

Measurement and Analysis of Physicochemical Properties of Honey Obtained from Birnin-Kebbi Market

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Abstract—Food quality assurance is becoming increasingly important in food processing industries as expectations from the consumers and competitions among food manufacturers continue to grow. Thus there is an increasing research interest in the area with a view to ensure safety products of foods. Honey, a natural viscous food which is well known for its high nutritional and medicinal values remains an important food every society demands. This research work aimed at studying the specific gravity, electrical conductivity and pH value of different samples of honey available in Birnin Kebbi (12.4318⁰N, 4.1956⁰E) market with a view to determine its quality and safety for consumption. Ten (10) samples were randomly selected from the market and the said parameters were determined. From the results sample KB₁₀ has the highest specific gravity with a value of 1.44 while sample KB₁ has the lowest specific gravity with a value of 1.31. This gives the range of the values as 1.31 – 1.44. The electrical conductivity values of the studied honey samples varied from 2.68 - 19.80 μ S/cm with sample KB₇ having the lowest value (2.68 μ S/cm) and KB₅ having the highest value (19.80 μ S/cm). Likewise the pH values ranges between 4.30 – 4.98 with an average of 4.59 with sample KB₈ as the lowest while KB₂ as the highest. The values of all the parameters obtained are within the safety limit as reported by NAFDAC and other reviewed literatures. Further researches on other physicochemical properties are recommended.

Keywords—Electrical conductivity; pH value; Specific gravity; Honey; Birnin Kebbi

1.0 Introduction

Honey is a natural and unpasteurised sweetener collected by bees from the flower's nectar or honeydew droplets. It is a "non – sucrose carbohydrate" as most of the sucrose is converted into monosaccharides such as glucose (25-37%) and fructose (25-45%) by the invertase enzyme. Generally, it contains 12-20% moisture content and 60.7-77% sugars which are responsible for its natural and distinct sweetness (Moreira *et al.*, 2010). Other constituents include proteins, enzymes, lipids, polyols, vitamins, phenolic acids, flavonoids, carotenoids etc. making it a complex biological product. Various types of ionisable organic acids and mineral salts are also found in honey which are responsible for its various physiochemical properties such as electrical conductivity, pH, acidity, and hydro-methyl furfural and diastase activities (Afonso *et al.*, 2018). Potassium, chlorine, sulphur, sodium, calcium, magnesium, iron, zinc, phosphorus, and manganese are some of the principal elements found in honey giving rise to its value for human consumption. Potassium is quantitatively the most relevant element found in honey (mean = 643 ppm), accounting for 79% of the total mineral content (ash) whereas calcium, sodium and magnesium account for 14%, 3% and 3% of the total mineral content respectively, while other minerals (Cu, Mn, Fe) are presented in very lesser amounts (Conti *et al.*, 2007). Honey is a sweet fluid produced by honey bees (*Apis Mellifera*) from the nectar of flowers (White, 1992). It is composed of mainly carbohydrates such as monosaccharides (glucose and fructose) and oligosaccharides like sucrose, maltose, melezitose, raffinose to mention a few. Pure honey also contains proteins, fats, water, vitamins and minerals. It is reputed to have a diverse set of nutritional and medicinal benefits. This and honey's pleasant taste of universal appeal ensure a sustained high demand for the product. The supply of honey is, however, quite constrained and hardly ever matches the demand (Ahmed *et al.*, 2007). A honey is a viscous, sweet fluid from plant nectar by bees which is often used as sweeteners in tea and other foods. Honey is a characteristic sweetener that is generally accessible over the world. It is a natural viscous food well known for its high nutritional and medicinal values (Manisha & Shyamapada, 2011). Honey is the oldest and only available unique natural sweetener to mankind and is the last of naturally, unprocessed food to be consumed (Ribeiro *et al.*, 2014). Honey is the natural sweet substance produced by honey bees 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 the honey comb to ripen and mature (Singh *et al.*, 1997). Even though there are diverse varieties of honey bees in the world, the major variety found in Nigeria is the *Apis mellifera* (Godwin *et al.*, 2017).

Generally, honey is a sweet and flavorful natural product, which is consumed for its high nutritive value and for its effects on human health, with antioxidant, bacteriostatic, anti-inflammatory and antimicrobial properties, as well as wound and sunburn healing effects [6]. Honey is a characteristic sweetener that is generally accessible over the world. It is a natural viscous food well known for its high nutritional and medicinal values (Guler *et al.*, 2007).

Honey is produced by bees from plant nectars, plant secretions and excretions of plant-sucking insects. Concerning its nutrient profile, it represents an interesting source of natural macro- and micro-nutrients, consisting of a saturated solution of sugars, of which fructose and glucose are the main contributors, but also of a wide range of minor constituents, especially phenolic compounds. The composition of honey is rather variable and depends primarily on its floral source; seasonal and environmental factors can also influence its composition and its biological effects. Several studies have shown that the antioxidant potential of honey is strongly correlated not only with the concentration of total phenolics present, but also with the color, with dark colored honeys being reported to have higher total phenolic contents and, consequently, higher antioxidant capacities (Manisha & Shyamapada, 2011).

According to its origin, honey can be classified into different categories as blossom honey, obtained predominantly from the nectar of flowers, honeydew honey, produced by bees after they collect "honeydew" (secretions of insects belonging to the genus,

Rhynchota), which pierce plant cells, ingest plant sap and then secrete it again (Agbajor *et al.*, 2017). Monofloral honey, in which the bees forage predominantly on one type of plant and which is named according to the plant and multifloral honey (also known as polyfloral) that has several botanical sources, none of which is predominant, e.g., meadow blossom honey and forest honey. It has been suggested that many of the medicinal properties of plants can be transmitted through honey, so that honey could be used as a vehicle for transporting plant medicinal properties (Godwin *et al.*, 2017). The electrical conductivity of honey samples 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 (Agbajor *et al.*, 2017). Various physical properties of honey such as phase transition, viscosity, electrical and optical properties, thermal characteristics and flavour content, vary, depending on temperature due to certain electrolytic properties in the form of acids and minerals, as such, exhibiting varying degree of electrical conductivity. Hence measurement of the electrical conductivity at different temperature is used to determine the quality of honey. This parameter is a good criterion related to the botanical origin of the honey samples and it is very often used in routine honey quality check (Afonso *et al.*, 2018). Due to the high nutritional and medicinal values of honey, even though it is highly priced worldwide, informative data on some of the physico-chemical characteristics of this natural product are limited in Nigeria (Godwin *et al.*, 2017).

Honey is one of humankind's oldest food products. It contains a number of nutritionally important substances that support good health and recovery. It is a characteristic sugary foodstuff; according to current regulations, apart from other forms of honey no other substances or additives can be added to it. The composition and properties of honey vary with the floral and honeydew sources utilized by honeybees, as well as regional and climatic conditions (Lazaridou *et al.*, 2004). Honey syrup preserves human health and shields them from various diseases. It is defined as a pure and natural product that does not include any other substances.

Adulteration of the honey take place results reduction in nutrition and medicinal value. 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 adulteration as well as to address processing and market's needs (Adenekan *et al.*, 2010). A properties of honeys have been helpful for comparison of natural honey samples from different locations and also serves as important indicators that can help to distinguish natural honey from artificial honey as adulteration alter quality characteristics of honey. Honey adulterated by sugar addition can present, in fact, changes in some chemical and/or biochemical parameters, such as enzymatic activity, electrical conductivity, and contents of specific compounds (HMF, glucose, fructose, sucrose, maltose, is maltose, proline, ash) when compared to a control. Moreover, some chemical parameters, such as HMF content, formerly suggested as a test to detect the addition of invert syrups, may be ambiguous because HMF and enzymatic activity vary in different honeys and can spontaneously change in honeys when subjected to heat or abusive storage in warm environments ((James *et al.*, 2009).

Going by all the literatures reviewed, none has conducted research to determine the physicochemical properties of honey available in Birnin Market.

1.1. Study Area

The urban centre of Birnin Kebbi is the state capital of Kebbi State and also the administrative headquarter of Gwandu Emirate and Birnin Kebbi Local Government Area. As shown in figure: 1a and figure: 1b, the city is located in the North-Western part of Nigeria at approximately latitude 12025'0"N and longitude 4020'0"E and it has a land area of about 1385.033 klm² with a population of 268,620 according to 2006 population census (NPC 2010; Ismail *et al.*, 2016).

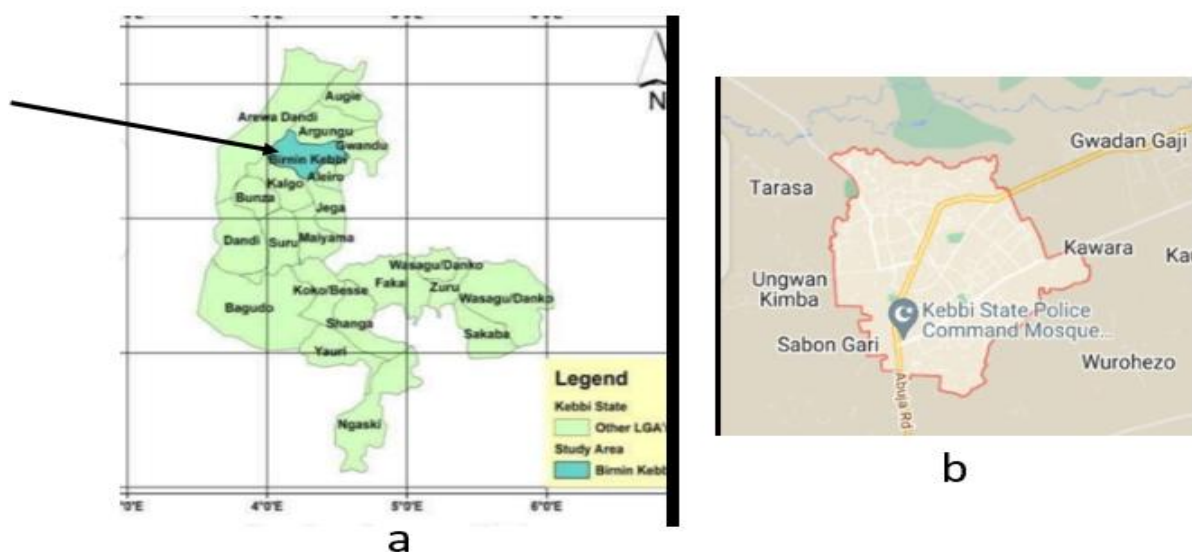


Figure 1.1: Map of the study area

2.0 Materials and Methods

The sample for this research is honey obtained from Birnin Kebbi. This honey was randomly purchased from ten (10) marketers in the market and outside the market but within the Birnin Kebbi metropolis. The samples are shown in figure 2.1. Density and

Gravity, Electrical conductivity and Temperature and pH values of the samples are all measured accordingly using standard procedures. The procedures are reported as shown below.



Figure 2.1: Honey samples: (A) Direct purchase from market, (B) Packed in sample containers.

2.1 Density and Specific Gravity Measurement

The density and specific gravity of the samples were determined using mass and volume weighing system and the results presented below.

Table 2.1: Equipment/Apparatus for Density and Specific Gravity Measurement

S/N	Equipment/Apparatus	Model/Specification	Manufacturer
1	Weighing balance	Digital type	Techmel USA
2	Measuring cylinder	Glass type	Germany Made
3	Sample containers	Plastic type	-



Figure 2.2: Mass Measurement

Procedure: The sample containers are washed, dried and labelled. Mass of the sample container is measured and 50 cm³ of the sample is measured and put into the sample container. The mass of the sample container with the sample is measured. The mass of the sample is obtained by subtracting the mass of the container from the total mass (container + sample). The density and specific gravity of the samples are obtained using the formulas:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} \quad (1)$$

$$\text{Specific gravity} = \frac{\text{Density of the sample}}{\text{Density of water}} \quad (2)$$

2.2: Electrical Conductivity and Temperature Measurement

The electrical conductivity and temperature measurement was carried out using digital conductivity meter

Table 2.2: Equipment/Apparatus for Electrical Conductivity and Temperature Measurement

S/N	Equipment/Apparatus	Model/Specification	Manufacturer
1	Conductivity meter	Digital type	Oakton, US

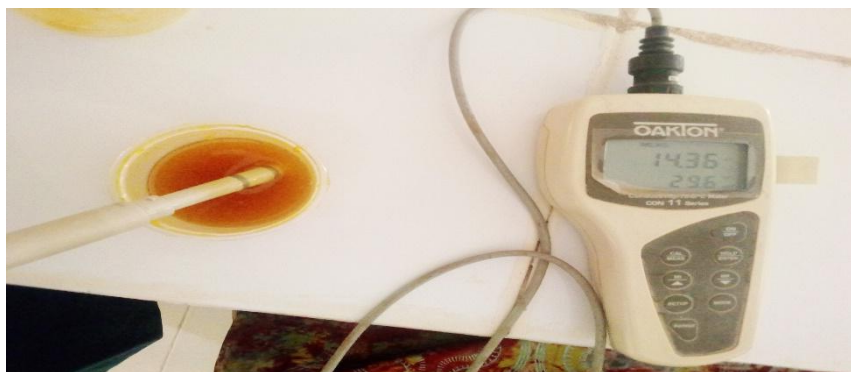


Figure 2.3: Electrical conductivity measurement

Procedure: The conductivity meter is powered ON and the probe of the meter is inserted directly in to sample. The values of the electrical conductivity and temperature are recorded simultaneously after some seconds.

2.3: pH Value Measurement

The pH value measurement was conducted using digital pH meter.

S/N	Equipment/Apparatus	Model/Specification	Manufacturer
1	pH meter	Digital type	827 pH Lab metrohm

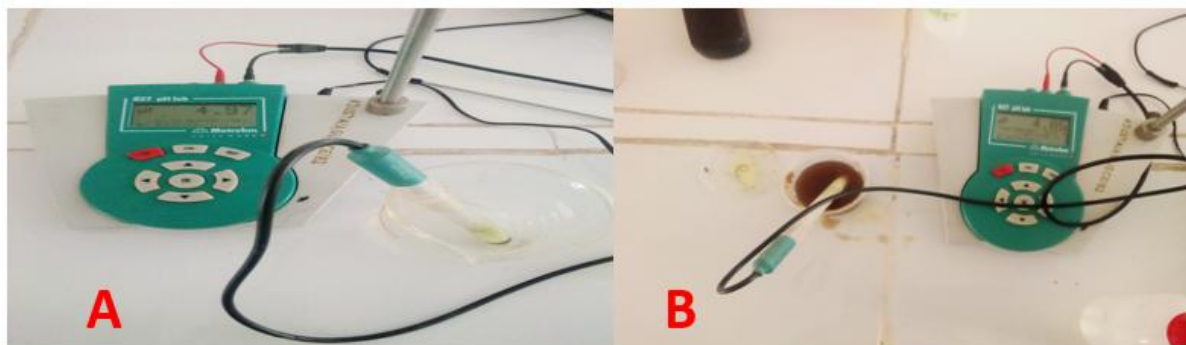


Figure 2.4: pH value measurement: (A) Calibration (B) Measurement

Procedure: The pH meter was first calibrated using buffer solution before inserting the probe into the sample for pH value measurement. **pH meter calibration** is the process of adjusting the pH meter by measuring the solutions of known pH value. The probe is inserted into the sample and the pH value of the sample is recorded after some seconds.

3.0 Results Analysis and Discussion

3.1 Density and Specific Gravity

The density and specific gravity of the samples were determined using mass and volume weighing system and the results presented below.

Table 3.1 Density and Specific Gravity

S/N	Sample Code	Volume (cm ³)	Mass (g)	Density (g/cm ³)	Specific Gravity
1	KB ₁	50	65.55	1.31	1.31
2	KB ₂	50	66.99	1.34	1.34
3	KB ₃	50	69.54	1.39	1.39
4	KB ₄	50	66.32	1.33	1.33
5	KB ₅	50	69.48	1.39	1.39
6	KB ₆	50	70.32	1.41	1.41
7	KB ₇	50	67.59	1.35	1.35
8	KB ₈	50	70.57	1.41	1.41
9	KB ₉	50	71.37	1.43	1.43
10	KB ₁₀	50	72.10	1.44	1.44
			68.98±2.24	1.38±0.04	1.38±0.04

Table 3.1 shows the density and specific gravity of the samples. The specific gravity is the ratio between the density of an object and a reference material. It tells us based on its value if the material under research can float or sink in the reference material. Sample KB₁₀ has the highest specific gravity with a value of 1.44 while sample KB₁ has the lowest specific gravity with a value of 1.31. This gives the range of the values as 1.31 – 1.44. The entire result has the average value of 1.38±0.04. These values are closer to the values reported by www.homework.study.com/honey-density and www.sydneypwater.com.education/practical-investigation-density who reported 1.36 and 1.40 as specific gravities of honey respectively. Similarly, Jasleen (2019) reported 1.392 as the specific gravity of honey and this seems to be closer to the values obtained in table 3.1. Furthermore, Gairola *et al.*,

(2013) reported the specific gravity of honey with a range between 1.3648 - 1.4101. Aida *et al.*, (2021) reported as the range of the specific gravity for his result on honey 1.420-1.44.8. The results of all the researchers agree with our own study here proving to some extent the quality of the honey under research.

Anoushka *et al.*, (2019) noted out that the density values of natural honey depend on water content. Natural honey has a higher density compared with the other adulterated samples. Adulterating pure honey with different concentration of starch, molasses and distilled water causes density decreases. They also emphasized that increasing concentration of starch to honey, same trend will be observed for adulterated honey where glucose and distilled water were used as adulterants but density values increases with increasing concentration of molasses to honey. Hence the specific gravity of any substance depends on its density and therefore water content. Pure honey (natural honey) has a higher density compared with the other adulterated samples except that of molasses as reported by Anoushka *et al.*, (2019).

In the other hand, Abdulwahid *et al.*, (2012) pointed out that the high concentration of heavy metals in honey can be another source of illness to human beings and these heavy metals are chemical elements with a specific gravity that is at least five times the specific gravity of water. The implication of this statement is that, heavy metals increases the specific gravity of natural honey. In this research, natural honey was used without adulterants and the results obtained when compared with the literatures reviewed shows that the quality of the honey is acceptable for consumption.

3.2: Electrical Conductivity and Temperature

The Electrical Conductivity and Temperature values were measured using digital conductivity meter and the results were presented as shown below.

Table 3.2: Electrical Conductivity and Temperature

S/N	Sample Code	Conductivity ($\mu\text{S}/\text{cm}$)	Temperature ($^{\circ}\text{C}$)
1	KB ₁	17.06	28.4
2	KB ₂	19.69	29.5
3	KB ₃	11.64	28.6
4	KB ₄	17.67	29.0
5	KB ₅	19.80	29.1
6	KB ₆	7.93	27.7
7	KB ₇	2.68	27.5
8	KB ₈	2.73	27.7
9	KB ₉	2.69	27.2
10	KB ₁₀	2.72	27.4
		10.46 \pm 7.57	

The measured electrical conductivity values of the ten honey samples are shown in Table 3.2. The electrical conductivity values of the studied honey samples varied from 2.68 - 19.80 $\mu\text{S}/\text{cm}$. The lowest value (2.68 $\mu\text{S}/\text{cm}$) is sample KB₇ followed by Sample KB₉ (2.69 $\mu\text{S}/\text{cm}$) and this was significantly different from the highest value (19.80 $\mu\text{S}/\text{cm}$) of electrical conductivity from KB₅ followed by sample KB₂ (19.69 $\mu\text{S}/\text{cm}$) as shown in Table 3.2. All the samples presented electrical conductivity values characteristic of nectar honey ($\leq 0.8 \text{ mS}/\text{cm}$) (NAFDAC, 2019; Bogdanov *et al.*, 1999). This result is similar to some values and also very lower to some values reported by Godwin *et al.*, (2017) who conducted a research on electrical conductivity of honey from six geopolitical regions of Nigeria and reported a range of 9.7 - 111.62 $\mu\text{S}/\text{cm}$. Even though his result was temperature dependence while this research used normal room temperature. From his result at the temperature of 30 $^{\circ}\text{C}$ which is close to the temperature recorded in this research, his values are higher than the ones reported here except for his sample 4 with a value of 8 $\mu\text{S}/\text{cm}$.

Jasleen (2019) in the other hand reported 144.90 and 412.55 μScm^{-1} as the electrical conductivities of some honey. These values are far above our values, probably due to difference in geographical and climatic diversity. Meseret *et al.*, (2020) conducted a research determine the effect of adulteration on the electrical conductivity of honey and obtained 0.69 \pm 0.02 mScm^{-1} as the electrical conductivity of pure honey. Their values are also higher than the values reported here which can also be attributed to environmental difference. Milica *et al.*, (2018) obtained the values of electrical conductivity of some honey samples in the range between 0.08 and 1.99 mS/cm . These values are also higher than our reported values here. Aida *et al.*, (2021) recorded 129 μScm^{-1} and 775 μScm^{-1} as the range of electrical conductivity values for honey.

Anoushka *et al.*, (2019) noted that the electrical conductivity of the honey is closely related to the concentration of mineral salts, organic acids and proteins. It is also a parameter that shows great variability according to the floral origin of honey and is considered one of the best parameters for differentiating between honeys of different floral origins. According to them pure honey is characterized by a conductance close to zero. Adulterated honey with water or saturated sugar solutions is therefore expected to display greater conductance than pure honey. This concentration of mineral salts, organic acids and proteins reported to be lower in commercial sugars than natural honey. These lower values of electrical conductivity reported in this research is connected to purity of the collected samples.

3.3: pH Value

The pH Values of the samples were measured using digital pH meter.

Table 3.3: pH Value

S/N	Sample Code	pH value
1	KB ₁	4.84
2	KB ₂	4.98
3	KB ₃	4.62
4	KB ₄	4.46
5	KB ₅	4.44
6	KB ₆	4.84
7	KB ₇	4.52
8	KB ₈	4.30
9	KB ₉	4.53
10	KB ₁₀	4.41

Table 3.3 presents the pH values of the samples. pH value is the measurement of a hydrogen ion concentration in a sample. So it is the measure of acidity or alkalinity of a solution that is a number on a scale on which a value of 7 represents neutrality and lower numbers indicate increasing acidity and higher numbers increasing alkalinity. All natural honeys are acidic because they contain some acids such organic, amino acid etc. From the results above, all the samples seemed to be slightly acidic as none have a value above 6 which is the pH value of an acid substance close to neutrality. The values ranges between 4.30 – 4.98 with an average of 4.59. This result is similar to that of Meseret *et al.*, (2020) who reported 4.46 ± 0.04 as the pH value of their sample assume to be pure with a view to determine its adulteration.

The result is also similar to that of Abdulwahid *et al.*, (2012) who recorded 3.2 – 4.5 as a range of pH values for Blossom honey and 4.5 – 6.5 for Honeydew honey. Aida *et al.*, (2021) equally obtained the pH values of honey samples from 3.77 - 5.32 which are very close to the results reported here. Molan (1995) mentioned 3.2 and 4.5 as a range of pH values for undiluted honey. This range agrees with all the ranges reported here. Molan went further to clarify that this range is inhibitory to many pathogenic bacteria. However, when consumed orally, the honey would be so diluted by body fluids that some effects of low pH is likely to be lost.

Despite the inhibitory ability of natural honey to pathogenic bacteria due to its low range of pH values, the low range also have negative effects as some small scale local beekeepers use low cost metallic containers due to low purchasing power for harvesting, processing and storage of natural honey. Thus, its acidic nature corrodes the metal containers (Molan, 1995). Lead is the most documented of all heavy metals causing honey contamination due to the various health problems it causes. The possible reason for its presence in different types of honey from several geographic locations could be as a result of the high concentration of Pb in the air due to oil extraction and automobile exhaust emissions (Bibi *et al.*, 2008). This inhibitory ability limits health problems to the consumers and gives stability and long duration product preservation. This low pH is attributed to the presence of gluconic acid, which also causes inhibitory effects to bacterial growth (White, 1992). This pH is considerably lower than the optimum pH required for the growth of most bacteria, which is around 7.0 (Molan, 1995).

4. CONCLUSION

The research work was carried out successfully. The specific gravity, electrical conductivity and pH value among other physicochemical parameters were determined. From the results sample KB₁₀ has the highest specific gravity with a value of 1.44 while sample KB₁ has the lowest specific gravity with a value of 1.31. This gives the range of the values as 1.31 – 1.44. The electrical conductivity values of the studied honey samples varied from 2.68 - 19.80 $\mu\text{S}/\text{cm}$ with sample KB₇ having the lowest value (2.68 $\mu\text{S}/\text{cm}$) and KB₅ having the highest value (19.80 $\mu\text{S}/\text{cm}$). Likewise the pH values ranges between 4.30 – 4.98 with an average of 4.59 with sample KB₈ as the lowest while KB₂ as the highest. The values of all the parameters reported are within the safety range as reported by NAFDAC and other reviewed literatures.

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