PHYSICAL AND CHEMICAL PROPERTIES OF SOME NIGERIAN HONEY COLLECTED IN KADUNA STATE

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Abstract

Some physical and chemical properties of twenty samples of honey collected from six locations in Kaduna State of Nigeria were analyzed for density, viscosity coefficient, electrical conductivity and opacity using standard methods while infrared spectrophotometer method was used to determine the functional groups present. The infrared spectrophotometer showed that the samples were a mixture of compounds including Carboxylic acids, Aldehydes, Alkynes, Alkenes, Nitrites, and Esters. The honey samples had physical and chemical properties comparable with honey obtained elsewhere in Nigeria and other parts of the world.

Introduction

The oldest sweet known to man, the only food that does not rot, the food with the highest number of medicinal qualities known to man, honey has been a part of the human diet from time immemorial. White and Doner (1980) described honey as nectar and saccharine exudation of plants, gathered, modified, and stored in the comb by honey bee (*Apis melliphera* and *A. dorsata*). Goswami (2008) found it "to be tasting perfect, even after thousands of years storage". Civilizations across the world have considered honey sacred and magical, largely because of its purity. It was made into an intoxicating drink called 'Meads', and offered to the groom; starting the tradition of 'honey moon' in ancient Babylon (Goswami, 2008).

White and Doner (1980) discussed the deterioration of honey quality, food value, granulation, ripened colours, flavor and aroma. They stated that honey contains the elements potassium, chlorine, sulfur, calcium, sodium, phosphorus, magnesium, silica, iron, manganese, copper, 24 types of carbohydrates and acids. Honey contains between 8 to 11 protein types, 21 free amino acids, and enzymes like invertase, diastste, glucose oxidase, catalase and an acid phosphotase. Krell (1996) described 21 food products in which honey form part of the recipes. Characterization of honey is been carried out in many part of the world. Faller and Faller (2000) studied physical characteristics and storage stability of a honey product.

Przybyowski and Wilczysky (2001) used atomic absorption spectrometer (AAS) and found that Pomeranian region honey samples contain Zn, Cd and Pb with mean value 7.76, 0.015 and 0.048 mg/kg respectively. They concluded that

Pomeranian honeys were of good quality, but they were not free of heavy metals and suggested that honey may be useful for assessing the presence of environmental contaminants.

Adebiyi, Akpan, Obiajunwa, and Olaniyi (2004) concluded that Nigerian honey contain twelve elements – K, Ca, Ti, Cr, Fe, Ni, Cu, Zn, Se, Br and Rb, while the infrared spectrometer revealed that the honey samples contain carboxylic acids, aldehydes, alkynes, nitrites, alkenes and ethers. For physical parameters, the mean ash content was 0.302%, moisture content was 30.955%, conductivity was 52.617µS/cm, refractive index was 1.481, P^H 4.75 and colour was 125.42pt.co.

Downey, Hussey, Kelly, Walshe, and Martin, (2005) concluded that there is consistency in the water content, p^H, electrical conductivity, ash content, free acidity, total acidity and mineral content of the artisanal honeys of island of Ireland. They used ash and acidity values for discriminating honeys of different floral origins, and concluded that p^H and electrical conductivity are most adequate parameter for discriminating honeys with changes of honey concentration.

Olaitan, Adeleke, and Ola, (2007) stated that "the production of honey as well as the storing process account for the presence of microorganisms". Most of these organisms are said to be in inactive forms as they can hardly survive in honey because of its several properties including hygroscopicity, hyperosmolarity, acidity, peroxide content, antibiotic activities and so on. However there is need for caution in the use of honey in wound management. Acquarone, Buera, and Elizalde, (2008) and Microsoft Encarta (2008) discussed the composition and method of processing honey for marketing. Composition of honey differs slightly from one geographical location to another, and investigation of its physical and chemical properties is a continuous process. This work investigates some physical and chemical parameters of 20 honey samples from six locations in Kaduna State of Northern Nigeria.

Materials and Method

The honey samples were collected from six locations – Kachia, Zonkwa, Anchau, Katari, Gidan waya and Maraban Jos in Kaduna State, Nigeria. The extracted honeys were purchased from market places of the towns and kept in sterile bottles prior to analysis.

Measurement of Physical Properties

Four physical parameters were measured (opacity, density, viscosity and electrical conductivity). Total ash content was calculated from the electrical conductivity.

Opacity: The transparency of honey was examined using a calibrated homemade opaque meter, which consists of white Light Emitting Diode (LED) and Light Dependent Resistor (LDR). Two perpendicular holes were drilled across each

other in a solid block of wood, such that a test tube of honey inserted in one of the holes intersects light ray in the other hole passing from the LED to LDR. The whole arrangement was enclosed in a lightproof box. Intensity of incidence and transmitted light through each honey sample was measured, and the percentage of light attenuated per unit length in the honey was calculated using the relation

$\frac{I_0 - I}{I_0 L} X\ 100$ (1)

Where I_0 is the intensity of light without honey, I is the intensity of light through honey and L is the diameter of the test-tube.

Density: A measuring cylinder and sensitive weighing balance was used to measure the volume (V) and mass (m) of honey samples. These were used to calculate the density (D) of each sample.

D = m/v (2)

Viscosity*:* Terminal-velocity method was employed for measurement of viscosity. The diameter (2r) of a metal ball was measured with micrometer screw gauge. The ball was allowed to fall freely, at constant terminal velocity through two marked points inside a tall glass jar filled with honey. The time of fall through the two marked points, and hence the terminal velocity was calculated as v. The density (mass/volume) of the ball and honey were also evaluated as ρ and σ respectively, while g is the acceleration due to gravity. Using the equation:

$\eta = \frac{2r^2 g(\rho - \sigma)}{9v}$ (3)

The coefficient of viscosity of each honey sample was obtained.

Electrical conductivity: A conductivity meter was set using two plates of copper fixed at 2cm apart and serving as input terminal of a circuit containing 9V battery and a micro-ammeter. When the terminals are dipped into honey sample, there was flow of some electric current whose magnitude is determined by the electrical resistance of column of honey between the terminal plates. The conductivity of a material is

(4)

Where d and A are distances apart and area of the copper plates respectively, and R is the resistance (voltage/current) of the column of honey between the plates. The conductivity, σ of each of the samples was calculated.

Total ash Content: Total ash content was calculated from electrical conductivity, using the following relation (Bogdanov , Lullmann, Martin, and Russmann, 2001);

C = 0.14 + 1.74A (5a)

Thus, $A = \frac{C - 0.14}{1.74}$ (5b)

where C is the electrical conductivity in milli Siemens cm^{-1} and A the total ash content g/100g.

Identification of Functional Groups*:* Scanning spectrophotometer, model IR 100, was calibrated using polystyrene. Each of the samples was subjected to scanning, and the resulting spectra were analyzed. The possible functional groups corresponding to each of the available wave numbers in the spectrum were assigned. t-test was used in Microsoft Office Excel 2007 for test of significance difference between the means of electrical conductivity and that of total ash content of these honey and those of Adebiyi, Akpan, Obiajunwa, and Olaniyi, (2004), while z-test was used to compare mean of opacity, electrical conductivity, and total ash content.

Results and Discussion

The result of the measured physical parameters; opacity, density, viscosity electrical conductivity and calculated total ash content respectively are presented in Table 1. Using the USDA colour standard p-fund scale, the opacity of the samples shows that the colour of the samples range from light amber to amber. The mean opacity was 83.731505 (range 49.1279 to 100.000), while the mean density of the honey samples was 1,387.65kg/m^3 (range 1,348 to 1425kg/m^3). The mean coefficient of viscosity was 3,403.321298 Nsm^{-2} (range 368.6416 to 5,626.21Nsm^{-2}). The mean electrical conductivity was 51.70522μscm^{-1} (range 6.6720 to 284.6720 μscm^{-1}) while the mean total ash content was 29.635g/100g (range 3.754 to 163.524g/100g).

Table 1: Physical Characterization of the 20 Honey Samples of Kaduna State

Honey sample	Opacity (%Attenuation)	Density (kgm^{-3})	Viscosity coefficient *10(Nsm^{-2})	Electrical conductivity (μScm^{-1})	Total ash content (g/100g)
Kachia					
Sample 1 Sample 2	90.5233	1,425	56.26214	22.7960	13.021
Sample 3 Sample 4	79.8240	1,400	41.17440	40.3656	23.118
Sample 5 Sample 6	82.9851	1,396	26.28674	50.5960	28.998
Zonkwa	82.2093	1,355	29.64565	51.7080	29.637
Sample 1 Sample 2	82.9815	1,366	23.67216	53.9320	30.915
Sample 3 Sample 4	81.6265	1,362	24.37093	54.6548	31.330
Sample 5					
Anchau	80.6567	1,369	37.88811	23.5188	13.436
Sample 1 Sample 2	96.1765	1,408	37.94398	29.4680	16.855
Kateri	82.6061	1,392	17.23254	30.9136	17.686
Sample 1 Sample 2	90.4069	1,390	30.25255	45.3696	25.994
Sample 3 Sample 4	72.3077	1,390	25.54543	54.6548	31.330
Gidan-waya					
Sample 1 Sample 2	81.3253	1,398	49.68882	22.7960	13.021
Maraban Jos	80.4217	1,402	27.36263	68.9440	29.543
Sample 1					
Mean	49.1269	1,390	37.94398	6.6720	3.754
Range	84.4767	1,414	31.68587	41.7000	23.885
	64.4578	1,390	14.24375	52.5976	30.148
	87.8006	1,390	29.06256	54.8216	31.426
	98.2353	1,378	18.59234	13.9000	7.908
	100.000	1,348	21.62900	284.6720	163.524
	96.4776	1,390	18.59234	30.0240	17.175
	83.731505	1,387.65	34.0321298	51.70522	29.635
	49.1279 to 100.00	1,348 to 1,425	3.686416 to 56.26214	6.672 to 284.672	3.754 to 163.524

T-test result showed that there was no significant difference ($P>0.05$) between the means of these results and those of Adebiyi, Akpan, Obiajunwa, and Olaniyi, (2004). In addition, z-test showed that some of the values of opacity, electrical conductivity, and total ash content are close to their means. Considering closeness of the values to the means value; Kachia sample 4 was more frequent appearing four times in the data, followed by Kateri sample 2. Kateri honey sample 1 and Gadan-waya sample 2 were always at opposite sides of the mean; i.e. if value of Kateri sample 1 of a parameter is less than the mean value, then Gidan-waya sample 2 value will be greater than the mean. z-test of opacity, electrical conductivity and total ash content (comparing their mean and these values) show that Kateri sample 1 value has no significant difference with their means but Gidan-waya sample 2 values has.

Data in table 2 shows the assignments of the possible functional groups for the honey samples based on spectrum obtained with infrared (IR) scanning spectrophotometer. The IR spectrum of all samples show similar peaks (i.e. OH carboxylic acids, COH (str) aldehydes, C≡C and C≡N (str) alkynes and nitriles, C=C (str) alkenes, C–C (bending) alkanes and C–O (str) ethers). Meanwhile, C–C of alkanes is not present in most samples. This include Kachia samples 1, 3, 4, 5 and 6, Zonkwa samples 1, 3 and 4, Anchau samples 1 and 2, Kateri samples 1, 3 and 4 Gidan-waya samples 1 and 2, and Maraban Jos sample 1. This result agrees with that of Adebiyi, Akpan, Obiajunwa, and Olaniyi (2004), except that C≡C and C≡N are the groups absent in some of their samples. The IR result show that the honey samples are mixture of many compounds including carboxylic acids, aldehydes, alkynes, alkenes, nitriles and ethers. This is in accordance with the result findings of other honey studies, that honey is a mixture of carbohydrates, acids, lipids, proteins, minerals, and vitamins (White and Doner, 1980; and Adebiyi, Akpan, Obiajunwa, and Olaniyi, 2004).

According to Bogdanov , Lullmann, Martin, and Russmann (2001), and Downey, Hussey, Kelly, Walshe, and Martin (2005), the CODEX and EU standard for honey is such that the total ash content is ≤ 0.6g/100g for general honey, and ≤ 1.2g/100g for honeydew, blossom honey or chestnut honey, and the electrical conductivity is $\leq 0.8\text{mScm}^{-1}$ for blossom honeys, or $\geq 0.8\text{mScm}^{-1}$ for honeydew and chestnut. These values are at variance with those obtained here. Considering absence of significant difference between values obtained in this work and that of Adebiyi, Akpan, Obiajunwa, and Olaniyi (2004), and both results are at variance with the standard set by CODEX and EU, there is the need to revisit the criteria for setting standard to accommodate the characteristics of Nigerian honeys.

Table 2: Result of IR Spectrophotometer Analysis of 20 Honey Samples of Kaduna State

Group of samples	Possible assignment on functional groups
Group a: Kachia sample 2, Zonkwa samples 2 and 5, Kateri sample 2 and Maraban Jos sample 1.	OH, Carboxylic acids, COH (str), Aldehydes, C≡C and C≡N (str), Alkynes and Nitriles C=C (str), Alkenes C–C (bending), C–O (str), Ethers.
Group b: Kachia samples 1, 3, 4, 5 and 6, Zonkwa samples 1, 3 and 4, Anchau samples 1 and 2, Kateri samples 1, 3, and 4 and Gadan waya sample 1 and 2.	OH, Carboxylic acids, COH (str), Aldehydes, C≡C and C≡N (str), Alkynes and Nitriles C=C (str), Alkenes C–O (str), Ethers.

Conclusion

The result of physical properties and the infrared spectrophotometer measurements of 20 honey samples showed that the samples are a mixture of many compounds including carboxylic acids, aldehydes, alkynes, alkenes, nitrites and ethers, and they have physical properties comparable with other honey sample in Nigeria. The honey samples contain carbohydrates, acids, lipids, proteins and vitamins. Most of the parameters here agree with those in similar previous work on honey samples in Nigerian, but are at variant with CODEX and EU standard. There is the need to revisit conditions for setting standards to accommodate characteristics of Nigerian honey.

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