeys. Besides this, the ash content of the present honey samples varied widely ranging from 0.075% to 0.33%. The observed ash contents were similar to Algerian honey samples (Ouchemoukh *et al.*, 2007). The maximum ash content was observed for the sample D11, followed by the sample D02 (0.222%). These differences in mineral content are dependent on the type of soil in which the original nectar bearing plant was located (Anklam, 1998).

4.3. pH and acidity

The pH of 15 honeys analyzed is less than 4.5; these are typical pHs in floral honeys. The pH values are of great importance during the extraction and storage of honey as they influence the texture, stability and shelf life (Terrab *et al*., 2003).

The acidity of honey developed due to the presence of organic acids. A high total acidity may mean that the

honey had fermented at some time, and that the resulting alcohol was converted into organic acid (Rodgers, 1979). In our samples, the values of total acidity ranged between 17.97–49.1 meq/kg; these values are similar to some locally produced honey in Algeria as reported by Chefrour *et al*. (2009). The total acidity was below the limit proved satisfactory in international trade (50 meq/kg of honey), indicating absence of undesirable fermentation in our samples.

4.4. Color

Based on the classification of Aubert and Gonnet (1983), nine honey samples are dark. The color of honey was related to its mineral content and the color of pollen (González-Miret *et al*., 2005; Terrab *et al*., 2004). On the other hand, the color intensity is supposed to be related to pigments (carotenoids, flavonoids, etc.), which are also known to have antioxidant properties (Frankel *et al*., 1998).

4.5. Hydroxymethylfurfural

HMF measurement is used to evaluate the quality of honey. It is not generally present in fresh honey (Zappalà *et al*., 2005). HMF values were found to be extremely high in 11 honey samples regarding the acceptable standard (≤40 mg/kg) (Council Directive of the European Union, 2002; Codex Alimentarius, 2001). Seven samples showed high levels of HMF (>80 mg/kg) and the most elevated HMF is observed in only one sample (205.04mg/kg). These excessive values of HMF indicate that there was overheating during processing, prolonged storage or adulteration with invert sugar (Singh *et al*., 1998; Kubis and Ingr, 1998; Doner, 1977; Zappalà *et al.*, 2005). Besides, honeys from subtropical countries have naturally high content of HMF due to the high temperatures (White, 1978). In our country without air-conditioning, storage temperatures during summer may reach somewhere close to 40°C.

5. Conclusion

The physico-chemical characteristics of five from the 16 honey samples analyzed in this study completely agree with the European Commission and the Codex Alimentarius indicating adequate processing, good maturity and freshness. Eleven honey samples did not agree with characteristics established in European and Codex standards relative to the HMF, although the other physico-chemical parameters were within the range of the allowable limits. The low moisture content helps to protect honey from microbiological activity and thus it can be preserved for long period.

This paper shows new results from honey composition of the central of Algeria (Laghoaut and Djelfa) that have not been studied yet. These results are also very important for the commercialization of the Algerian honey.

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