

# Quality Evaluation of Awka Market Honey and Honey from Beekeepers in Two Floral Regions of Anambra State, Nigeria

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**Abstract** Honey sold in Awka market is supplied from within and outside Anambra State, Nigeria. The quality from identified sellers in the market was evaluated and compared with honey from two floral regions in the state and some reported international standards. Analyses were carried out on the proximate composition, some mineral elements, physical properties, microbial counts and inhibition activities, and organoleptic qualities using standard methods. The parameter values of the market samples and samples from apiarists in the floral regions were found to be similar. The moisture content of the samples ranged between 8.42 and 10.52 g/ 100 g; protein, 0.70 and 1.27 g/ 100 g; ash, 0.40 and 0.60 g/100 g; fat, 0.14 and 0.20 g/ 100 g; and carbohydrate 87.80 and 89.19 g/ 100 g. In descending order, elemental mineral values of K, Ca, Na, Mg and Fe ranged from 47.77 to 54.86 mg/ 100 g, 4.21 – 6.04 mg/ 100 g, 3.82 – 4.28 mg/ 100 g, 2.11 – 3.40 mg/ 100 g and 0.54 – 1.09 mg/ 100 g, respectively. Hydroxymethyl furfural (HMF) values of 13.62 and 10.28 g/ 100g were observed for floral regions of Adazi-Enu and Ikenga, respectively, but values of 23.26, 24.35 and 45.48 g/ 100 g for market samples 1, 2 and pharshop, respectively. Market honey samples inhibition activity against *P. aeruginosa* was 4 cm as against 1 cm for floral region samples. The honey samples had inhibition activity against *E. coli* except one market sample with activity of 2.6 cm. Adazi-Enu floral region sample exhibited slightly above double the inhibition activity of 7.6 cm against *S. aureus* than the market samples (3.4 – 3.8 cm). Organoleptic qualities of the floral region samples were comparable to the market samples except the Pharmshop sample that was less acceptable. Except for HMF of pharshop sample that exceeded international standard, parameters in all honey samples are within the standard and comparable indicating non adulteration of the samples.

**Keywords:** Awka market, floral region, honey, international standard, quality

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## 1. Introduction

Honey has been variously defined but Codex Alimentarius Commission [1] comprehensively defined it as a natural sweet substance produced by honey bees, *Apis mellifera*, from the nectar of plants (blossoms) or from the secretions of living plants or secretions of plant sucking insects on the living parts of plants, which honey bees collect, transform by combining with specific substances of their own, deposit, dehydrate, store and leave in the honey comb to ripen and mature. This implies two official types of honey: Blossom or nectar honey created by bees from nectar of plant; and honeydew honey, which bees created mainly from sap secreted by insects (Hemiptera) from the living parts of plants or secretion of living part of plants.

The quality, and consequently the physicochemical composition, flavor and texture of honey, vary due to several factors enumerated to include the climatic region, soil, the environmental temperature, the type of botanical

plant used to produce it, the bee species, the sugar composition, the treatment of honey during extraction process and subsequent storage condition [2,3,4].

Honey has been used as a natural food source and as ingredient in various culinary preparations as sweetener and flavouring agent [5,6]. In Nigeria, the traditional and principal use of honey is as sweetening and flavoring agent in culinary preparations. It serves as substitute for table sugar (sucrose from beet or cane sugar) in sweetening and flavoring such culinary preparations as cereal gruel, tea and coffee drinks. However, its high cost has favored demand for table sugar. Recently, awareness that honey contains, apart from glucose and fructose that constitute average of 30.30% and 38.40%, respectively [7], vitamins B2 and B6, iron, manganese [2,8], phytochemicals such as flavonoids and other polyphenols that make it a potential functional ingredients and antimicrobial agents [9,10,11], plays a beneficial role attributable to both the antimicrobial and anti-inflammatory properties and serves as treatment for cold, skin wound and various gastrointestinal diseases [3]. These attributes have increased the demand for honey.

Honey is available in Awka, Nigeria, but not secure. Hence, it is not commonly used by majority of residents and families. Some use it on recommendation for a particular purpose or by chance occurrence and very few whenever they can afford it. Due to patronage emanating from poor socio-economic status of the urban dweller, sellers cannot depend on the sales of honey only for their livelihoods. They often combine the trade with other enterprises. Hence very few dealers are found in the market.

Honey sold in Awka market of Anambra State, Nigeria, is sourced from both within and outside the State. There were reports of adulterated honey in the market. Samples of honey were purchased from the few available or identifiable dealers in the market and evaluated for their quality; comparison was made with those obtained from beekeepers in two floral regions in the state and, where available, reported international standards.

## 2. Materials and Methods

### 2.1. Honey Samples Collection

Honey samples were purchased in triplicate from three (3) dealers in Eke-Awka market and a supermarket; and two (2) beekeepers from two floral regions of Adazi-Enu in Anaocha Local Government Area and Ikenga in Aguata Local Government Area of Anambra State of Nigeria. The individual honey samples were thoroughly homogenized to prepare representative samples for the analysis.

### 2.2. Analytical Methods

#### 2.2.1. Preliminary Qualitative Test for Honey

A preliminary assessment was conducted qualitatively to identify if common adulterants were added to honey sold in the local markets. This was carried out using the following methods:

**2.2.1.1. Flame Test:** Honey was ignited with laboratory Bunsen burner. Pure honey gives smokeless flame while smoky flame and/or cracking sound revealed the presence of adulterants

**2.2.1.2. Heating Effect:** A gentle heating was given to honey sample to dissolve crystallized substances. Clear transparent viscous solution showed pure unadulterated honey on melting while wax materials adulterant floated on top of melted honey.

#### 2.2.2. Proximate Analysis

Crude protein determination was carried out using the microKjeldahl method No. 955.04C of AOAC [12] called the Kjeldahl method (%Protein = %N x 6.25). Ash Content was determined by incinerating 5 g sample in a muffle furnace at 550°C as described by AOAC [12] method no 942.05. Moisture Content was determined using air-oven method [12]. Fat content determination was carried out using Soxhlet extraction method as described by AOAC [12] method no 920.39. The carbohydrate content of the sample was estimated by difference. That is, subtracting the sum of percentage moisture, fat, protein, and ash from 100.

#### 2.2.3. Determination of Minerals

Mineral composition was determined using Atomic absorption spectroscopy [13] except that dry ashing at 550°C of known weight of honey in a muffle furnace was used rather than wet ashing with Hydrogen peroxide, Perchloric acid and Nitric acid. The resulting ash was allowed to cool to room temperature and the volume made up to 50 ml with de-ionized water. The ash sample was analyzed in triplicate, using a flame atomic absorption spectrophotometer (Model 3300, MS-DOS, PerkinElmer Inc., USA). Stock solutions, 1000 mg/l each of Ca, Mg, Fe, K, and Na (analytical grade) purchased from Chemical store in Onitsha Head Bridge Market were used for AAS analysis. Calibration standard for each element was prepared using these stock solutions by employing serial dilution technique. The mineral element composition in each sample was deduced from the calibration curves.

#### 2.2.4. Electrical Conductivity

This was estimated by calculation that depends on the content of ash following the equation reported by Alqarni *et al.* [14] and Piazza *et al.* [15]

$EC \text{ (mS/cm)} = 0.14 + 1.74A$  in which A is the ash content (g/100 g honey).

#### 2.2.5. Hydroxymethyl Furfural (HMF) Content Determination

The White method as described by International Honey Commission [16] was used. The analysis of the hydroxymethyl furfural (HMF) content was done based on the determination of UV absorbance of HMF at 284nm. In order to avoid the interference of other components at that wavelength, the difference between the absorbance of a clear aqueous honey solution and the same solution after addition of bisulphite was determined. The HMF content was calculated after subtraction of the background absorbance at 336 nm. The HMF content of the sample was calculated by the following formula:

$$HMF(\text{mg / Kg}) = (A_{284} - A_{336}) \times 149.7 \times 5 / W$$

Where,  $A_{284}$  = absorbance at 284nm;  $A_{336}$  = absorbance at 336nm; W = Weight of sample taken

#### 2.2.6. Microbiological Analysis

The determination of the microbial load (mesophilic aerobic bacteria, coliforms, yeast and mold counts) in the products was performed by the method outlined in Compendium of Methods for the Microbiological Examination of Foods [17]. This procedure made use of pour plate method. Maintaining an aseptic condition near a Bunsen flame, 1ml of the honey sample was measured into a 9 ml peptone water broth and homogenized. Then 1ml each of the homogenate was taken and put into three different petri dishes. The media (CRA, PCA and PDA) were respectively poured into the dishes and allowed to solidify before transferred to the incubator and incubated for three days.

#### 2.2.7. Antibacterial Activity

Antibacterial activities of the different honeys were determined by direct assay procedure [10]. Nutrient agar

plates were swabbed with the respective overnight culture of 3 clinically important bacterial strains (*S. aureus*, *E. coli* and *P. aeruginosa*) obtained from the National Agency for Food and Drug Administration and Control laboratory. Sterile 6 mm diameter filter paper disc impregnated with the honey sample was placed on the pre-seeded agar and incubated at room temperature for 24 hours. The anti-bacterial activity was observed as increased diameter (mm) of clear zone of growth inhibition.

### 2.2.8. Sensory Evaluation

The sensory evaluation on preference of honey samples was conducted as described by Ihekoronye and Ngoddy [18]. The evaluation was carried out in a Food Processing Laboratory well illuminated by sun light. A panel of 20 students of Nnamdi Azikiwe University, Awka, Nigeria, assessed the samples on 9-point Hedonic Scale with 1 representing extremely disliked, 5 neither liked nor disliked and 9 extremely liked. Five coded samples of honey were served simultaneously in white plastic cups. The panelists were asked to judge each sample for flavor, color, taste, mouthfeel, and general acceptability. A soft drink precisely Sprite (a mineral water) was provided as neutralizers to remove after taste between assessments.

### 2.2.9. Data Analysis

Data were analyzed using analysis of variance (ANOVA) [19] and significant means discriminated using least significant difference (LSD) test.

## 3. Results and Discussion

### 3.1. Qualitative Analysis of Honey

The results of the qualitative assessment of honey samples presented in Table 1 revealed that all the honey samples are of good quality. Interviews and physical observation results on adulteration of honey revealed that the common substances usually added to honey as adulterants are: Sugar syrup, maize and/or wheat flour syrup, banana, and sweet potato. These adulterants are usually added to honey individually or in combination by some honey traders to maximize their profit.

### 3.2. Proximate Composition

The results of the proximate composition of different honey samples are presented in Table 2. The moisture content of the honey samples varied from 5.67% to 10.52%. This is below the maximum acceptable limit of

21% by the Codex Alimentarius Commission [1] and European Union [20]. The moisture content of honey is one of the factors that influences the shelf stability of honey [21,22]. The higher the moisture, the higher the probability that honey will ferment upon storage by osmotolerant yeasts [23]. A high moisture content of honey is also an indicator of adulteration [24].

Very low values of protein (0.70 to 1.27%) were observed for various honey samples (Table 2). Though protein of honey has no proposed or established International limit, these values are higher than the values 1.69 – 4.67 mg/ g (0.169 – 0.467%) for honey samples from Egypt, Yemeni, Saudi and Kashmiri [25].

The fat content of the honey samples ranged from 0.14 to 0.20% (Table 2). The results obtained were in agreement with that reported by other authors [2,21,26]. High fat content makes food to be susceptible to rancid spoilage during storage [5].

The ash content the honey samples varied from 0.40 to 0.60%, with Adazi-Enu, Pharmshop, Awkamkt1 and Awkamkt2 honey samples having the same ash content (0.6%) while the Ikenga honey sample had the least ash content (0.40 %). Ash content is a reflection of the total inorganic minerals that are present in a sample after incineration [8] and it is a quality criterion for botanical and geographical origin of honey [25]. The ash values fall within the range typical of natural nectar honeys [24] and not of honeydew honeys, which have been reported to have high ash content [23]. According to Areda [4], the maximum limit set for nectar or blossom honey by Codex Alimentarius Commission, European Union and Quality Standards Authority of Ethiopia (QSAE) is 0.6 mg/100g honey. In routine honey control, electrical conductivity has been accepted in international standard as replacement for the determination of the ash content [14], [27]. EC measurement depends on the ash and acid content of honey. Using the conversion factor,  $0.14 + 1.74A$ , [14], [15] where A represents ash content, the EC of the honey samples calculated ranged from 0.84 – 1.18 mS/cm. This range is lower than EC values ranged between 2.0035 mS/cm and 3.1388 mS/cm reported by Alqarni *et al.* [14] for local and imported honeys in Saudi Arabia.

**Table 1. Qualitative Information on the Honey Samples Sold in Awka Market and Two Floral Regions in Anambra State, Nigeria**

Honey samples	Qualitative tests	
	Flame test	Heating test
Adazi-Enu	Smokeless	Clear viscous liquid
Ikenga	Smokeless	Clear viscous liquid
Pharmshop	Smokeless	Clear viscous liquid
Awkamkt 1	Smokeless	Clear viscous liquid
Awkamkt 2	Smokeless	Clear viscous liquid

**Table 2. Proximate Composition of Different Honey Samples**

Parameters (g/ 100g)	Floral Regions Samples		Market Honey Samples			Int'l Standard
	Adazi-Enu	Ikenga	Pharmshop	Awkamkt1	Awkamkt2	
Protein	0.88 <sup>b</sup> ±0.05	0.88 <sup>b</sup> ±0.07	0.70 <sup>a</sup> ±0.05	1.27 <sup>a</sup> ±0.12	1.18 <sup>a</sup> ±0.88	NA
Carbohydrates	87.80 <sup>a</sup> ±0.32	89.19 <sup>a</sup> ±0.13	88.89 <sup>a</sup> ±0.22	89.55 <sup>a</sup> ±0.48	88.24 <sup>a</sup> ±0.61	NA
Ash	0.60 <sup>a</sup> ±0.21	0.40 <sup>a</sup> ±0.02	0.60 <sup>a</sup> ±0.04	0.60 <sup>a</sup> ±0.06	0.60 <sup>a</sup> ±0.07	< 0.6 g/ 100g
Fat	0.20 <sup>a</sup> ±0.34	0.20 <sup>a</sup> ±0.10	0.14 <sup>a</sup> ±0.01	0.16 <sup>a</sup> ±0.03	0.14 <sup>a</sup> ±0.04	NA
Moisture	10.52 <sup>a</sup> ±0.69	9.33 <sup>b</sup> ±0.58	9.67 <sup>ab</sup> ±1.02	8.42 <sup>c</sup> ±0.92	9.84 <sup>ab</sup> ±0.72	< 20 g/ 100g

Values with the same superscripts are significantly the same ( $p < 0.05$ ). NA – Not available.

The carbohydrate content of the honey samples was in the range of 87.80 to 89.19%. This is higher than the average total carbohydrate content of 80-85% [1,28] and 82.69% for honeydew honey and 82.28% for blossom or nectar honey [29] comprising of 38.19% and 31.80% levulose, 31.28% and 26.08% dextrose, 1.31% and 0.80% sucrose, 7.31% and 8.80% maltose, 1.50% and 4.70% higher sugars, and 3.1% and 10.1% undetermined, respectively; and average total of 79.7% [7] comprising 38.4%, 30.3%, 1.3%, 7.3% and 1.4%, respectively of fructose, glucose, sucrose, other disaccharides and higher sugars. The carbohydrate content in this work, unlike in the reported works, was estimated by difference and the values could be likened to crude as other constituents like gluconic acid determined in reported work may be inclusive in this estimated values.

### 3.3. Mineral Composition

The mineral content of the honey samples is presented in Table 3. The results showed that the honey samples are quite rich in minerals. The percentage mineral content is considered as a quality criterion indicating the possible botanical origin of honey [8]. The differences in mineral content majorly depend on the type of soil in which the original nectar bearing plant was located [2,3]. The table revealed that potassium is the predominant mineral in honey with Awkamkt2 sample having the highest value of 54.86 mg/100g while that of Adazi-Enu was the least (45.77 mg/100g). The results were in agreement with previous reports [7,8,14] on the predominance of potassium. Next in descending order is calcium (4.21 – 6.04 mg/ 100 g) closely followed by sodium (3.82 – 4.28 mg/ 100 g), then magnesium (2.7 – 3.4 mg/ 100 g) and iron that has the least value (0.54 – 1.09 mg/ 100 g) among the minerals determined. In contrast to the observation on predominance, Alqarni *et al.* [14] gave the following order after K; Mg, Ca, Fe, P, Na, and Mn. for all local and exotic honey types

in Saudi Arabia. The range between 45.77 to 54.86 mg/ 100g observed in this work is higher than 298.69 – 491.40 ppm (29.869 – 49.14 mg/100 g) reported by Alqarni *et al.* [14] for honey in Saudi Arabia; and 205 ppm (20.5 mg/ 100g) reported by Ball [7] on US honey. From Table 3, the calcium content of honey samples is comparable to the lower values of the range 60.75 – 99.95 ppm reported by Alqarni *et al.* [14] for the local and exotic honey in Saudi Arabia. However, the Na in honey of this work is higher than that of Saudi while Mg and Fe are much less than the ranges (80.70 – 199.30 and 67.18 – 98.13 ppm, respectively) reported by Alqarni *et al.* [14].

### 3.4. Physicochemical Properties of the Honey Samples

This is shown in Table 4 below. The pH ranged from 3.50 to 4.12 with the honey from Pharmshop having the lowest value and the Adazi-Enu sample having the highest. The Pharmshop sample pH differed significantly ( $p < 0.05$ ) from other samples pH which ranged from 4.0 to 4.12. According to Areda [4] who observed a range of 4.13 to 5.02 for honey in Guji Zone of Ethiopia, honey pH has great importance during storage of honey, as it influences the texture, stability and shelf life of honey.

The mean specific gravity of the honey samples was 1.43, with a range of 1.40 - 1.44. This value is similar to those reported by (Adebiyi *et al.*, [31]). The Adazi-Enu honey sample had the highest specific gravity of 1.44 while the Pharmshop honey sample had the lowest specific gravity of 1.40. The specific gravity could be used to determine the level of adulteration and hence quality, based on the specification [31]. There is no reference international standard to use to infer the quality but the closeness of the values from apiarists and market samples could be enough evidence of the high or good quality of the honey samples. This could also justify the traditional qualitative results in Table 1 above.

Table 3. Mineral Contents of Awka Market and Floral Regions Honey Samples

Parameters (mg/100 g)	Floral Regions Samples		Market Honey Samples			LSD
	Adazi-Enu	Ikenga	Pharmshop	Awkamkt1	Awkamkt2	
Sodium	4.20 <sup>a</sup> ±0.51	4.01 <sup>a</sup> ±0.23	3.82 <sup>a</sup> ±0.73	4.28 <sup>a</sup> ±0.51	3.94 <sup>a</sup> ±0.19	0.65
Potassium	45.77 <sup>c</sup> ±0.38	50.28 <sup>c</sup> ±0.51	53.41 <sup>b</sup> ±1.05	48.37 <sup>d</sup> ±0.94	54.86 <sup>a</sup> ±0.47	1.02
Calcium	5.83 <sup>a</sup> ±0.46	6.04 <sup>a</sup> ±0.33	4.80 <sup>b</sup> ±0.80	4.21 <sup>c</sup> ±0.39	5.02 <sup>b</sup> ±0.33	0.56
Magnesium	2.80 <sup>b</sup> ±0.06	3.40 <sup>a</sup> ±0.07	2.11 <sup>c</sup> ±0.26	2.71 <sup>b</sup> ±0.08	2.90 <sup>b</sup> ±0.03	0.43
Iron	1.09 <sup>a</sup> ±0.10	0.67 <sup>b</sup> ±0.02	0.54 <sup>b</sup> ±0.04	0.76 <sup>b</sup> ±0.02	0.82 <sup>ab</sup> ±0.02	0.31

Values are means of triplicate determinations. Values with the same superscript are significantly the same ( $p < 0.05$ ).

Table 4. Physicochemical Properties of Honey Samples from Awka Market and Two Floral Regions in Anambra State, Nigeria

Parameters	Floral Region Samples		Market Honey Sample		
	Adazi-Enu	Ikenga	Pharmshop	Awkamkt1	Awkamkt2
pH	4.12 <sup>a</sup> ±0.06	4.05 <sup>a</sup> ±0.12	3.50 <sup>b</sup> ±0.17	4.0 <sup>a</sup> ±0.27	4.05 <sup>a</sup> ±0.22
Specific gravity	1.44 <sup>a</sup> ±0.14	1.42 <sup>a</sup> ±0.08	1.40 <sup>a</sup> ±0.04	1.42 <sup>a</sup> ±0.05	1.43 <sup>a</sup> ±0.06
Soluble solid (%)	81.60±1.16	82.02±1.34	81.57±1.23	80.92±1.18	81.20±1.12
Total solids (%)	83.26±1.21	84.33±1.22	82.14±1.03	82.60±1.29	83.00±1.33
HMF (mg/100g)	13.62 <sup>c</sup> ±0.88	10.28 <sup>d</sup> ±0.75	45.48 <sup>a</sup> ±0.73	23.26 <sup>b</sup> ±0.81	24.35 <sup>b</sup> ±0.91
EC (meS/cm)	1.184 <sup>a</sup> ±0.79	0.695 <sup>b</sup> ±0.50	1.184 <sup>a</sup> ±0.61	1.184 <sup>a</sup> ±0.13	1.184 <sup>a</sup> ±0.42

Values are means ± Standard deviation and those with different superscripts are different at 5% confident level.

The total solids of the honey samples ranged from 82.14 to 84.33% with Pharmshop honey sample having the lowest value and Ikenga honey sample having the highest value. Soluble solid content had the range of 80.92 to 82.02%.

This is similar to the results reported earlier [23] on honey samples from different origins, with honey sample Awkamkt1 having the lowest value and Adazi-Enu having the highest value. Total soluble solids is a measure of dissolved solids in the honey samples. In all the honey samples, the total soluble solids were generally more than 82%. Honey with total soluble solids greater or equal to 81.4% is considered of higher grade (A and B), while that falling between 80% and 81.3% is considered to be of lower grade C [24,32]. The soluble solids content of honey is a reliable index of adulteration [23] and a major factor for the categorization of the glycemic index, a major concern for diabetic persons.

The HMF contents of the honey samples are presented in Table 4. The results ranged from 10.28 to 45.48 mg/kg with mean value of 23.26 mg/kg of honey. Among the honey samples under study, Pharmshop sample had HMF contents higher than the maximum permissible limit of 40 mg/kg honey [32]. Hydroxymethyl furfuraldehyde (HMF) is a decomposition product of fructose. In fresh honey it is present only in trace amounts and its concentration increases with storage and prolonged heating of honey. It is a major honey quality factor that indicates honey freshness and adulteration associated with overheating or addition of caramel to the honey. The high values indicate that the honey samples might have been severely heated, stored longer or adulterated with processed sugar. The information on the storage conditions and time, and heat treatment prior to purchase of the samples are, however, unknown.

### 3.5. Microbial Quality

The mean bacteria counts of the honey samples that were studied, as shown in Table 5, ranged from  $4 \times 10^2$  to  $5 \times 10^2$  (cfu/100 ml) with the honey sample Awkamkt1 having the highest loads while honey sample Pharmshop had no load. The yeast and mould contents of the honey samples also ranged from  $1.0 \times 10^2$  to  $1.1 \times 10^2$ . The low microbial loads of the honey samples except for Pharmshop sample which had no Yeast and Mould could be attributed to their low moisture and pH values and high amounts of total soluble sugars and possibly phenolic compounds and their synergistic inter-actions [2]. Yeasts, moulds and spore-forming bacteria (*Coliforms*) have been implicated to survive in honey and are indicative of the sanitary quality of the honey [6,22]. No microorganism was observed

in sample Pharmshop. There were no coliform detected in all the honey samples. The microbiological quality of honey will give an indication of the hygienic conditions under which the product was processed, handled and stored.

### 3.6. Inhibitory Activity

The results of the assessment of the inhibitory activity of the honey samples against various bacterial strains are shown in Table 6. The honey samples showed varying activity against the tested bacteria as shown by the different zones of inhibition. The maximum zone of bacterial inhibition was recorded for *S. aureus* (7.6 cm) by Adazi-Enu honey sample. While the least zones of inhibition were observed for *E. coli* in Adazi-Enu, Ikenga, Pharmshop and Awkamkt2 honey samples. The factors responsible for the inhibitory activity of honeys are high osmolarity [6,33]; acidity, the enzymatic formation of hydrogen peroxide [34,35]; bee-origin, floral source and possible contribution of phytochemicals [2,33].

It is possible that the honeys with high antimicrobial activities could contain high quantities of polyphenols or glucose oxidases or both as these have also been reported to possess antibacterial properties [9]. Thus for optimum antibacterial activity, honey should be stored in a cool, dark place and be consumed when fresh.

### 3.7. Sensory Quality

The mean sensory scores of the organoleptic quality of different honey samples are shown in Table 7.

There were significant differences ( $p < 0.05$ ) in the sensory attributes of honey. Adazi-Enu and Awkamkt2 honey samples had the highest scores of 7.2 and 7.15 respectively, on appearance (colour) attribute. Usually a lighter colour will indicate a milder flavour [3]. Darker honeys were also reported to have higher pH, phytochemicals, antioxidant activities, mineral content but lower amount of sugars than lighter honeys [30], [36]. Adazi-Enu and Ikenga honey samples had the highest scores of 6.9 and 6.9 respectively on taste and similar trend was noticed for flavour with Adazi-Enu and Ikenga samples. The lowest scores of 3.35 and 5.75 were recorded for texture (smoothness) of the Pharmshop and Awkamkt1 honey samples respectively. The texture of honey is a function of the viscosity. The viscosity of honey is affected greatly by temperature and water content and to a lesser extent by the composition of the honey [5]. Adazi-Enu and Awkamkt2 honey samples had the best overall acceptance scores of 6.95 and 6.75 respectively.

Table 5. Microbial Analysis of Different Honey Samples (cfu/100ml)

Parameters (cfu/ ml)	Floral Region Sample		Market Honey samples		
	Adazi-Enu	Ikenga	Pharmshop	Awkamkt1	Awkamkt2
TVC	$4.0 \times 10^2$	$2.0 \times 10^2$	NIL	$17.0 \times 10^2$	$5.0 \times 10^2$
TCC	NIL	NIL	NIL	NIL	NIL
TYMC	$1.0 \times 10^2$	$1.0 \times 10^2$	NIL	$1.1 \times 10^2$	$1.0 \times 10^2$

Note: TVC= Total viable count, TCC= Total Coli form count, YMC= Total Yeast and Mould count.

**Table 6. Inhibition of Pathogenic Bacteria by honey samples**

Test organisms	Honey samples				
	Adazi-Enu	Ikenga	Pharmshop	Awkamkt1	Awkamkt2
<i>P. aeruginosa</i>	1cm	1cm	4cm	4cm	3cm
<i>E. coli</i>	0	0	0	2.6cm	0
<i>S. aureus</i>	7.6cm	0	3.6cm	3.8cm	3.4cm

**Table 7. Mean Sensory Scores of Different Honey Samples**

Parameters	Floral Region Samples		Market Honey Samples			
	Adazi-Enu	Ikenga	Pharmshop	Awkamkt1	Awkamkt2	LSD
Appearance	7.20 <sup>a</sup> ±0.88	6.55 <sup>a</sup> ±0.41	4.25 <sup>b</sup> ±0.66	6.4 <sup>a</sup> ±0.36	7.15 <sup>a</sup> ±0.81	1.08
Taste	6.90 <sup>a</sup> ±0.46	6.92 <sup>a</sup> ±0.25	3.40 <sup>c</sup> ±0.75	5.85 <sup>b</sup> ±0.69	6.65 <sup>ab</sup> ±0.6	0.88
Texture	6.15 <sup>a</sup> ±1.02	6.80 <sup>ab</sup> ±0.83	3.35 <sup>c</sup> ±0.38	5.75 <sup>ad</sup> ±0.72	6.45 <sup>a</sup> ±0.44	0.96
Flavour	6.30 <sup>a</sup> ±0.73	6.60 <sup>a</sup> ±0.77	3.40 <sup>b</sup> ±1.20	6.05 <sup>a</sup> ±0.94	6.20 <sup>a</sup> ±0.90	0.98
General acceptability	6.95 <sup>ab</sup> ±0.9	6.55 <sup>a</sup> ±1.10	3.34 <sup>c</sup> ±0.92	5.80 <sup>ad</sup> ±0.5	6.75 <sup>a</sup> ±0.48	0.96

Values with different superscripts along a row are significantly different (p<0.05).

## 4. Conclusion

Qualitative analysis of flame and heating tests and quantitative analyses of the chemical and physical properties revealed that the market honeys were not adulterated. Moreover, the values of all parameters showed comparable results between the market and floral region samples. Only the Pharmshop sample had HMF value above international standard, scores low in organoleptic quality, and had no viable microorganism in it. The honeys are recommended for consumption.

## Statement of Competing Interest

The authors have no competing interest

## References

- [1] Codex Alimentarius Commission. *Draft Revised Standard for Honey (at step 10 of the Codex Procedure)*. Codex Alimentarius Commission, FAO, Rome, Alinorm, 25, 19-26, 2001.
- [2] Alvarez-Suarez, J., Tulipani Romandini, S., Bertoli, E. and Battino, M. "Contribution of Honey in Nutrition and Human Health: a review". *Mediterranean Journal of Nutrition and Metabolism*, 3: 15-23. 2010.
- [3] Amril, A. and Ladjama, A. "Physicochemical characterization of some multifloral honeys from honeybees *Apis mellifera* collected in the Algerian northeast". *African Journal of Food Science*, 7(7): 168-173, 2013.
- [4] Areda, B.T. "Honeybee production and honey quality assessment in Guji Zone, Ethiopia". *Food Processing Technology*, 6(11): 2015.
- [5] Durrani, A., Srivastava, P. and Verma, S. "Development and quality evaluation of honey based carrot candy". *Journal of Food Science and Technology*, 48(4): 502-505, 2011.
- [6] Eleazu, C.O., Iroaganachi, M. and Okoronkwo, J. "Determination of the physicochemical composition, microbial quality and free radical scavenging activities of some commercially sold honey samples in Aba, Nigeria". *Journal of Nutrition and Food Science*, 3(2): 189, 2013.
- [7] Ball, D.W. "The chemical composition of honey". *Journal of Chemical Education*, 84(10): 1643-1646, 2007.
- [8] Vanhanen, L., Emmertz, A. and Savage, G. Mineral analysis of mono-floral New Zealand honey, *Food Chemistry*. 128: 236-240, 2011.
- [9] Khalil, M., Sulaiman, S. and Boukraa, L. "Antioxidant properties of honey and its role in preventing health disorder". *The Open Nutraceuticals Journal*, 3: 6-16, 2010.
- [10] Gulfranz, M., Itkihar, F., Imran, M., Zeenat, A., Asif, S. and Shah, I. "Composition analysis and antimicrobial activity of various honey types". Pakistan. *International Journal of Food Science and Technology*, 46: 263-267, 2011.
- [11] Ramanauskiene, R., Stelmakiene, A., Briedis, V., Ivanauskas, L. and Jakstas, V. "The quantitative analysis of biologically active compounds in Lithuanian honey". *Food Chemistry*, 132: 1544-1548, 2012.
- [12] AOAC. "Official Methods of Analysis", Association of Official Analytical Chemists, 15<sup>th</sup> Edition. Horwitz, W. and Latimer, G.W. (Eds). AOAC International, Maryland-USA, (2005).
- [13] Lawal, N.S., Tajuddeen, N. and Garba, B.B. "Assessment of some mineral elements in different brands of powdered milk sold in Samaru Zaria". Nigeria. *International Food Research Journal* 22(6): 2634-2636, 2015.
- [14] Alqarni, A.S., Owayes, A.A., Mahmoud, A.A. and Hannan, M.A. "Mineral content and physical properties of local and imported honeys in Saudi Arabia". *Journal of Saudi Chemical Society*, 18: 618-625, 2014.
- [15] Piazza, M.G., Accorti, M., Persano-Oddo, L. "Electrical conductivity, ash, colour and specific rotatory power in Italian unifloral honeys". *Apicoltura* 7, 51-63. (1991).
- [16] IHC. "Harmonized methods of the International Honey Commission". *International Honey Commission, World Network of Honey Sciences*, p. 26 (2009)
- [17] A.M.P.H. "Compendium of Methods for the Microbiological Examination of Foods". American Public Health Association, Washington DC, 1992.
- [18] Ihekoronye, A. I. and Ngoddy P.O. *Integrated Food Science and Technology for the Tropics*. McMillan Publishers Ltd, London and Basingstoke, pp. 172-190, 1985.
- [19] Snedecor, G.W., Cochran, W.G. *Statistical Methods*, 7th edn. The Iowa State University Press, Ames, Iowa, USA, p. 507, 1981.
- [20] SBRC. "Honey quality, methods of analysis and International regulatory standards: Review of the work of the International Honey Commission". Swiss Bee Research Center, 2000.
- [21] Azeredo, L.C., Azeredo, M.A.A., De Souza, S.R. and Dautra, V.M.L. "Protein content and physicochemical properties in honey samples of *Apis Mellefera* of different floral origins". *Food Chemistry*, 80(2) 249-254, 2003.
- [22] Ezeama, C.F. *Food Microbiology, Fundamental and Application*. Natural Prints Limited, Lagos, Nigera, 2007.
- [23] Viuda-Martos, M., Ruiz-Navajas, Y., Zaldivar-Cruz, J., Kuri, V., Juana Fernandez-Lopez, J., Carbonell-Barrachina, A. and Perez-Alvarez, J. "Aroma profile and physico-chemical properties of artisanal honey from Tabasco, Mexico". *International Journal of Food Science and Technology*, 45: 1111-1118, 2010.
- [24] Nyau, V., Mwanza, P. and Moonga, B. "Physicochemical qualities of honey harvested from different beehive types in Zambia".

- African Journal of Food Agric. Nutrition and Development*, 13(2): 7415-7427, 2013.
- [25] El Sohaimy, S.A., Masry, S.H.D. and Shehata, M.G. "Physicochemical characteristics of honey from different origins". *Annals of Agricultural Science*, 60(2): 279-287, 2015.
- [26] Ndife, J. Abioye, L. and Dandago, M. "Quality assessment of Nigerian honey sourced from different floral locations". *Nigerian Food Journal*, 32(2): 48-55, 2014.
- [27] Adenekan, M.O., Amusa, N.A., Lawal, A.O., Okpeze, V.E. "Physico-chemical and microbiological properties of honey samples obtained from Ibadan". *J. Microbiol. Antimicrobial* 2 (8): 100-104. 2010.
- [28] Buba, F., Gidado, A and Shugaba, A. "Analysis of biochemical composition of honey samples from North East Nigeria". *Biochem. & Anal. Biochem.* 2(3):138, 2013.
- [29] White, J.W.(jr) and Doner, L.S. "Honey composition and properties". *Beekeeping in the United States Agricultural Handbook (Revised)*, No. 335, pp 82 -91, 1980.
- [30] Adebisi, F.M., Akpan, I., Obiajunwa, E.I. and Olaniyi, H.B. "Chemical and physical characterization of Nigeria honey". *Pakistan J. Nutr.*, 3: 278-281. 2004.
- [31] USDA. "United States Standards for Grades of Extracted Honey", fifth ed., In: *Agricultural Marketing Service Fruit and Vegetable Division Processed Products Branch*. Washington, DC: US Department of Agriculture, 1985.
- [32] QSAE, (2005). "Ethiopian Standard Specifications for Honey", Quality Standard Authority of Ethiopia ES 1202: 2005.
- [33] Snowden, A. and Cliver, O. "Review article: Microorganisms in honey". *Int. J. Food Microbiol.* 31: 1-26. 8, 1996.
- [34] Baltrusaityte, V., Venskutonis, P. and Ceksteryte, V. "Antibacterial activity of honey and bee bread of different origin against *S. aureus* and *S. epidermidis*". *Food Technol. Biotechnol.* , 45 (2): 201-208, 2007.
- [35] Al-Habsi, N. and Niranjana, K. "Effect of high hydrostatic pressure on antimicrobial activity and quality of manuka honey". *Food Chemistry*, 135: 1448-1454, 2012.
- [36] Escuredo, O., Seijo, M. and Fernandez-Gonzalez, M. "Descriptive analysis of rubeus honey from the north-west of Spain". *International Journal of Food Science and Technology*, 46: 2329-2336, 2011.