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Physicochemical Properties of Some Honeys Sold in Different Places in Dakar

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Abstract: Honey is characterized as a natural and raw foodstuff that can be consumed not only as a sweetener but also as medicine due to its therapeutic impact on human health. It is prone to adulterants caused by humans that manipulate the quality of honey. The aim of this work is to evaluate some physicochemical parameters that can be used to characterize the honeys from Dakar region in Senegal. Physicochemical characterisation was carried out on 08 honey samples collected from different places where honey is sold. Parameters such as the color, smell, flavor, density, pH, electrical conductivity, water content, viscosity, glucose and fructose were analyzed for each honey sample. Honey analyses were performed as described by the official methods. The mean results were: density (1.41), pH (4.24), electrical conductivity (0.24 mS/cm), refractive index (1.4862), viscosity (6.9720 mPa.s), optical activity (F/G > 1). The sensory and physicochemical values were in the range of approved limits for all honeys tested. The results showed that the use of sensory methods and physicochemical parameters can be a useful tool to characterize different types of honeys sold in Dakar and even in the country. This will only be feasible when enough data is available to establish upper and lower limits for the physicochemical parameters used for quality control.

Keywords: Dakar Honey, Sensory, Physicochemical Properties, Viscosity, Density

1. Introduction

Honey produced by the honey bees (Apis mellifera) from the nectar of blossoms or from secretions of living parts of plants is a viscous, high-nutrient food. Its most important contents are fructose and glucose (80% ± 2), water (16% ± 1), ash (0.2%), and amino acids (<0.1%), while enzymes, vitamins, phenolic compounds, and other substances are present in trace amounts [1-3].

The composition of honey depends on the plant species, the type of flowers visited by the honey bees, the environmental as well as the climatic conditions, the processing and storage conditions [4, 5].

Honey reflects the chemical constituents of the plants from which the bees collect their food, and the content of trace elements can indicate the botanical origin of a particular honey [6].

In Senegal, the number of hives per beekeeper varies according to climate. In the south, where the climate is favorable, a beekeeper has an average of 15 or more hives, which provide an average production of 20 kg of honey each

[7]. In 2015, the country's annual honey production barely exceeded 400 tons while the national demand is 1,000 tons [8].

Honey, traditionally, is used for its anti-aging properties, enhancing the immune system, killing bacteria, treatment of bronchial phlegm, and relieving a sore throat, cough, and cold [9]. Moreover, according to literature, honey represents various pharmacological properties such as anti-inflammatory, antioxidant, anti-cancer activities against breast and cervical cancer, prostate cancer, and osteosarcoma [10].

It is widely consumed in Senegal as a curative agent either alone or as a carrier for medicinal herbal mixtures and is used as the main constituent in several traditional foods throughout the country and there are not enough investigations regarding its quality and characterization.

According to Jaafar et al. [11], olive oil, milk, honey, saffron, orange juice, coffee, and apple juice are the seven most likely food ingredients to be targeted for economically-motivated adulteration of food (food fraud), as per their article published in the Journal of Food Science.

Considering the multiple uses of honey, it was necessary to make a control of the physicochemical and organoleptic characteristics of this last one with regard to the obsolescence of the means of production and the conditions of storage in the places of production and sale (popular markets).

2. Materials and Methods

2.1. Sample Collection

The total numbers of 8 honey samples were obtained from different markets of Dakar in Senegal during one month of the year (May 2022) (Table 1). All samples were collected directly from professional beekeepers and were transferred to the laboratory and kept at 10°C in dark condition until analysis.

Table 1. *Origin of the honey samples collected from different site.*

N° Samples	Markets	Type of distribution
E1	Super Diaba	Large scale market
E2	General Food Haddad	Large scale market
E3	Casino Sahm	Large scale market
E4	Les Cendres	Large scale market
E5	Port Dakar	Public market
E6	Grand Dakar	Public market
E7	Tilene	Public market
E8	Castor	Public market

2.2. Sensory Analysis

Sensory analysis includes color, smell, taste, and flavor assessment. All samples were sensory assessed by at least three members of the sensory group.

2.3. Physicochemical Analyses

Samples were analysed for pH, electrical conductivity, ash content, moisture content, viscosity, glucose according to the standardized methods proposed by the Harmonised Methods of the International Honey Commission [12]. Samples were analysed during the same time period to ensure uniform conditions and comparability. All physicochemical tests were performed in duplicate.

2.3.1. Density Determination

Density is the ratio between the weight of a volume of substance and the weight of an equal volume of water, or of the same volume of air for gases. Density has no unit.

The measurement is done with a pycnometer (type Herka intercolor). Results were calculated from the following equation:

$$dl = \frac{p_2 - p_o}{p_1 - p_o} \quad (1)$$

Where, P_0: the weight of the empty and dry pycnometer in g; P_1: the weight of the pycnometer filled with water in g; P_2: the weight of the pycnometer filled with honey in g.

2.3.2. pH and Electrical Conductivity

Honey pH and Electrical conductivity was measured at 20°C by conductimetric assay (Schott Geräte CG820 pH meter), from a solution containing 20 g of honey in 100 mL of distilled water and the results were expressed as mS/cm [12].

2.3.3. Determination of Refractive Index

Water content was determined by refractometry, measuring the refractive index (RI) according to Harmonised methods of the International Honey Commission Methods (2009), using a standard model Abbe type refractometer at 20°C. Water content (%) was then obtained from the Chataway table.

2.3.4. Honey Viscosity

The instrument used is a falling ball viscometer (KUGELFALL VISKOSIMETER, COLORA, A0163). The measuring system consists to feel the column with honey of density (ρ) in which a spherical ball of radius r, volume v and density (ρ_0) is dropped. Then, we measure the time (t) of fall of the ball between two points A and B 10 cm apart.

All the commercial honey samples were non-crystalline liquid honeys and any air bubbles which could interfere in the viscosity analysis were removed.

The dynamic viscosity η (Pa.s) results were calculated from the following equation:

$$\eta = k\left(\rho_0 - \rho\right)t \quad (2)$$

Where, k: calibration constant of the viscometer and η: dynamic viscosity.

2.3.5. Determination of Optical Activity

The rotatory power is the property that some media have to rotate the light vector of a light beam passing through them. Compounds inducing clockwise deviation characterizes dextrorotatory (sucrose) compounds while levorotatory compounds (-) lead to an opposite deviation (fructose). The measurement was carried out on solutions of honey diluted to

1/10 thanks to the polarimeter of Laurent equipped with a sodium lamp.

The diluted honey solution, introduced in a cell of 10 cm length (l), is crossed by a light beam polarized at the wavelength of the D line of sodium (589,3 nm). The formula used is then the following one:

$$\alpha_D = \frac{\alpha}{L\,C} \quad (3)$$

Where, α = angle of rotation in degrees read at temperature T; L= length in decimeters of the polarimetric cell; C= concentration of the substance in g/l.

3. Results

3.1. Sensory Analyzes

Honeys from large scale market (E1-E4) have a color ranging from yellow to brown with a weak odor and a strongly sweet taste. While, honeys from ordinary markets (E5-E8) have a brown color with a powerful odor and a slightly sweet, tangy taste without bitterness.

3.2. Physicochemical Analysis of Honey Samples

The detected physicochemical results for 8 honey samples are shown in Table 2.

Table 2. *Physicochemical analysis of honey samples.*

N° sample	Statistics	Density	pH	Electrical Conductivity (mS/cm)	Refractive index Water content	Viscosity (mPa.s)	Optical activity ($°.dm^{-1}.g^{-1}.ml$)
E1	Mean± SD Range	1.4147 ± 10^{-4}	4.71 ± 6.10^{-2}	0.34 ± 0,00	1.48767 ± 5.10^{-4}	9.2247 ± 5.10^{-5}	-10.903 ± 10^{-3}
E2	Mean± SD Range	1.3911 ± 10^{-4}	4.14 ± 4.10^{-2}	0.27 ± 0,01	1.48167 ± 5.10^{-4}	7.6697 ± 10^{-4}	-14.545 ± 10^{-3}
E3	Mean± SD Range	1.4401 ± 10^{-4}	4.81 ± 10^{-2}	0.15 ± 0,00	1.48967 ± 5.10^{-4}	8.2035 ± 10^{-4}	-6.275 ± 2.10^{-3}
E4	Mean± SD Range	1.4181 ± 10^{-4}	4.28 ± 3.10^{-2}	0.26 ± 0,00	1.48867 ± 5.10^{-4}	8.1803 ± 10^{-4}	-7.271 ± 10^{-3}
E5	Mean± SD Range	1.4008 ± 10^{-4}	4.11 ± 10^{-2}	0.23 ± 0,00	1.48567 ± 5.10^{-4}	6.5732 ± 10^{-4}	-10.006 ± 210^{-3}
E6	Mean± SD Range	1.4017 ± 10^{-4}	3.97 ± 10^{-2}	0.22 ± 0,00	1.48267 ± 5.10^{-4}	5.2910 ± 10^{-4}	-9.097 ± 2.10^{-3}
E7	Mean± SD Range	1.3975 ± 10^{-4}	4.04 ± 10^{-2}	0.22 ± 0,00	1.48633 ± 5.10^{-4}	6.3759 ± 10^{-4}	-10.006 ± 10^{-3}
E8	Mean± SD Range	1.4147 ± 10^{-4}	3.87 ± 2.10^{-2}	0.22 ± 0,00	1.48267 ± 5.10^{-4}	4.2583 ± 10^{-4}	-9.091 ± 10^{-3}
	overall average	1.4098	4.24	0.24	1.4862 (<20%)	6.9720	F/G >1

Note: F (Fructose), G (Glucose).

4. Discussion

Our work was limited to the control of the physicochemical and organoleptic parameters of the honey sold on the market of Dakar without any microbiological evaluation. Regarding the organoleptic characteristics, it can be seen that the samples from the supermarkets (E1 to E4) have a color, taste and a smell in accordance with the codex standards.

Honeys from the popular markets (E5 to E8) have a color and taste consistent with the codex standards, however their pungent odor is different from that indicated in the codex [13, 14].

This difference of smell between the honeys of the supermarkets and those of the popular markets can be due to the storage conditions. In fact, in supermarkets, honeys are kept in a thermostatic atmosphere (4-10°C), which guarantees a good storage without any risk of alteration of the organoleptic characteristics.

On the other hand, in the popular markets, the honeys are exposed to the ambient temperature which is much higher than that prevailing in the supermarkets, hence the change in smell observed in the honeys of the popular markets (E5 to E8). This difference can be also the fact of food adulteration. Honey adulteration is due to various reasons, such as adding sugars to enhance the taste based on the consumer's preference or gaining financial profits by mixing cheap and low-quality honey to the expensive honey to increase the yield.

Food adulteration is described as the act of intentionally decreasing the quality of food either by adding or swapping low-quality materials or eliminating various important integrant [15]. When the cheaper and low-grade elements are added to an original product threaten the consumer's health, it is considered and declared "adulterated." Honey, as one of the most common foods worldwide, also has been subjected to adulteration [16] and several actions have been taken to detect fraud and solve the problem, but there is no actual solution to control the production of adulterated honey [17].

The values for the density ranged from 1.3911 to 1.4401 which some agree with data reported in the literature (table 2). For example, the densities of samples E8 (1.3975) and E2 (1.3911) are lower than the reference value of 1.4. This variation in density may be due to poor storage conditions or an increase in temperature [18].

The pH of honey is affected by conditions during extraction and storage, which also affects texture, stability and endurance. The analyzed results for all honeys showed acidic character. Their pH values ranged from 3.3 to 4.71 (Table 2). The pH values of honeys were in accordance with AOAC (1990) and AOAC (2000) [19, 20]. In the present study, E1 honey had highest pH values (mean 4.71) than the other samples. In literature, the pH values of Portugal, Indian and Spanish honeys have been found to vary between 3.18 and 4.10, 3.7 and 4.3, 3.7 and 4.4 and 2.25 and 4.71 respectively [4, 21-23].

The natural acidity of honey can be increased by the

storage and ripening of honey, as well as during the fermentation of honey. Honey that is adulterated with sugar syrup has very low acidity (<1), while honey that is adulterated with invert sugar has a pronounced high acidity [24]. The acidity value related to the balance of organic acids naturally present in honey varies according to the floral source and the bee species [25].

According to the codex, theoretical pH values ranging from 3.3 to 4.6 indicate honey from nectar or a mixture (nectar/ honeydew) and pH values ranging from 4.2 to 5.5 indicate honey from honeydew or a mixture. Based on the codex data, it is safe to say that samples E2, E5, E6, E7 and E8 are of nectariferous origin while samples E1, E3 and E4 are from honeydew or a nectar/ honeydew mixture with a high proportion of nectar.

The electrical conductivity (EC) in honey samples varied in the range of 0.15-0.34 mS/cm (Table 2). The electrical conductivity results for samples honeys showed a large variation depending on the origin. The samples from the supermarkets (E1 to E4) had the highest values for electrical conductivity (mean 0.25 mS/cm) compared with Honeys from the popular markets (E5 to E8).

Generally, the levels of the range of electrical conductivity value found were in accordance with values reported in the literature [2-5].

The EC is very often used in routine honey quality control. This property of honey is considered very good criterion for assessment of botanical origin and purity of honey. Among other things, honey contains components such as organic acids and minerals, which in an aqueous solution have the ability to dissociate into the ions or to conduct an electric power. The bright color of honey usually points to a lower conductivity than dark color of honey [26].

Using regression analysis, Chua and al. found that the total element content of honey was strongly correlated with the EC, but only moderately correlated with the ash content and honey color [27].

None of the analyzed honey samples showed electrical conductivity values superior to 0.8 mS/cm (variation between 0.15 and 0.34 mS/cm), suggesting that all samples are from nectar honey, which is not corroborated by the content of theoretical pH values ranging for all honeys samples.

The measured refractive indices ranged from 1.48167-1.48967 (Table 2). None of the analyzed honey samples showed refractive indices values superior to 1.50129 (maximum value fixed by the codex). Thus, the water content values in all investigated honey samples were below 20%, which is the maximum permitted level set by local regulations for honeys. [28].

Honey adulteration has become a common problem due to the difficulties in distinguishing pure honey from adulterated honey. Foreign substances such as glucose syrup, corn syrup, sugar syrup and inverted syrup are used as adulterants and added directly to pure honey at certain ratios after production to increase the honey sweetness to recover more honey from the bee hives. Although these adulterants increase the quantity of honey, they decrease the nutritional properties, thus degrading the quality [29].

Dynamic viscosity is the internal friction of a liquid or its tendency to resist flow. Viscosity can be influenced by some factors such as water content and sugar content. In this study, the mean of viscosity was 6.972 mPa.s in all honey samples. The lowest mean value of the viscosity was 4.2583 mPa.s in the honeys from the popular markets while the highest mean value for the viscosity was 9.2247 mPa.s in the honeys from the super markets. The viscosities of all our samples are included in the Codex standards, therefore no major fraud like dilution or addition of sugar (glucose) [28].

The results of optical rotation values (Table 2) ranged from $-14.545°.dm^{-1}.g^{-1}.ml$ to $-6.27°.dm^{-1}.g^{-}1.ml$ indicating a Fructose/Glucose ratio > 1. Indeed, fructose and glucose being respectively levorotatory and dextrorotatory, the negative sign assigned to the rotatory powers of the different samples results from a predominance of fructose over glucose.

The monosaccharides glucose and fructose are the major constituents of honey. Fructose is always the most important sugar quantitatively followed by glucose. Fructose/glucose ratios greater than one observed in all our honey samples indicate that the honeys are produced by bees.

5. Conclusion

In this work, several sensory and physicochemical parameters have been determined in 8 honeys from different commercial places of Dakar, Senegal. The first systematic study of the physicochemical of Dakar honey was performed. The characterisation of eight honey types was carried out based on some common physicochemical parameters (density, pH, electrical conductivity, refractive index, viscosity, optical activity. The sensory and physicochemical values were in the range of approved limits (AOAC, 1990; AOAC International, 2000; International Honey Commission, 2009) for all parameters. Considerable differences were observed between the honey samples concerning the physicochemical parameters according to the places of sale. The results of our study could contribute to raising people's awareness of the importance of respecting storage conditions on the qualities of honey. Indeed, poor conservation alters the organoleptic and physicochemical characters of honey, which will inevitably affect its virtues. In view of the results obtained by sensory methods and physicochemical parameters can be a useful tool to characterize different types of honeys sold in our country.

These results suggest the application of multivariate analyzes on the different physicochemical parameters to characterize the different types of honey and the differentiation of botanical origins.

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