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Quality Assessment of Honey Sourced from Natural and Artificial Apiaries in Ekiti State, Nigeria.

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ABSTRACT

Honey samples were obtained from wild and domesticated sources and analyzed for some physicochemical properties such as color, pH, moisture content, ash content, refractive index, specific gravity, total solid, viscosity, glucose and fructose content following Standard Association of Official Analytical Chemistry. The following range of values for pH (3.55-4.20), moisture content (18.50-25.60%), soluble solids (74.10-81.20%), ash content (0.08-0.14%), specific gravity (1.38-1.47), refractive index (81.3-83.4%), fructose content (40.5-63.04%) and glucose content (19.35-32.34%). The mineral composition analyzed revealed potassium to be the dominant mineral in the honey samples followed by Calcium. However, Cadmium and lead where not detected in the honey samples. The results indicated that parameters such as pH, moisture content, ash content, specific gravity, sugar (majorly fructose and glucose content), fructose/glucose ratio, glucose/water ratio conform within the limit of the international standard for honey. However, moisture contents of the wild honey samples (22.05% and 25.60%) were a little higher than the Codex Standards of ≤ 21%. In conclusion, the honey samples investigated have the needed quality criteria and are good for human consumption. The results also revealed excellent organoleptic acceptability of the honey samples, hence are suitable for human uses.

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Introduction

Honey is one of the most important processed foods that are rich in carbohydrate, amino acids, proline, essential minerals and vitamins provided by the nature to the human body. Honey is produced in Nigeria by honey bee species *Apis mellifera* and variety *adansonii.* Bees forage for different plant species both nectariferous and non necteriferous to produce different honey that varies in quantity, quality, color and flavor. Honey is considered as a very complex food product with an unusual composition. Its composition and characteristics are due to its geographical origin and different plant species that bees visit during honey production (Joseph et al., 2007). Despite the geographical differences, the main constituents of honey will remain the same (Terrab et al., 2003). Honey composition and quality also depend on several other factors such as humidity inside the hive, nectar sources, methods employed during honey extraction and storage. The beneficial and medicinal properties of honey have been appreciated all over the world for several thousand of years. Honey has not only been used as a sweetener in food, but also for therapeutic and religion purposes since millennia (National Honey Board, 2002). Traditionally, honey has been reported as a plant product with good medicinal remedy for the treatment of wounds and various ailments such as cough, (Abell et al., 1996), constipation, diabetes, sore, arthritis (Famuyide et al., 2014) as well as skin diseases. Many researchers such as Adenekan et al. (2012) and Nnwanko et al. (2014) reported that the healing capacity of honey is strongly influenced by its physical and chemical properties. The belief that honey is a food, drug and an ointment has been carried into our days. Several workers reported that honey serves as part of raw materials for food, pharmaceutical, cosmetic and beverages industries (Ojeleye, 1999). Honey has both social and economic benefits. It has received much attention particularly at the commercial level in Nigeria. Honey consumers are particularly interested in the quality and source of the honey they buy. They rely on the physical characteristics such as color, aroma, and conventional methods in discerning good quality honey. Neither the taste, visual, or physical aspect of honey are enough to discern which region the honey is produced. Physicochemical properties such as ash content, pH, moisture content, total solid,

proline content, viscosity, refractive index and total sugar are important criteria for the determination of good quality honey.

Interestingly, Ekiti State which falls in the rainforest ecological zone of Nigeria has great potential for beekeeping (Kayode and Oyeyemi, 2014). In recent time, there has been an increase in production and demand for honey in the state. The demand for honey is increasing everyday due to its nutritive and medicinal value. The major limiting factor to the acceptability of honey from this area is the fear of adulteration which led to lack of confidence in the product. Pure honey is scarce and most of what is sold locally in Nigeria is caramelized sucrose (Omode and Ademukola, 2008). There is a need to verify the source of the product. This will help to reveal the possible presence of adulterants (sugar or caramel) during honey processing. Assessing honey for quality control purposes requires determination of its pH, moisture, ash, total solids, sugar content (sucrose, glucose and fructose), viscosity, refractive index and specific gravity.

Several researchers have worked on the quality assessment of honey from various geographical locations in Nigeria. The physical characteristics of four honey samples from North-Central Nigeria have been reported by James et al. (2009). Quality assessment of natural honey from Adamawa State, North Easter Nigeria was documented by Igwe et al. (2012). The study of the physicochemical analysis of honey produced from Hawan Kibo hills in the Plateau State of Nigeria was reported by Anhwange et al. (2015). The physicochemical assessment of commercial honey from Edo State, Nigeria was carried out by Oshomah and Agbaji (2015). There is inadequate information on the physical and chemical properties of honey from Ekiti State, Nigeria. This study was conducted with aim of determine the physicochemical properties of honey from different sources (artificial hives and natural hives) in order to authenticate their quality.

Materials and Methods

Four honey samples were procured from local honey producers in Ado Ekiti, Ekiti State, Nigeria. Two honey samples were obtained from Ilawe road (samples A and B) and two samples (samples C and D) were obtained from Ago Aduloju, Ado Ekiti. The collected honey samples were stored in airtight plastic containers and later taken to Jagee Nig. Ltd. Ibadan, Oyo State, Nigeria for physicochemical analysis.

Physicochemical parameters such as pH, moisture content, ash content, total solid, viscosity, Refractive index, specific gravity, glucose and fructose were determined.

Determination of Color

The color of the samples was determined by using the P-fund scale (mm). In order to analyze, 2ml of the honey sample was taken in a beaker, the instrument was calibrated and dipped into the sample while the readings were taken from the meter and compared (Terreb et al., 2004).

Determination of Moisture Content

Two grams each of the honey samples was weighed and transferred into a pre-weighed crucible. The crucible was kept in an oven at 100 – 105°C over night. After this, they were removed and cooled in a desiccator and re-weighed. The loss in weight was then calculated as the percentage moisture content (AOAC, 1990) using the following formula:

$$M = \frac{WFH\text{-}WDH}{WFH}$$

Where;
M :Moisture (%),
WFH :Weight of fresh honey sample,
WDH :Weight of dry honey sample,

Determination of pH

The pH was determined using pH meter Model 610 by direct insertion into the honey samples.

Determination of Ash Content

For each test, 10g of each sample was separately weighed in a crucible. The crucible was heated in a muffle furnace for about 3hrs at 500^0C. It was then cooled in a desiccator and weighed. To ensure that the ashing was completed, it was reheated again in the furnace for 30 minutes more cooled, weighed and repeated until the weight became constant (AOAC, 2000). The percentage ash content was calculated by the following formula:

$$A = \frac{WAA}{WBA} \times 100$$

Where;
M : Ash (%),
WAA : Weight of sample after ashing,
WBA : Weight of sample before ashing,

Determination of the Total Solid

The percentage total solid of each honey sample was determined using the following formula:

Total solid (%) = 100 - Moisture content

Determination of Viscosity

Viscosity was determined using Brookefield Viscosity VHA 605-0109, USA with a spindle 62 at 20rpm. Results were obtained directly in units of Millipascal.

Determination of Specific Gravity

The specific gravity (SG) of the honey samples was obtained as the ratio of the weight of sample to that of an equal volume of water.

$$\text{Specific gravity} = \frac{Wsp\text{-}Wp}{Wwp\text{-}Wp}$$

Where;
Wp :Weight of the pycnometer
Wsp :Weight of sample + pycnometer
Wwp :Weight of water + pycnometer

Determination of the Refractive Index

The refractive indices of the honey samples were measured at a room temperature of 20°C using an Abbe Refractometer (AOAC, 1990).

Determination of the Total Titrable Acidity

Twenty five milliliters of each sample (diluted) was titrated against 0.1N NaOH using phenolphthalein as an indicator, up to pH 8.3 (Jacobs, 1999). The results were expressed in milliqualent of acid at 1 kg of honey.

Glucose and Fructose Determination

Glucose and Fructose content were evaluated following the method of Association of Analytical Chemist (AOAC, 2002).

Determination of the Mineral Composition

The mineral composition of the honey samples including K, Na, P and Zn were quantitatively determined using an atomic absorption spectrophotometer, after digestion by the wet ashing method (Escuredo et al., 2011).

Results and Discussion

The first physical observation of honey that is usually encountered by the consumers is its color (Bogdanov et al., 2004). The color of the honey varied from amber to light yellow to golden yellow to dark. Eleazu et al. (2013) reported that honey comes in different shades of color such as white, amber, red, brown and almost black. Our observations agree with the previous works of Archling (2007) and Kayode and Oyeyemi (2014). Colors of honey are influenced by several factors such as the nectar source, plant species, processing and packaging techniques. Dark honey has been reported to contain more minerals than light honey (White, 1975) as well as more phenolic acid derivatives but less flavonoid (Amiot et al., 1989).

The pH value of honey samples analyzed ranged from 3.55 - 4.40 with mean value of 4.02. This implies that all the honey samples were acidic. Published reports showed that the pH of honey should be between the range of 3.2-4.5 (Bogdanov, 1995). The results of our finding conformed to the acceptable range specified by Codex Alimentarium (2001). The pH values obtained in this study are low enough to prevent microbial growth especially in wound treatment.

The differences in the acid and minerals composition as well as floral variation may leads to differences in the pH values.

The moisture content of the honey samples A and B fall below the maximum value of 21% moisture content as prescribed by Codex Alimentarium (2001) and EU Commission (2002). Honey sample C and D (wild honey) have values 22.05% and 25.60% respectively which are higher than the 21% maximum value. This may be attributed to the high relative humidity of the area where the honey was obtained as well as processing and storage defects. Moisture content plays an important role in honey viscosity, taste and shelf life (Kayode and Oyeyemi, 2014).

The values reported for ash content for the four honey samples examined varied from 0.08±0.01% to 0.12± 0.02%. The results obtained in this study fall within the permissive range. The results obtained corroborate with the reports of Kayode and Oyeyemi, (2014) with range between 0.004% and 0.44% for honey samples from different locations in Ekiti State. Olugbemi et al. (2013) reported a range of 0.33% to 0.63%.

Codex Alimentarium Commission (2014) proposed ≤ 0.6% ash content for normal honey. Viscosity values were found to be between 680.25%- 781.40%. Viscosity is one of the physicochemical parameter used to measure the quality of the honey sample. Pure honey has a high viscosity (Lawal et al., 2009). The high viscosity values obtained in this work is an indication that the honey had not been diluted with other products. Honey consists of sugars mostly glucose and fructose.

Table 1 Physicochemical compositions of honey from natural and artificial hives in Ekiti State, Nigeria

Physichochemical parameter/Honey samples	Artificial Hives		Natural Hives	
	(A)	(B)	(C)	(D)
Color	Golden yellow	Light yellow	Amber	Golden dark
pH	4.2± 0.0	3.55±0.07	4.40±0.14	3.90±0.00
Moisture content (%)	18.50±0.0	21.80±0.28	22.08±0.07	25.60±0.28
Ash content (%)	0.12±0.02	0.10±0.01	0.08±0.01	0.14±0.00
Total soluble solid (%)	81.20±0.42	78.60±0.21	78.00±0.14	74.14±0.14
Total Titratable Acidity (meq/kg)	47.40±0.05	20.40±0.26	28.40±0.14	16.90±0.14
Specific gravity	1.38±0.02	1.45±0.01	1.47±0.04	1.42±0.01
Refractive index (Brix %)	83.20±0.01	82.60±0.28	81.30±0.14	82.50±0.0
Viscosity (mpas.)	722.00±1.56	635.00±7.07	781.40±0.85	704.66±13.19
Glucose (%)	19.35±0.50	32.34±0.17	34.86±0.20	28.62±0.53
Fructose (%)	40.50±0.01	41.71±0.85	63.04±0.05	50.90±0.03
Glucose +Fructose (%)	59.86±0.50	74.05±0.26	86.27±0.24	82.02±0.23
Glucose/Fructose ratio	2.1	1.3	1.9	2.0
Glucose/Water ratio	1.05	1.59	1.23	1.65

Table 2 Mineral composition of honey from natural and artificial hives in Ekiti State, Nigeria

Honey samples/ Mineral elements (mg/kg)	Artificial Hives		Natural Hives	
	(A)	(B)	(C)	(D)
Calcium	23.10±1.29	20.36±0.17	37.76±0.66	40.90±0.14
Potassium	1609±13.61	1540.66±29.08	1627.11±17.79	1887.28±4.92
Phosphorus	379.19±4.34	418.90±3.28	382.32±6.46	300.76±0.74
Zinc	7.47±0.35	5.32±0.07	3.34±0.10	7.96±0.09
Cadmiun	0.00±0	0.00±0	0.00±0	0.00±0
Lead	0.00±0	0.00±0	0.00±0	0.00±0

All the honey samples analyzed contained more fructose than glucose which is an indication that the honey would be less prone to crystallization. Honey with high fructose to glucose ratio would remain liquid for a longer period. It is also a parameter that can be used to differentiate pure honey from commercial inverted sugar (White and Donner, 1980).

The sum of fructose and glucose for our investigated honey samples are within the proposed limit by the international norms ≥ 60g/100g. Beside the sum of fructose and glucose, another important factor in honey quality is the fructose/glucose ratio. Honey remains liquid at high fructose/glucose ratio. Honey crystallization is slow at ratio more than 1.3 (Amir et al., 2010). The result of fructose/glucose ratio falls in the range of 1.3 to 2.1 with mean value of 1.75 while the glucose/water ratio is within the range of 1.05 and 1.65 with average value of 1.39.

The glucose/water ratio is considered more appropriate than the fructose/glucose ratio when considering honey crystallization. Amir et al. (2010) stated that there is no or little crystallization when G/W ratio is less than 1.3 and fast or almost complete at ratio greater than 2.0. The results of the specific gravity of the honey samples were higher (1.38-1.50) compared to other reports from other locations (Olugbemi et al., 2013) but compared favourably with a range of 1.42 to 1.44 (Ndife et al., 2014) as well as 1.299 to 1.315 (Igwe et al., 2012). Determination of honey specific gravity is an important parameter for its quality assessment. Total solid is a measure of dissolved solid in the honey samples. A reduction in the total solid of honey showed that the honey has been diluted. The results of this study with a range of 74.1% - 83.75% and with mean value of 77.96% conformed to the total solid range of 58.4 to 80.0% as reported by Igwe et al. (2012) for Nigerian honey. The result obtained in this investigation is higher than the range of 11.33 to 21.30% reported for five honey samples from Umuachia, Nigeria (Olugbemi et al., 2013).

The mineral content of the honey samples showed that the highest mineral element was recorded for Potassium. Others were in order of Phoshorus > Calcium > Zinc. Several researchers had reported the dominant metals such as Potassium, Phosphorus, Calcium and Zinc in their previous studies (Agbagwa et al. (2011); Oyeyemi et al. (2015). The abundance of Potassium in all the honey samples analyzed is in agreement with the submission of Adebiyi et al. (2004); Agbagwa et al. (2011) and Ndife et al. (2014). They reported the dominance of Potassium in their previous studies on honey from different locations in Nigeria.

Conclusion

The result of our findings has shown that honey from artificial and natural apiaries are of good quality in respect to some important physicochemical parameters. The values of pH, ash, glucose, fructose contents as well as glucose/fructose ratio fall within the prescribed international standard limit. Honey samples produce from this state are of good quality and can be exported if properly packed. In addition, there is a need for further physical/chemical investigation on more honey samples from this region to assess their quality and exportability.

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