MedCrave
Step into the World of Research
Journal of Analytical & Pharmaceutical research

Research Article
Open Access
CrossMark

The physicochemical analysis and health benefits of fresh and branded honey produced in delta state, Nigeria

Volume 11 Issue 2 - 2022

Great Iruoghene Edo,[1,2] Favour Ogheneoruese Onoharigho,[3] Oghenerume Lucky Emakpor,[4] Patrick Othuke Akpoghelie[5]
[1]Faculty of Science, Department of Petroleum Chemistry, Delta State University of Science & Technology, Ozoro, Nigeria
[2]Faculty of Arts and Sciences, Department of Chemistry, Cyprus International University, Nicosia, Cyprus
[3]Faculty of Science, Department of Biochemistry, Elizade University, Ondo, Nigeria
[4]Faculty of Agriculture, Department of Agronomy, Delta State University, Delta State, Nigeria
[5]Department of Food Science and Technology, Delta State University of Science and Technology, Ozoro, Nigeria

Correspondence: Great Iruoghene Edo, Faculty of Science, Department of Petroleum Chemistry, Delta State University of Science & Technology, Ozoro, Nigeria, Email greatiruo@gmail.com

Received: May 30, 2022 | **Published:** June 22, 2022

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 fresh and branded honey samples produced in Delta State 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 produced from living parts of flowers.[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.[4–6]

The physicochemical analysis parameters are based on the nectar`s (type and region), soil composition, climatic conditions, processing, storage and transportat[7]. 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.[8]

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 2001. 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, Poland and Serbia,[9,10] in Africa, mainly in Nigeria, Benin and Morocco,[7,11,12] and in South America, mainly in Ecuador.[13] 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*.[14] 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.[10,15] However, honey has an important role in local medicine in Delta. It has been primarily used for wound remedies and intestinal infections.[6,16] 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.

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.[17]

Electrical conductivity

A conductivity meter (wp 600 series) was used to determine the conductivity.[17]

Color intensity

The color intensity was determined in accordance with the mean absorption method.[18] 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 (0.45µl). The absorbance of the honey solution filtrate was measured at 450nm and 720nm 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.[17]

Ash content

Ash content was measured through the gravimetric method.[19] 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.[17]

Invertase number

Invertase number was determined by spectrophotometric method.[20]

Hydroxymethylfurfuraldehyde (HMF)

The HMF content was measured through the spectrophotometric method.[17]

Sugar content

External calibration curves constructed from the standard solutions was used to quantify sugars in the sample.[10]

Lipid content

The crude fat was measured using the gravimetric method.[19]

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

This test were determined using the qualitative method.[21]

Mineral contents

The mineral composition was determined by the spectrometric method.

Statistical Analysis

The analysis was carried out in triplicate (n = 3) and results were expressed as mean ± 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 sixteen samples of honey (FHs n = 8, BHs n= 8) in 2021 from Delta State, Nigeria were investigated. Tables 1 - 2 represents 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,[22] lifespan, stability and quality of honey is influence by the pH. All the analysed BHs and FHs honeys were all acidic promoting the healing of wounds by releasing oxygen from haemoglobin 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[9,23] are in accordance with our results. However,[7] recorded pH range (5.08 – 5.48) for Benin and[7] recorded pH range (5.08 – 5.18) were higher than the present study.

Figure 1 Map of Delta State, Nigeria.

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.[24] 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.[25] 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[26] an.[62,39] 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[12] which also can be used to identify the botanical origin of honey.[27] The FHs and BHs displayed significant difference ($p < 0.05$). All honey samples (Table 1) analysed in this current research were within the international limit ≤0.8 mS/cm (FHs honey mean value of 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 [25] and current results are more than those recorded by[28] and comparable results was previously recorded by Lokossou.[10]

Color intensity of honeys

The color intensity is usually represented by AB_{450}, which is an essential parameter for detecting the existence of certain pigments having antioxidant activities.[18, 29] There is no international limit mean values of color intensity in FHs honey (319 ± 4.18) and BHs honey (372 ± 5.49) samples (Table 1) and a significant difference ($p < 0.05$) were noted between analysed honey samples. This is validated in the research of[30,31] and[32] The resulted variation in color intensity may be as a result of pigments contaminated during handling, processing, and storage techniques during development of honey.[18]

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.[10,23] The moisture content can alter different physicochemical parameters.[33] 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 (Table 1) samples were within the international limit (≤21%) recommended.[17] The FHs and displayed significant difference ($p < 0.05$) than BHs. The moisture content values reported have been validated by[34] and[35] Although,[36] and[10] 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.[37] All honey samples (Table 1) analysed in this current research were within the limit (≤0.6%) proposed by Bogdanov[25]. However, the results (Table 1) 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[37] who analysed Northwest Portugal honeys. The ash content recorded by[7] 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.[3]

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[10] and a criterion for determining honey quality[13] 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 (≥180mg/kg) recommended.[25] 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[13] and greater than Tunisian honeys (39.62 to 102.22 mg/kg) reported by[10,38] 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.[25] 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.[1] In this current research, all examined honey samples were above the minimum value of ≥8, which is the standard[25] 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).[39] and[40] reported 17.75–28.68 (DN) for Iranian honeys and 9.43–25.4 (DN) Australian honeys which are similar to present result.[41 ,42] 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.[11] 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 research was lower than the limit (not more than 40 mg/kg) recommended.[25] 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[11, 43] and[10] 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[44] 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.[44] 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.[25] Similar values were obtained by[10] who analysed Tunisian honeys (46.25 to 184.68 unit/kg). Although lower values (1.47 to 15.2 unit/kg) were recorded by.[8]

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.[45] In several research, fructose has been the essential sugar found in honey followed by glucose during the quantitation of sugars in honey.[46] The glucose, fructose, and sucrose concentrations in different honey is affected greatly by botanical and geographical origin, climatic factor, processing, and storage techniques.[47] 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 42.1g/100g and 29.2 to 38.7g/100g), and Hatay region honeys (27.8 to 42.8g/100g and 20.7 to 37.9g/100g) recorded by.[48] and (Yücel & Sultanoğlu, 2013) are similar to current results. The F + G contents depends 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[25] without significant differences ($p>0.05$). The F + G results were within Egyptian honeys values (15.11 to 72.36 g/100g) reported by[23] and higher than Nigerian honey (36.3 to 40.8 g/100g) reported by.[49] The F/G ratio (Table 2) is used to check the crystallization of honey[50] and crystallization of honey is very slow when fructose/glucose ratio in honey sample exceeds the limit 1.3.[51]

The F/G ratio in honey samples were within the range of reported by.[8] and.[51] 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.[52] 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.[52] 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.[25] The sucrose concentration of current research was within the range of Poland honey (0.72 to 6.03 g/100g) and below Ecuadorian honey (3.72 g/100g) recorded by.[53] and.[54]

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)[29,55,56] 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,[57] 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.[58]

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.[59] 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 % (Table 2). 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.[31] 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. A significant difference ($p<0.05$) was noted between FHs and BHs honeys.[39] and[60] recorded potassium content from China (1081.4 mg/kg) and honey from Poland (2641.9 mg/kg) were above the range of present study. 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 (Table 3). 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 by.[4,5,62]and.[60]

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 ($p<0.05$).[62] 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 (Table 3). 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 by.[61] 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 (Table 3).

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 ± Sd	4.67 ± 0.34a	16.8 ± 4.97b	0.60 ± 0.06a	319 ± 4.18a	13.1 ± 1.02a	0.58 ± 0.15a	346.58 ± 43.30a	31.99 ± 8.43b	3.04 ± 0.89b	183.28 ± 3.67a
	min	4.13	10.3	0.53	312	11.7	0.5	286.33	22.5	1.7	178.78
	max	4.98	24	0.68	323	14.4	0.77	406.97	44.77	4.07	187.7
BHs (n=8)	mean value ± Sd	4.40 ± 0.07b	19.0 ± 2.34a	0.41 ± 0.01b	372 ± 5.49b	17.1 ± 0.27b	0.48 ± 0.18b	296.83 ± 37.25b	13.03 ± 1.58a	32.85 ± 4.67a	73.9 ± 3.61b
	min	4.34	16.3	0.39	205	16.8	0.23	241.47	11.1	25.6	69.8
	max	4.52	22.7	0.42	530	17.5	0.7	341.07	15.5	38.5	78.9

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

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 ± Sd	30.1 ± 1.47a	35.8 ± 1.54a	65.9 ± 2.61b	1.19 ± 0.05a	0.99 ± 0.25a	0.38 ± 0.01a
	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 ± Sd	31.6 ± 1.49a	37.7 ± 1.83a	69.3 ± 2.44b	1.20 ± 0.08a	2.95 ± 0.52b	0.38 ± 0.01a
	min	29.5	36.3	66	1.1	2.11	0.37
	max	33.7	40.8	72.3	1.3	3.49	0.38

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

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 ± 79.6a	568.33 ± 39.8b	272.75 ± 15.9b	46.48 ± 2.33b	24.1 ± 1.07b	2.17 ± 0.05b	2.14 ± 0.03b	0.22 ± 0.01a
	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 ± 79.6b	485.83 ± 17.4a	219.78 ± 49.2a	23.85 ± 3.61a	14.2 ± 1.26a	1.16 ± 0.05a	1.09 ± 0.04a	0.13 ± 0.03b
	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.

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

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.[63] 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 [63] 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.[63] 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.[63]

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.[64]

Acknowledgments

None.

Conflicts of interest

The author declared there is no conflict of interest.

References

1. Ajlouni S, Sujirapinyokul P. Hydroxymethylfurfuraldehyde and amylase contents in Australian honey. *Food Chemistry*. 2010;119(3):1000–1005.
2. Terrab A, Díez MJ, Heredia, et al. Characterisation of Moroccan unifloral honeys by their physicochemical characteristics. *Food Chemistry*. 2002;79(3):373–379.
3. Kamal MA, Klein P. Determination of sugars in honey by liquid chromatography. *Saudi Journal of Biological Sciences.* 2011;18(1):17–21.
4. Yücel Y, Sultanoğlu P. Characterization of Hatay honeys according to their multi-element analysis using ICP-OES combined with chemometrics. *Food Chemistry*. 2013;140(1–2):231–237.
5. Yücel Y, Sultanoğlu P. Characterization of honeys from Hatay Region by their physicochemical properties combined with chemometrics. *Food Bioscience*. 2013;1:16–25.
6. Nwosu LC, Edo GI, Ozgor E. The phytochemical, proximate, pharmacological, GC-MS analysis of Cyperus esculentus (Tiger nut): A fully validated approach in health, food and nutrition. *Food Bioscience*. (2022);101551.
7. Azonwade FE, Paraïso A, Agbangnan Dossa C, et al. Physicochemical Characteristics and Microbiological Quality of Honey Produced in Benin. *Journal of Food Quality*. 2018;1–13.
8. da S Sant'ana R, de Carvalho CAL, Oda-Souza M, et al. Characterization of honey of stingless bees from the Brazilian semi-arid region. *Food Chemistry*. 2020;327:127041.
9. Bakier S, Miastkowski K, Bakoniuk JR. Rheological Properties of Some Honeys in Liquefied and Crystallised States. *Journal of Apicultural Science*. 2016;60(2):153–166.
10. Boussaid A, Chouaibi M, Rezig L, et al. Physicochemical and bioactive properties of six honey samples from various floral origins from Tunisia. *Arabian Journal of Chemistry*. 2018;11(2):265–274.
11. Sakač MB, Jovanov PT, Marić AZ, et al. Physicochemical properties and mineral content of honey samples from Vojvodina (Republic of Serbia). *Food Chemistry*. 2019;276:15–21.
12. Lokossou SC, Tchobo FP, Yédomonhan H, et al. Physicochemical Characterization and Polyphenolic Content of Beninese Honeys. *International Scholarly Research Notices*. 2017;1–8.
13. Aazza S, Elamine Y, El-Guendouz S, et al. Physicochemical characterization and antioxidant activity of honey with Eragrostis spp. pollen predominance. *Journal of Food Biochemistry*. 2018;42(1):e12431.
14. Guerrini A, Bruni R, Maietti S, et al. Ecuadorian stingless bee (Meliponinae) honey: A chemical and functional profile of an ancient health product. *Food Chemistry*. 2009;114(4):1413–1420.
15. Abdullah I, Gary SR, Marla S. Field trial of honey bee colonies bred for mechanisms of resistance against Varroa destructor. *Apidologie*. 2007;38:67–76.
16. Edo GI. Antibacterial, phytochemical and GC-MS analysis of Thevetia peruviana extracts: An approach in drug formulation. *Natural Resources for Human Health*. 2022a.
17. Bogdanov S. Harmonised Methods of the International IHC. *Bee Product Science.* 2009;(5):1–62.
18. Beretta G, Granata P, Ferrero M, et al. Standardization of antioxidant properties of honey by a combination of spectrophotometric/fluorimetric assays and chemometrics. *Analytica Chimica Acta*. 2005;533(2):185–191.
19. Al-mentafji HN. *Official Methods of Analysis of AOAC International*. AOAC. 2006.
20. Makhloufi C, Kerkvliet JD, D'Albore GR, et al. Characterization of Algerian honeys by palynological and physico-chemical methods. *Apidologie*. 2010;41(5):509–521.
21. Odair Zenebon, Neus Sadocco Pascuet PT. *Métodos Físicos-Quimicos Para Análise de Alimentos*, (Instituto Adolfo Lutz). *1ª Edição Digital*. 2008;1020.
22. Terrab A, Díez MJ, Heredia FJ. Characterisation of Moroccan unifloral honeys by their physicochemical characteristics. *Food Chemistry*. 2002;79(3):373–379.
23. El Sohaimy SA, Masry SHD, Shehata MG. Physicochemical characteristics of honey from different origins. *Annals of Agricultural Sciences*. 2015;60(2):279–287.
24. Duman E. Some physico-chemical properties, fatty acid compositions, macro-micro minerals and sterol contents of two variety tigernut tubers and oils harvested from east mediterranean region. *Food Science and Technology*. 2019;39:610–615.
25. Bogdanov S, Jurendic T, Sieber R, et al. Honey for Nutrition and Health: A Review. *Journal of the American College of Nutrition*. 2008;27(6):677–689.
26. El-Haskoury R, Kriaa W, Lyoussi B, et al. Ceratonia siliqua honeys from Morocco: Physicochemical properties, mineral contents, and antioxidant activities. *Journal of Food and Drug Analysis*. 2018;26(1):67–73.
27. Terrab A, González AG, Díez MJ, et al. Mineral content and electrical conductivity of the honeys produced in Northwest Morocco and their contribution to the characterisation of unifloral honeys. *Journal of the Science of Food and Agriculture*. 2003;*83*(7):637–643.
28. Guler A, Bakan A, Nisbet C, et al. Determination of important biochemical properties of honey to discriminate pure and adulterated honey with sucrose (Saccharum officinarum L.) syrup. *Food Chemistry*. 2007;105(3):1119–1125.
29. Cimpoiu C, Hosu A, Miclaus V, et al. Determination of the floral origin of some Romanian honeys on the basis of physical and biochemical properties. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*. 2013;100:149–154.
30. Kek SP, Chin N L, Yusof YA, et al. Total Phenolic Contents and Colour Intensity of Malaysian Honeys from the Apis spp. and Trigona spp. Bees. *Agriculture and Agricultural Science Procedia*. 2014;2:150–155.
31. Puscas A, Hosu A, Cimpoiu C. Application of a newly developed and validated high-performance thin-layer chromatographic method to control honey adulteration. *Journal of Chromatography A*. 2013;1272:132–135.
32. Saxena S, Gautam S, Sharma A. Physical, biochemical and antioxidant properties of some Indian honeys. *Food Chemistry*. 2010;118(2):391–397.
33. Escuredo O, Míguez M, Fernández-González M, et al. Nutritional value and antioxidant activity of honeys produced in a European Atlantic area. *Food Chemistry*. 2013;138(2–3):851–856.
34. Kayacier A, karaman S. Rheological and some physicochemical characteristics of selected turkish honeys. *Journal of Texture Studies*. 2008;39(1):17–27.
35. Karabagias I, Maia M, Karabagias V, et al. Characterization of Eucalyptus, Chestnut and Heather Honeys from Portugal Using Multi-Parameter Analysis and Chemo-Calculus. *Foods*. 2018;7(12):194.
36. Gidamis AB, Chove BE, Shayo NB, et al. Quality Evaluation of Honey Harvested From Selected Areas in Tanzania With Special Emphasis on Hydroxymethyl Furfural (HMF) Levels. *Plant Foods for Human Nutrition*. 2004;59(3):29–132.

37. Feás X, Pires J, Iglesias A, et al. Characterization of artisanal honey produced on the Northwest of Portugal by melissopalynological and physico-chemical data. *Food and Chemical Toxicology*. 2010;48(12):3462–3470.

38. Wakgari M, Yigezu G. Honeybee keeping constraints and future prospects. *Cogent Food & Agriculture*. 2021;7(1):1872192.

39. Zhou J, Suo Z, Zhao P, et al. Jujube honey from china: Physicochemical characteristics and mineral contents. *Journal of Food Science*. 2013;78(3):387–394.

40. Naila A, Flint SH, Sulaiman AZ, et al. Classical and novel approaches to the analysis of honey and detection of adulterants. *Food Control*. 2018;90:152–165.

41. Samborska K. Powdered honey – drying methods and parameters, types of carriers and drying aids, physicochemical properties and storage stability. *Trends in Food Science and Technology*. 2019;88:133–142.

42. Kahraman T, Buyukunal SK, Vural A, et al. Physico-chemical properties in honey from different regions of Turkey. *Food Chemistry*. 2010;123(1):41–44.

43. Kivrak Ş, kivrak İ, karababa E. Characterization of Turkish honeys regarding of physicochemical properties, and their adulteration analysis. *Food Science and Technology*. 2016;37(1):80–89.

44. Sajid M, Yamin M, Asad F, et al. Comparative study of physio-chemical analysis of fresh and branded honeys from Pakistan. *Saudi Journal of Biological Sciences*. 2020;27(1):173–176.

45. Tornuk F, Karaman S, Ozturk I, et al. Quality characterization of artisanal and retail Turkish blossom honeys: Determination of physicochemical, microbiological, bioactive properties and aroma profile. *Industrial Crops and Products*. 2013;46:124–131.

46. Ruiz-Matute AI, Sanz ML, Martinez-Castro I. Use of gas chromatography–mass spectrometry for identification of a new disaccharide in honey. *Journal of Chromatography A*. 2007;1157(1–2):480–483.

47. da Costa GAF, Morais MG, Saldanha AA, et al. Antioxidant, Antibacterial, Cytotoxic, and Anti-Inflammatory Potential of the Leaves of Solanum lycocarpum A St Hil (Solanaceae). *Evidence-Based Complementary and Alternative Medicine*. 2015;1–8.

48. Bentabol MA, Hernández GZ, Rodríguez GB, et al. Physicochemical characteristics of minor monofloral honeys from Tenerife, Spain. *LWT - Food Science and Technology*. 2014;55(2):572–578.

49. Shugaba A. Analysis of Biochemical Composition of Honey Samples from North-East Nigeria. *Biochemistry & Analytical Biochemistry*, 2012;2(3).

50. Pontis JA, Costa LAMA da, Silva SJR da, et al. Color, phenolic and flavonoid content, and antioxidant activity of honey from Roraima, Brazil. *Food Science and Technology*. 2014;34(1):69–73.

51. Missio da SP, Gonzaga LV, Biluca FC, et al. Stability of Brazilian Apis mellifera L. honey during prolonged storage: Physicochemical parameters and bioactive compounds. *Lwt*. 2020;129:109521.

52. Radia D, Azzedine C, Nicoletta D, et al. Physicochemical parameters and antibiotics residuals in Algerian honey. *African Journal of Biotechnology*. 2015;14(14):1242–1251.

53. Popek S, Halagarda M, Kursa K. A new model to identify botanical origin of Polish honeys based on the physicochemical parameters and chemometric analysis. *LWT - Food Science and Technology*. 2017;77:482–487.

54. Guerrini A, Bruni R, Maietti S, et al. Ecuadorian stingless bee (Meliponinae) honey: A chemical and functional profile of an ancient health product. *Food Chemistry*. 2009;114(4):1413–1420.

55. Escuredo O, Dobre I, Fernández-González, et al. Contribution of botanical origin and sugar composition of honeys on the crystallization phenomenon. *Food Chemistry*. 2014;149:84–90.

56. Onyibe PN, Edo GI, Nwosu LC, et al. Effects of vernonia amygdalina fractionate on glutathione reductase and glutathione-S-transferase on alloxan induced diabetes wistar rat. *Biocatalysis and Agricultural Biotechnology*. 2021;36:102118.

57. Hassan F, Edo GI, Nwosu LC, et al. An inventory of medicinal plants used as sedative, analgesic and blood tonic in Abeokuta, Ogun State, Nigeria. *Acta Ecologica Sinica*. 2021.

58. Edo GI. Effects of paraquat dichloride on adult male wistar rat. an approach in the toxicity of body weights and hematological tissues. *Journal of Analytical & Pharmaceutical Research*. 2022b;11(1):1–7.

59. Estevinho LM, Feás X, Seijas JA, et al. Organic honey from Trás-Os-Montes region (Portugal): Chemical, palynological, microbiological and bioactive compounds characterization. *Food and Chemical Toxicology*. 2012;50(2):258–264.

60. Chudzinska M, Baralkiewicz D. Estimation of honey authenticity by multielements characteristics using inductively coupled plasma-mass spectrometry (ICP-MS) combined with chemometrics. *Food and Chemical Toxicology*. 2010;48(1):284–290.

61. de Alda-Garcilope C, Gallego-Picó A, Bravo-Yagüe JC, et al. Characterization of Spanish honeys with protected designation of origin "Miel de Granada" according to their mineral content. *Food Chemistry*. 2012;135(3):1785–1788.

62. Silva MS, Rabadzhiev Y, Eller MR, et al. Microorganisms in Honey. In *Honey Analysis*. *InTech*. 2017.

63. de Almeida-Muradian LB, Stramm KM, Horita A, et al. Comparative study of the physicochemical and palynological characteristics of honey from Melipona subnitida and Apis mellifera. *International Journal of Food Science & Technology*. 2013;*48*(8):1698–1706.

64. Pohl P, Bielawska-Pohl A, Dzimitrowicz A, et al. Recent achievements in element analysis of bee honeys by atomic and mass spectrometry methods. *TrAC Trends in Analytical Chemistry*. 2017;93:67–77.