

The physicochemical analysis and health benefits of fresh and branded honey in Delta State, Nigeria.

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Abstract

This research is aimed to investigate and evaluate the physicochemical characteristic of different honey produced in Delta State, Nigeria, to confirm its economical and nutritional quality in comparison with the international standard. The quality of Delta fresh and branded honey samples was assessed using physicochemical and mineral analysis. Eight Fresh Honey (FHs) samples and eight Branded Honey (BHs) samples were collected from the Autonomous Province of Delta State, Nigeria. The tested parameters were pH, free acidity, electrical conductivity, color intensity, moisture, ash, proline, diastase, HMF, invertase, glucose, fructose, sucrose, lipid and mineral content. A qualitative test (Fiehe, Lund and Lugol) was performed to test the purity of honey. Both honey samples displayed good physicochemical properties. The concentration level of sugars was higher in the branded honey in comparison to fresh honey samples. The physicochemical parameters of fresh and branded honey were in concordance with the international standard.

Keywords: Physicochemical analysis, Branded honey, Fresh honey, Adulteration, Delta.

Introduction

Honey is a sweet, naturally occurring substance manufactured by honeybee workers from the flowers' nectar or living parts of flowers and discharge produced when insects suck plant parts [1]. Honey is a popular sweet substance used in several products such as bakery items, meats, cereals, mead and is still used in cosmetics and medicines [2]. In most places around the globe, honey was used for medicinal purposes and religious practices [3]. In recent years, honey has been used as a source of energy- giving food and a major ingredient in cereal-based food for flavoring, coloring and sweetening [4].

High-quality grade honey is commonly found from the physicochemical parameter and microbiological characteristics. The physicochemical analysis parameters are based on the nectar's (type and region), soil composition, climatic conditions, processing, storage and transportation [5]. The adulteration of honey can be measured from the physicochemical analysis results. Most expensive honey like the premium kinds of honey can be targeted for adulteration, by mixing the finished product with cheap sugar syrups which are very common. Honey that is adulterated with sugar products can be quite difficult because of the varieties of products that can be used for adulteration and the natural alternation among different unifloral kinds of honey. In most cases, adulteration of honey may alter some of the physicochemical characteristics of the honey [6].

Chemical compounds and sweetness characteristics of honey are strongly connected to the geographical source. The concentration of minerals tends to be stable after the production of honey and it may be due to the geographical location as well as possible sources of environmental contamination. Monofloral kinds of honey are composed of single plant nectar with a minimum amount of 45%. Monofloral kinds of honey, arises mainly from a single geographical region where the consumers make high demand. The nectar's content, beekeepers' activity, soil types, and climatic conditions contribute to the formation of honey. The differences in the honey composition mean differences in the nutritional properties of honey products. A good quality grade honey should contain an EC (not >0.8 mS/cm), DN (not <8), FA (not >50 meq/kg), ash content (not >0.5 g/100 g), HMF (not >40 mg/kg) and other physicochemical characteristics with exception to some different types of honey as stated in the Codex Alimentarius Commission. Around the globe, honey qualities vary excessively depending on some factors which include environmental and climatic conditions, the plant source and species of bee. Besides, the quality of honey is affected by the industrial process of commercial honey during the extraction and storage of honey. Nowadays, the honey bee products, *Apis mellifera* L, have attracted great concern in various fields, e.g. food and drug industries. Researchers around the world have previously studied the geographical origin of honey around Europe, especially in Portugal [7]. In Africa mainly in Nigeria, Benin and Morocco and in

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South America, mainly in Ecuador [8]. The physicochemical characteristics such as moisture content, pH, conductivity and sugar concentration have been determined by the authors. They found that the geographical region strongly affects and defines honey's physicochemical characteristics.

The Delta honey bees were described as a separate subspecies, *Apis mellifera* [9]. Although the essential constituents found in honey are almost similar in all honey products, the physicochemical characteristic of fresh honey is depended on climatic conditions, floral, refining and storage techniques [10]. However, honey has an important role in local medicine in Delta. It has been primarily used for wound remedies and intestinal infections. Unfortunately, no physicochemical analysis has been applied in investigating its quality.

This research aims to investigate and evaluate the physicochemical characteristic of different honey produced in Delta State, Nigeria, to confirm its economic and nutritional quality compared to the international standard (Figure 1).

Materials and Methods

Samples

Eight Fresh Honey (FHs) samples and eight Branded Honey (BHs) samples from different regions such as Isoko, Urhobo, Itsekiri and Ijaw in the Autonomous Province of Nigeria during the year 2021, were obtained from beekeepers and supermarkets. Samples of fresh honey were preserved in sealed plastic containers certified for food storage, dated and stored at ± 25 °C for three weeks until the investigation was complete. No evidence of fermentation or spoilage was seen in all samples.

pH and free acidity

A pH metre (Mettler-Toledo) and potentiometric titration method were used to measure the pH and free acidity by International Honey Commission.

Electrical conductivity

A conductivity meter (wp 600 series) was used to determine the conductivity by International Honey Commission.

Color intensity

The color intensity was determined in accordance with the mean absorption method [11]. In order to proceed with the method, twenty percent of honey solution was warmed to a temperature of 45 to 50 °C. The solution was screened with a Whatman filtering paper (0.45 μ l). The absorbance of the honey solution filtrate was measured at 450 nm and 720 nm using a spectrophotometer (SHIMADZU UV-2450), and the mAU difference was measured and expressed for each absorbance.

Moisture content

The moisture content was determined using a technique called refractive index in International Honey Commission.

Ash content

Ash content was measured through the gravimetric method. Ten grams of sample was weighed into the crucible and heated in the furnace at 550 °C for 12 hours. After heating, the crucible was covered to prevent gas ash particles from escaping after 30 minutes of cooling in the desiccator.

Proline content and diastase activity

Proline content and diastase activity was determined by the spectrophotometric method.

Invertase number

Invertase number was determined by spectrophotometric method [12].



Figure 1. Map of Delta State, Nigeria.

Hydroxymethylfurfuraldehyde (HMF)

The HMF content was measured through the spectrophotometric method [13].

Sugar content

External calibration curves constructed from the standard solutions was used to quantify sugars in the sample.

Lipid content

The crude fat was measured using the gravimetric method [14].

Fiehe's, lund's and lugol's test

This test was determined using the qualitative method [15].

Mineral contents

The mineral composition was determined by the spectrometric metho [16].

Statistical analysis

The analysis was carried out in triplicate (n=3) and results were expressed as mean \pm standard deviation. Comparisons among each type of honey (FHs and BHs) were conducted using one-way ANOVA followed by Tukey's test. All the statistical analysis was carried out using the program IBM SPSS Statistics 23, embracing the significance level ($p < 0.05$).

Results and Discussions

Physicochemical results

Parameters of 8 samples of each type of honey in 2021 from Delta State, Nigeria were investigated. Table 1 and Table 2 represent the parameters (moisture, ash, pH, EC, free acidity, color intensity, proline, diastase, HMF, invertase, glucose, fructose, sucrose, and lipid) of FHs and BHs honey samples.

pH of honeys

According to Terrab lifespan, stability and quality of honey are influence by the pH. All the analysed BHs and FHs honeys were all acidic promoting the healing of wounds by releasing oxygen from hemoglobin by preventing the growth of bacteria species on wounds. The mean pH values (Table 1) of FHs honey samples (4.67 ± 0.34) and BHs honey sample (4.40 ± 0.07) were acidic and within 3.5 and 5.5. The FHs and BHs displayed significant difference ($p < 0.05$). The values of pH (3.49 to 4.70 and 4.11 to 4.67) for Polish and Egyptian honeys described by El Sohaimy. are in accordance with our results. However, Azonwade recorded pH range (5.08-5.48) for Benin and Azonwade recorded pH range (5.08-5.18) were higher than the present study.

Free acidity of honeys: Acidity in honey exists as a result of a wide range of organic acid, inorganic ions, lactones, phosphate, esters and chloride. The free acidity in honey is present due to polyphenol, ascorbic acid, and amino groups [17]. The fermentation process of sugar into organic acids results in an increase in the honey acidity degeneration. The free acidity value of FHs honey samples (16.8 ± 4.97) and BHs honey samples (19.0 ± 2.34) samples (Table 1) were within the International limits of not more than 50 meq/kg. The FA results were within Moroccan and Portuguese honeys Acidity values (11.0 to 42.5 meq/kg and 6.4 to 38.1 meq/kg) reported by El-Haskoury and Silva, Alquari found significantly higher values (55.5 – 145.5 meq/kg) than present research.

Electrical conductivity of honeys: Mineral deposits discovered in honey are mostly brought by the electrical conductivity as well as the pollen content which also can be used to identify the botanical origin of hone. The FHs and BHs displayed significant difference ($p < 0.05$). All honey samples (Table 2) analysed in this current research were within the international limit ≤ 0.8 mS/cm (FHs honey mean value of

Table 1. Physicochemical parameters of FHs and BHs honey in Delta (n=16).

Type	pH	Free Acidity (meq/kg)	EC (mS/cm)	Color Intensity (mAU)	Moisture (%)	Ash (%)	Proline (mg/kg)	Diastase Number	HMF (mg/kg)	Invertase Activity (unit/kg)	
FHs (n=8)	mean value \pm Sd	4.67 ± 0.3^a	16.8 ± 4.9^b	0.60 ± 0.0^a	319 ± 4.1^a	13.1 ± 1.0^a	0.58 ± 0.1^a	346.58 ± 43.30^a	31.99 ± 8.43^b	3.04 ± 0.89^b	183.28 ± 3.67^a
	min	4.13	10.3	0.53	312	11.7	0.50	286.33	22.50	1.70	178.78
	max	4.98	24.0	0.68	323	14.4	0.77	406.97	44.77	4.07	187.7
BHs (n=8)	mean value \pm Sd	4.40 ± 0.07^b	19.0 ± 2.34^a	0.41 ± 0.01^b	372 ± 5.49^b	17.1 ± 0.27^b	0.48 ± 0.18^b	296.83 ± 37.25^b	13.03 ± 1.58^a	32.85 ± 4.67^a	73.9 ± 3.61^b
	min	4.34	16.3	0.39	205	16.8	0.23	241.47	11.10	25.6	69.8
	max	4.52	22.7	0.42	530	17.5	0.70	341.07	15.50	38.5	78.9

Table 2. The concentration of glucose, fructose, sucrose and lipid in the Delta honey (n=16).

Type	Glucose (g/100g)	Fructose (g/100g)	F + G (g/100g)	F/G	Sucrose (g/100g)	Lipid (%)	
FHs (n=8)	mean value \pm Sd	30.1 ± 1.4^a	35.8 ± 1.5^a	65.9 ± 2.61^b	1.19 ± 0.05^a	0.99 ± 0.25^a	0.38 ± 0.0^a
	min	27.9	34.3	62.2	1.11	0.66	0.37
	max	31.9	38.4	69.2	1.25	1.34	0.39
BHs (n=8)	mean value \pm Sd	31.6 ± 1.4^a	37.7 ± 1.8^a	69.3 ± 2.44^b	1.20 ± 0.08^a	2.95 ± 0.52^b	0.38 ± 0.0^a
	min	29.5	36.3	66.0	1.10	2.11	0.37
	max	33.7	40.8	72.3	1.30	3.49	0.38

Mean value \pm Sd, having different superscript are significantly different ($p < 0.05$) in the same column.

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0.60 ± 0.06 mS/cm; BHs honey mean value of 0.41 ± 0.01 mS/cm) indicating that all the honey samples are from nectar and meet the standard of EC criteria of honey product sold In the market of Codex Alimentarius Commission; European Commission and current results are more than those recorded by Guler and comparable results was previously recorded [18].

Color intensity of honeys: The color intensity is usually represented by AB₄₅₀, which is an essential parameter for detecting the existence of certain pigments having antioxidant activities. There is no international limit mean values of color intensity in FHs honey (319 ± 4.18) and BHs honey (372 ± 5.49) samples (Table 3) and a significant difference (p<0.05) were noted between analysed honey samples. This is validated in the research. The resulted variation in color intensity may be as a result of pigments contaminated during handling, processing, and storage techniques during development of honey [19].

Moisture content of honeys: Moisture is produced in honey as a result of the conditions of the environment, season of harvest, storage process by beekeepers, and type of nectar used by the honeybee [20]. The moisture content can alter different physicochemical parameters [21].

The FHs honeys recorded moisture content ranging from 11.7% to 14.4% and BHs honeys recorded 16.8% to 17.5%. Despite honey samples were taken from different floral source, moisture content (%) of all the FHs and BHs honey samples were within the international limit (≤ 21%) recommended by Codex Alimentarius Commission; European Commission. The FHs and displayed significant difference (p<0.05) than BHs. The moisture content values reported have been validated by Kayacier & Karaman and Karabagias. Although, Gidamis and Boussaid found higher values (21.6 to 22.8% and 17.27 to 19.73%) in Tanzanian and Tunisian honeys.

Ash content of honeys: The ash content variability has been qualitatively related with different botanical regions of honeys. It is an essential criterion to possibly determine the botanical origin of honey [22]. All honey samples (Table 1) analysed in this current research were within the limit (≤ 0.6%) proposed by Codex Alimentarius Commission (2001). However, the results for FHs honeys (0.58 ± 0.15%) were higher than that obtained for BHs honeys (0.48 ± 0.18%). The FHs and BHs displayed significant difference (p<0.05). Comparable results were obtained by Feás who analysed Northwest Portugal honeys. The ash content recorded by Azonwade who analysed

Benin honeys were greater than present results. The variation existing between honey samples maybe due to soil texture, atmospheric conditions, type and physiological variation of each plant species [23].

Proline content of honeys: Proline is the essential amino acid among other amino acids found in honey. It is used for the characterization of honey and the location of botanical origin Boussaid and a criterion for determining honey quality [24]. The Proline concentration of FHs honey samples ranged from 286.33–406.97 mg/kg and BHs honey ranged from 241.47–341.07 mg/kg (Table 1). Proline content of honey samples were within the limit (≥ 180 mg/kg) recommended by Codex Alimentarius Commission; European Commission. The FHs and BHs displayed significant difference (p<0.05). The proline contents results were within Moroccan honeys proline values (251.46 to 924.98 mg/kg) described by Aazza and greater than Tunisian honeys (39.62 to 102.22 mg/kg) reported [25]. Moloudian recorded much higher values (414 to 562 mg/kg) for Iranian honeys.

Diastase number of honeys: Diastase number is generally stated as diastase or amylase activity, symbol DN, and also a unit called Gothe. One unit of Gothe is known as the 1% starch solution hydrolysed by an enzyme in 1 gram of honey at 40 C for one hour International Honey Commission. Diastase activity is a parameter that is used to check the heating duration of honey during processing, because the diastase (enzyme) is affected during heating and long storage period [26]. In this current research, all examined honey samples were above the minimum value of ≥ 8, which is the standard Codex Alimentarius Commission; European Commission with a significant difference (p<0.05) were noted between analysed honey samples. The diastase number ranged from 22.50 to 44.77 (DN) in the tested FHs honeys and from 11.10 to 15.50 (DN) in BHs honeys (Table 1). Moloudian and Ajilouni, Sujirapinyokul reported 17.75-28.68 (DN) for Iranian honeys and 9.43-25.4 (DN) Australian honeys which are similar to present result. Diafat reported 43.67-129.49 (DN) for Algerian honeys which was higher than present study.

HMF content of honeys: Hydroxymethylfurfural (HMF) is formed during the degradation of sugar to produce furanic compound from hexoses dehydration in acidic medium [27]. The HMF content has been used to determine freshness in honey. Although, in natural honey, there should be low or no concentration of HMF, which is used to indicate the freshness of honey. The evaluated HMF content in the current

Table 3. Mineral content of FHs and BHs honey in Delta (n=16).

Type	Potassium (mg/kg)	Sodium (mg/kg)	Calcium (mg/kg)	Magnesium (mg/kg)	Iron (mg/kg)	Zinc (mg/kg)	Copper (mg/kg)	Phosphorus (mg/kg)	
FHs (n=8)	mean value ± Sd	662.98 ± 79.6 ^a	568.33 ± 39.6 ^b	272.75 ± 15.9 ^b	46.48 ± 2.3 ^b	24.1 ± 1.0 ^b	2.17 ± 0.05 ^b	2.14 ± 0.03 ^b	0.22 ± 0.01 ^a
	min	587.6	499.9	256.8	42.7	22.7	2.13	2.12	0.201
	max	786.7	598.9	289.5	48.8	25.6	2.24	2.19	0.232
BHs (n=8)	Mean value ± SD	563.08 ± 79.6 ^b	485.83 ± 17.4 ^a	219.78 ± 49.2 ^a	23.85 ± 3.61 ^a	14.2 ± 1.26 ^a	1.16 ± 0.05 ^a	1.09 ± 0.04 ^a	0.13 ± 0.03 ^b
	min	487.7	456.8	155.6	18.6	12.5	1.12	1.01	0.101
	max	686.8	489.9	277.6	27.8	15.9	1.24	1.12	0.124

Mean value ± Sd, having different superscript are significantly different (p<0.05) in the same column.

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research was lower than the limit (not more than 40 mg/kg) recommended [28]. The FHs and BHs displayed significant difference ($p < 0.05$). On the other hand, FHs honeys ranging from 1.70 to 4.07 mg/kg has mean value 3.04 ± 0.89 mg/kg, and for the BHs honeys ranging from 25.6 to 38.5 mg/kg has mean value 32.85 ± 4.67 mg/kg (Table 1). The HMF content values reported have been validated by Sakac, Kivrak and Boussaid who documented similar HMF content 1.19 to 3.37 mg/kg, 0.58 to 3.87 mg/kg and 24.07 to 35.49 mg/kg in Serbian, Turkish and Tunisian honeys respectively. The HMF content was lesser than those proposed by Sajid who reported 316.86 to 516.26 mg/kg for Pakistan honeys.

Invertase number of honeys: Invertase is an enzyme present in honey which is widely used in Europe as a contributing factor of freshness [29]. Its concentration depends on freshness and geographical origins of the honey. The FHs and BHs displayed significant difference ($p < 0.05$). The Invertase activity ranged from 178.78 to 187.7 unit/kg in the tested FHs honeys and from 69.8 to 78.9 unit/kg in BHs honeys (Table 1). In Addition to that, all honey samples contain a significant invertase number. Note that all analysed samples were within the standard ≥ 40 unit/kg honey Codex Alimentarius Commission. Similar values were obtained by Boussaid who analysed Tunisian honeys (46.25 to 184.68 unit/kg). Although lower values (1.47 to 15.2 unit/kg) were recorded [30].

Sugar content in honeys: There are several sugars present in honey, but monosaccharides (e.g. fructose and glucose) and disaccharides (e.g. sucrose) are essential sugars found in honey [31]. In several researches, fructose has been the essential sugar found in honey followed by glucose during the quantitation of sugars in honey [32]. The glucose, fructose, and sucrose concentrations in different honey are affected greatly by botanical and geographical origin, climatic factor, processing, and storage techniques [33,34]. The FHs and BHs honey mean values (Table 2) for glucose and fructose displayed insignificant difference ($p > 0.05$) within the two types of honey. The fructose and glucose content displayed insignificant difference ($p > 0.05$) within the two types of honey. The fructose and glucose content of Spain honeys (ranges: 35.9 to 42.1 g/100 g and 29.2 to 38.7 g/100 g), and Hatay region honeys (27.8 to 42.8 g/100 g and 20.7 to 37.9 g/100 g) recorded by Manzanares and Yucel & Sultanoğlu are similar to current results. The F+G contents depend on the amount of glucose and fructose present in the honey. These current research shows that BHs honey contains high amount of fructose and glucose compared to FHs honey making the honey samples not to be easily granulated. The F+G for FHs and BHs displayed insignificant difference ($p > 0.05$) within the two types of honey (Table 2). The F+G was more than the limit minimum value 60 g/100 g, which is the standard Codex Alimentarius Commission; European Commission, without significant differences ($p > 0.05$). The F+G results were within Egyptian honeys values (15.11 to 72.36 g/100 g) reported by El Sohaimy and higher than Nigerian honey (36.3 to 40.8 g/100 g) reported by Shugaba. The F/G ratio (Table 2) is used to check the crystallization of honey and crystallization of honey is very slow when fructose/glucose ratio in honey sample exceeds the limit 1.3. The F/G ratio in

honey samples were within the range of reported [35,36]. The crystallization of honey can be determined with the fructose/glucose ratio, making the current research samples with high fructose/glucose ratio to be slow to crystallization, since glucose dissolve easily in water when compared with fructose [37,38]. The crystallization of honey is rapid when ratio of fructose and glucose is below 1.0 and slow when the ratio is greater than 1.0 [39]. Sugars formed in honey contains about 75% of monosaccharides, disaccharides of about 10–15% and little quantity of other sugars. The sugars formed in the honey are responsible for variety of properties such as heat capacity, adhesiveness, deliquescent, and crystallization. The composition of sugars is built upon the type of flowers used by the bees, geographical region, climatic condition, processing and storage processes. The sucrose content in honey is another parameter use to verify the authenticity of honey following proline content and Electrical conductivity. The FHs and BHs displayed significant difference ($p < 0.05$) within the limit (not more than 5 g/100 g), which is the standard by Codex Alimentarius Commission 2001; European Commission. The sucrose concentration of current research was within the range of Poland honey (0.72 to 6.03 g/100 g) and below Ecuadorian honey (3.72 g/100 g) recorded by Popek and Guerrini. The low sucrose contents in researched samples indicates no adulteration (addition of low-cost sweeteners e.g. cane or refined sugars) and early harvest (indicating that the sucrose in honey samples were totally converted into sugars e.g. glucose and fructose) [40,41]. The sucrose quantity is evaluated with the aim to detect some unsuitable manipulation in honey, and high percentage may be as a result of several adulterations, such as mixing with low-price sweeteners like sugar cane, which means that the sucrose was not completely broken down to glucose and fructose, or feeding the honeybees with syrups of sucrose, resulting to high commercial profit.

Lipid content in honeys: Lipids are in part responsible for the physical chemical features of foods and the fatty acid esters are of major nutritional interest [42]. In FHs honey, the mean value was 0.38 ± 0.01 %, ranging from 0.37 to 0.39 %; and for the BHs honey, it was 0.38 ± 0.01 %. The minimum value detected for this honey was 0.37 % and the maximum was 0.38 %. The results obtained for total fat in honey samples were showing some homogeneity ($p > 0.05$). It is important to remember that it is not very common to determine lipids that could originate in bees' pollen, which is difficult in comparing the findings.

Mineral contents

The concentration of minerals in honey depends on its geographical and botanical region. Metals are long-term stable in honey, obtained from soil, taken around the root system to plant nectar [43,44]. The mineral concentrations of FHs and BHs honey samples are presented in table 3. Concentration level of K ranged from 587.6 to 786.7 mg/kg and 487.7 to 686.8 mg/kg (Table 3). A significant difference ($p < 0.05$) was noted between FHs and BHs honeys Zhou and Chudzinska & Baralkiewicz recorded potassium content from China (1081.4 mg/kg) and honey from Poland (2641.9 mg/kg) were above the range of present study.

Table 4. Results of the qualitative test of honey in Delta.

	Lund (mL)	Fiehe	Lugol
FHs (n=8)	2.45 ± 0.27	Neg	Neg
BHs (n=8)	1.95 ± 0.35	Neg	Neg
Pure standard honey	0.6 – 3.0	Neg	Neg

Neg-negative.

Sodium represents the second-most abundant element discovered in honey samples. The concentration of Na ranged from 499.9 to 598.9 mg/kg and 456.8 to 489.9 mg/kg. It was lower than honeys produced from Turkey (52.4 to 289.2 mg/kg), Spain (9 to 152 mg/kg) and Poland (21.6 to 28.4 mg/kg) reported [45-46].

Calcium is the third-most abundant element discovered in honey samples. The concentration of Ca ranged from 256.8 to 289.5 mg/kg and 155.6 to 277.6 mg/kg (Table 3). The lower concentration was found in BHs honey and higher concentration was found in FHs honey. The FHs and BHs displayed significant difference ($p < 0.05$). Silva reported calcium levels (10.28 to 93.37 mg/kg) which were below the range of present study. Magnesium and iron contain lower quantity of minerals. The concentration of magnesium (mg) found in all samples, ranged from 42.7 to 48.8 mg/kg and 18.6 to 27.8 mg/kg. Higher concentration of magnesium was found in FHs Honey and lower was found in BHs honey. The FHs and BHs displayed significant difference ($p < 0.05$). The magnesium concentration possesses the same order of level as reported [47,48]. The concentrations of Zn and Cu were measured as trace elements between honey samples (less than 3 mg/kg), while the concentration of phosphorus was less than 0.3 mg/kg. The FHs and BHs displayed significant difference ($p < 0.05$) among zinc, copper and phosphorus concentrations.

Qualitative results

Fiehe's result: The detection of HMF during dehydration of fructose from acidic hydrolysis of sucrose is the Fiehe's test. This furfural derivative reacts with resorcinol producing a color. If the color is red the test is regarded as positive [49,50]. In this analysis, all samples of the two honey forms were evaluated negatively (Table 4), Confirming the findings of the HMF quantitative test showing that this natural substance is fresh.

Lugol's reaction result: This evaluation is based on iodine and-potassium iodine response to glucose, which generates a tainted solution forming red purple to blue coloration is the Lugol's reaction. The color intensity varies depending on the amount of glucose dextrines. Condition that the tainted solution is blue the test will be regarded as positive [51,52]. Throughout this analysis, the Lugol's reaction of all honey samples was negative (Table 4), confirming that adulteration is not present. The findings obtained in the quantitative tests are verified in this sense by this rapid test.

Lund's reaction result: The precipitation of proline in honey samples by reacting with tannic acid is the Lund's reaction. A positive confirmation indicating honey purity when a precipitate volume (0.6-3.0 mL) is observed [48]. In accordance with precipitate volume of natural honeys (2.45 ±

0.27 mL) and commercial honeys (1.95 ± 0.35 mL) samples (Table 4) were within the limit (0.6 to 3.0 mL) indicating the purity of honey [53-55].

Conclusion

The physicochemical characterization of FHs and BHs honey samples collected from Delta State, Nigeria during 2021 was examined to review the quality of honey samples. The FHs displayed good physicochemical properties when compared to BHs. The presence of metals like K, Na, Ca and Mg in all honey samples represents the high nutritional values of Delta honey. In this present study, the qualitative test was conducted to test the consistency of quantitative results. The findings in this current research showed that fresh honey samples have good consumable quality when compared to branded honey samples. The high HMF content and low diastase number indicated in branded honey samples denoted a slight increase in temperature during processing and improper storage techniques. In Delta, fresh honey has been recommended more in treating several infectious diseases due to its high pharmacological potentials. Most of the knowledge expressed hereby is entirely new and applicable not only to academics but in real life.

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