

Quality Profile of Honey Marketed In Different Locations in Enugu Metropolis, Nigeria

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Abstract: Honey is widely consumed for its nutritional and medicinal benefits. However, poor handling and storage practices may compromise its quality and safety. This study therefore evaluated the quality profile of honey marketed in different locations within Enugu metropolis. Eighteen honey samples were randomly purchased from Ogbete Main Market (Enugu North), Mayor Market (Enugu South), and Abakpa Market (Enugu East), alongside an unadulterated control sample. The phytochemical composition was assessed using qualitative screening and High-Performance Liquid Chromatography (HPLC), while trace metals were determined using Atomic Absorption Spectrometry (AAS). All the assayed honey samples contained saponins, tannins, glycosides, terpenoids, steroids, flavonoids, and phenolics, with strong reactions observed for flavonoids and phenolics. HPLC analysis detected alkaloids including lunamarin, ribalinidine, sparteine, and ephedrine in both market samples and the control, whereas these compounds were not detected by qualitative screening. HPLC analysis further confirmed the presence of catechin, epicatechin, flavan-3-ols, rutin, naringenin, naringin, proanthocyanidins, and anthocyanins, with catechin and flavan-3-ols recording the highest peak areas. The peak areas of the control sample were generally higher than those of the market samples. Metal analysis showed iron as the most abundant element. Lead, cadmium, and arsenic were detected only in market samples at concentrations ranging from 0.008 to 0.021 mg/kg, while they were absent in the control sample. However, all detected metals were within WHO/FAO permissible limits. This study provides baseline data on the phytochemical and traces metal content of honey in Enugu and confirms that, although market handling introduces trace metals, the products remain within safe limits.

Keywords: Alkaloid, Flavonoid, Metals, Phenolic, Phytochemical, Qualitative, Quantitative, Unadulteration.

1. INTRODUCTION

Honey is a natural, viscous, and nutritionally valuable liquid product synthesized by honey bees from the nectar of flowers (Kolawole et al., 2024). Honey is a principal product of bees, presented as a viscous, sweet, and aromatic food. It originates from flower nectar or from sugary excretions of sap-feeding insects. Worker bees gather this material, enzymatically transform it, place it into comb cells, reduce its moisture content, store it, and allow it to mature before it is fully ripened (Majewska et al., 2019).

The physicochemical properties flavour, and texture of honey, and thus its overall quality, differ depending on multiple factors. These include climate and soil of the region, ambient temperature, the botanical source of nectar, bee species, sugar profile, as well as handling during extraction and the conditions under which it is stored (Areda 2015).

Honey has long been consumed by humans as a natural food. It plays an important role in nutrition, medicine, and various industries. Widely regarded as one of the best natural health foods, it possesses numerous therapeutic and nutritional benefits. In many parts of Africa, honey has traditionally been harvested using indigenous methods (Osugwu et al., 2020).

It is rich in phytochemicals such as flavonoids and other polyphenols, which give it potential as a functional ingredient and as an antimicrobial agent. Its health benefits are linked to both antimicrobial and anti-inflammatory activities, and it has been used traditionally for treating skin wounds, cold and various gastrointestinal disorders (Amril et al., 2013).

This product has been traditionally and scientifically recognized for several therapeutic applications. It has been reported to confer cardio-metabolic benefits, including improvements in blood glucose control, lipid metabolism, and antioxidant status (Alvarez-Suarez et al., 2022; Ahmed et al., 2022). In addition, honey is widely used for wound healing due to its antimicrobial, anti-inflammatory, and tissue-regenerative properties. It is also commonly applied for cough and sore throat relief because of its soothing and antimicrobial effects (Almasaudi et al., 2020; Oduwole et al., 2018).

It is classified among the most commonly adulterated foods worldwide. The issue of honey adulteration is a global problem, as it adversely affects the nutritional value and health of consumers. Due to high market demand and limited supply, the practice of adulterating honey has become widespread (Ahmed et al., 2025). The high market value and constrained supply of honey as a natural commodity make it particularly vulnerable to fraudulent practices, such as dilution with lower-grade honey, sugars, and other substances (Damto 2021).

Even with existing regulations, adulterated and substandard honey products remain in circulation. In northwest Nigeria, more than 50% of honey sold in markets showed elevated HMF and sucrose levels or reduced sugar content, suggesting dilution with syrups or poor storage practices (Musa et al., 2023). To address this, advanced analytical methods such as isotope ratio mass spectrometry and rheological profiling are increasingly recognized as effective tools for distinguishing pure honey from adulterated samples (Ciursa and Oroian, 2021).

Beyond economic fraud, consumption of adulterated honey poses serious health risks. It may lead to fatty liver disease; acute and chronic kidney damage, elevated blood sugar and increased insulin secretion that can result in type 2 diabetes. It is also associated with abdominal obesity, elevated blood lipid levels, and hypertension (Sonia et al., 2017; Wang et al., 2015). The aim of this study was to evaluate the quality profiles of honey using qualitative and quantitative analysis in Enugu Metropolis, Nigeria.

2. MATERIALS AND METHODS

2.1 Sample Collection

A total of 18 commercial honey samples were purchased from three major markets in Enugu metropolis: Ogbete Main Market in Enugu North, Mayor Market in Enugu South, and Abakpa Market in Enugu East. Pure, unadulterated honey obtained from certified beekeepers in Opi, Nsukka was used as the control sample (Ugwu 2023).

2.2 Qualitative Phytochemical Screening Tests of Honey Samples

The honey sample was subjected to qualitative phytochemical screening using standard methods;

Test for Alkaloids:

A total of 0.4 g of honey sample was dissolved in 8 mL of distilled water. From this solution, 2 mL was taken and treated with Dragendorff's reagent (potassium bismuth iodide). The formation of turbidity or an orange-brown precipitate was taken as positive evidence for the presence of alkaloids.

Test for Saponins:

A total of 20 mL of honey sample was mixed with 20 mL of distilled water and boiled in a water bath for 5 minutes, after which it was filtered using filter paper. From the filtrate, 10 mL was collected and mixed with 5 mL of distilled water, then shaken vigorously to observe froth formation. Thereafter, 3 drops of olive oil were added to the froth and shaken vigorously. The formation of a stable emulsion was taken as evidence for the presence of saponins.

Test for Terpenoids:

To test for terpenoids, 5 mL of honey extract at a concentration of 1 mg/mL was mixed with 2 mL of chloroform. To this mixture, 3 mL of concentrated H_2SO_4 was carefully added along the side of the test tube. The development of a reddish-brown coloration at the interface was considered indicative of the presence of terpenoids.

Test for Steroids:

Five drops of concentrated H_2SO_4 were added to 1 mL of the honey extract in a test tube. The development of a red coloration was taken as an indication of the presence of steroids.

Test for Flavonoids:

A total of 50 mg of honey sample was dissolved in 100 mL of distilled water and filtered to obtain the filtrate. To 10 mL of the filtrate, 5 mL of diluted ammonia solution was added, followed by the addition of a few drops of concentrated H_2SO_4 . The appearance of a yellow coloration confirmed the presence of flavonoids.

Test for Tannins:

A total of 50 mg of honey sample was added to 20 mL of distilled water and boiled in a water bath, after which it was filtered. To the filtrate, 3 drops of 0.1% $FeCl_3$ solution were added. The development of brownish-green or blue-black coloration was taken as evidence for the presence of tannins.

Test for Glycosides:

To the honey extract dissolved in glacial acetic acid, 3 drops of ferric chloride solution were added, followed by the careful addition of concentrated H_2SO_4 along the side of the test tube. The appearance of a reddish-brown coloration at the interface of the two layers, with a bluish-green color in the upper layer, was taken as a positive indication of glycosides.

2.3 Quantitative Determination of Metals in Honey Samples using ASS

A total of 2.0 g of honey sample was digested with concentrated HNO_3 . The mixture was allowed to pre-digest at room temperature, and then heated gently on a hot plate until frothing ceased and brown fumes were minimal. Additional HNO_3 was added to ensure complete oxidation of organic matter, and heating continued until a clear digest was obtained. After cooling, the digest was diluted with deionized water, filtered, and made up to 100 mL in a volumetric flask. The resulting solution was analyzed for Fe, Zn, Cu, Mn, Pb, Cd, and As using Atomic Absorption Spectrophotometry (AAS) according to AOAC official methods for trace metals in food.

2.4 Quantitative Determination of Phenolics, Flavonoids and Alkaloids in Honey Samples using HPLC

HPLC was used for quantitative profiling of phytochemicals in the honey samples. Each sample (5 mL) was dissolved in distilled water, filtered through a 0.45 μm membrane filter, and transferred into HPLC vials. Separation was done using an HPLC system with a UV-Vis detector and C18 column. A mobile phase of methanol, acetonitrile, and water was used at a constant flow rate. A fixed injection volume was used and detection was at wavelengths suitable for phenolics and flavonoids. Compounds were identified by comparing retention times with standards and quantified using external calibration. Results were used to determine the phytochemical composition of the honey samples.

3. RESULTS

Table I: Qualitative Profile of Compounds in Honey Markey Samples and Control (Unadulterated)

Parameter	Ogbete (Enugu North)						Abakpa (Enugu South)						Mayor (Enugu East)						Control
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
Alkaloids	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Saponins	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Terpenoids	+	+	++	+	++	+	+	+	+	++	+	++	++	+	++	+	++	+	++
Steroids	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Flavonoids	++	+	++	++	+	++	++	++	++	++	++	++	++	++	++	++	++	++	++
Tannins	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Glycosides	++	++	++	++	+	++	++	++	++	++	++	++	++	++	++	++	++	++	++
Phenolics	++	+	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++

“++” = strong presence,

“+” = presence,

“–” = absence (no detectable reaction),

Control =Unadulterated Honey

TABLE II: Quantitative Profile of Trace Metals in Honey (mg/per/kg)

Parameter	Ogbete (Enugu North)						Abakpa (Enugu South)						Mayor (Enugu East)						Control	Acceptable range
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6		
Iron (Fe)	3.45 ^a	3.37 ^a	3.44 ^a	3.40 ^a	3.35 ^a	3.46 ^a	2.97 ^b	2.88 ^b	2.91 ^b	2.96 ^b	2.90 ^b	2.95 ^b	2.63 ^c	2.57 ^c	2.65 ^c	2.60 ^c	2.55 ^c	2.63 ^c	1.86 ^d	0.5–10
Zinc (Zn)	1.28 ^a	1.23 ^a	1.30 ^a	1.27 ^a	1.22 ^a	1.28 ^a	1.07 ^b	1.01 ^b	1.05 ^b	1.08 ^b	1.02 ^b	1.06 ^b	0.94 ^c	0.89 ^c	0.96 ^c	0.93 ^c	0.88 ^c	0.95 ^c	0.62 ^d	≤5 to 10
Copper (Cu)	0.44 ^a	0.39 ^a	0.45 ^a	0.42 ^a	0.38 ^a	0.46 ^a	0.38 ^b	0.33 ^b	0.36 ^b	0.36 ^b	0.32 ^b	0.39 ^b	0.33 ^c	0.28 ^c	0.33 ^c	0.31 ^c	0.27 ^c	0.34 ^c	0.19 ^d	≤2 to 5
Manganese (Mn)	0.60 ^a	0.55 ^a	0.61 ^a	0.58 ^a	0.54 ^a	0.62 ^a	0.51 ^b	0.46 ^b	0.51 ^b	0.50 ^b	0.45 ^b	0.53 ^b	0.45 ^c	0.40 ^c	0.45 ^c	0.44 ^c	0.39 ^c	0.47 ^c	0.28 ^d	≤2 to 82

ND = Not Detected at method detection limit.

Control = Unadulterated Honey

Superscript a, b and c are statistically different in all parameters at p<0.05

TABLE III: Quantitative Profile of Toxic Trace Metals in Honey (mg/per/kg)

Parameter	Ogbete (Enugu North)						Abakpa (Enugu South)						Mayor (Enugu East)						Control	Acceptable range
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6		
Lead (Pb)	0.020 ^a	0.015 ^a	0.020 ^a	0.018 ^a	0.014 ^a	0.021 ^a	0.016 ^b	0.012 ^b	0.016 ^b	0.015 ^b	0.011 ^b	0.018 ^b	0.013 ^c	0.009 ^c	0.013 ^c	0.012 ^c	0.008 ^c	0.015 ^c	ND ^d	≤0.10
Cadmium (Cd)	ND ^a	ND ^a	0.002 ^b	ND ^a	ND ^a	0.003 ^b	ND ^a	ND ^a	ND ^a	0.002 ^b	ND ^a	ND ^a	ND ^a	ND ^a	ND ^a	ND ^a	ND ^a	ND ^a	ND ^a	≤0.05
Arsenic (As)	ND ^a	ND ^a	ND ^a	0.004 ^b	ND ^a	ND ^a	ND ^a	ND ^a	ND ^a	0.003 ^b	ND ^a	ND ^a	ND ^a	ND ^a	ND ^a	ND ^a	ND ^a	ND ^a	ND ^a	≤0.10

ND = Not Detected at method detection limit.

Control = Unadulterated Honey

Superscript a, b and c are statistically different in all parameters at p<0.05

Table IV: Quantitative Profile of Compounds in Honey Market Samples

Component	Retention Time	Area	Height	External	Units
Proanthocyanin	0.386	2631.0434	206.270	2.4670	ppm
Lunamarin	0.873	4824.9767	377.473	7.0644	µg/ml
Cardiac glycoside	3.093	3387.3150	265.781	2.1020	µg/ml
Flavan-3-ol	5.483	2954.8422	231.937	1.7164	ppm
Anthocyanin	7.873	4968.0357	389.418	4.2608	µg/ml
Ribalinidine	9.350	3057.1151	240.132	1.3109	µg/ml
Naringenin	10.830	6002.7683	470.450	2.5366	µg/ml
Sparteine	14.036	3250.6604	255.555	5.8256	µg/ml
Rutin	19.973	4928.6840	387.165	3.0584	µg/ml
Cyanogenic glycoside	20.616	3419.6849	268.983	4.5964	ppm
Flavonones	23.363	6921.5652	536.497	5.9362	ppm
Steroids	25.960	7289.2832	570.180	12.5031	ppm
Epicatechin	29.326	5263.8132	410.175	7.8986	µg/g
Phytate	31.653	6802.6676	532.675	9.1434	µg/ml
Flavone	34.150	3084.5690	241.227	1.9141	µg/ml
Oxalate	36.773	4449.9928	348.939	7.0284	µg/ml
Catechin	38.640	8023.9062	624.600	1.7616	µg/ml
Sapogenin	43.536	5031.2616	394.788	8.2682	µg/ml
Ephedrine	45.066	10.1155	0.225	0.0130	µg/ml

Total Area: 86302.1875

Total External: 89.4031

Table V: Quantitative Profile of Compounds in Honey Control Sample (Unadulterated)

Component	Retention Time	Area	Height	External	Units
Proanthocyanin	0.210	5426.7124	354.142	7.6325	ppm
*Naringin	2.390	12419.2996	701.553	18.1835	µg/ml
Cardiac glycoside	4.120	6543.2930	371.126	6.0906	µg/ml
Flavan-3-ol	6.016	18234.4938	1020.754	21.1844	ppm
Anthocyanin	7.470	8483.3000	480.619	10.9133	µg/ml
Ribalinidine	10.366	19625.3075	1096.775	42.0783	µg/ml
Naringenin	12.970	6252.9987	354.931	2.6423	µg/ml
Sparteine	15.460	4978.2621	282.655	8.9216	µg/ml
Rutin	17.963	11351.0066	641.436	14.0875	µg/ml
Cyanogenic glycoside	20.313	12766.1384	680.813	22.8784	ppm
Flavonones	22.730	9583.1170	539.390	16.4376	ppm
Steroids	25.650	10090.1302	570.418	17.3072	ppm
*Kaempferol	27.536	11538.7025	649.857	7.9908	µg/ml
Epicatechin	29.860	5484.7925	311.586	7.0529	µg/g
Phytate	32.993	14337.0773	803.990	25.6937	µg/ml
Flavone	34.600	6059.4052	344.109	7.5202	µg/ml
Oxalate	36.876	6996.1836	394.001	13.6654	µg/ml
*Resveratrol	39.200	10239.6298	576.278	11.6713	ppm
Sapogenin	42.276	3510.2092	199.554	5.7686	µg/ml
Ephedrine	44.170	10547.7802	596.529	18.0922	µg/ml

Total Area: 194467.8126

Total External: 285.8124

*= Component found in only control sample

4. DISCUSSION

Table 1 show the qualitative phytochemical screening of honey samples from Enugu markets revealed the presence of saponins, terpenoids, steroids, flavonoids, tannins, glycosides, and phenolics. Alkaloids were not detected in any of the samples, including the control. The absence of alkaloids is consistent with the findings of Ciansiosi et al. (2018), who reported that alkaloids are not typical constituents of floral honey. In addition, the presence of saponins aligns with Almasaudi et al. (2017), who observed antibacterial activity in honey samples containing these compounds. The strong flavonoid reactions observed across all samples suggest considerable antioxidant potential. This finding is consistent with Ciansiosi et al. (2018) and Adebisi et al. (2021), who reported significant flavonoid levels in Nigerian honey. In addition, the presence of tannins aligns with Oyeleke et al. (2016), who associated tannin constituents in Nigerian honey with antibacterial activity.

Tables 2 and 3 present the concentrations of toxic heavy metals in honey samples obtained from Ogbete, Abakpa, and Mayor Markets, in comparison with the unadulterated control. A consistent trend was observed whereby metal concentrations were higher in market samples than in the control, although all detected values remained within internationally accepted safety limits.

Lead (Pb) was detected in all market samples but was absent in the control honey. The highest concentrations were recorded in Ogbete samples, ranging from 0.014 to 0.021 mg/kg, followed by Abakpa samples with 0.011 to 0.018 mg/kg, and Mayor Samples with 0.008 to 0.015 mg/kg. All values were below the permissible limit of ≤ 0.10 mg/kg. Comparable low lead levels in Nigerian honey have been reported by Adenekan et al. (2014), who observed detectable but safe concentrations in honey from mangrove regions. In contrast, Ndife et al. (2014) reported even lower or undetectable lead levels in some Nigerian honey samples, suggesting that environmental exposure and handling practices may influence lead contamination.

Cadmium (Cd) was largely absent, with only trace amounts detected. Ogbete samples 3 and 6 recorded 0.002 mg/kg and 0.003 mg/kg, respectively, while Abakpa sample 4 contained 0.002 mg/kg. Cadmium was not detected in any Mayor sample or in the control. All values were well below the acceptable limit of ≤ 0.05 mg/kg, indicating minimal cadmium contamination. This agrees with Adenekan et al. (2014), who reported cadmium as either absent or present only in trace amounts in Nigerian honey.

Arsenic (As) was also largely absent. Detectable traces were observed only in Ogbete sample 4 (0.004 mg/kg) and Abakpa sample 4 (0.003 mg/kg), while all other samples, including the control, recorded no detectable arsenic. These concentrations were far below the permissible limit of ≤ 0.10 mg/kg, indicating no immediate health concern. Similarly low or undetectable arsenic levels have been reported in Nigerian honey by Ndife et al. (2014). The presence of arsenic in these few samples may be attributed to soil contamination through heavy metal accumulation and atmospheric deposition.

Tables 4 and 5 present the HPLC analysis of phytochemical compounds in honey samples from Ogbete, Abakpa, and Mayor Markets compared with the unadulterated control. The market honey samples contained a variety of phytochemical constituents. Several flavonoids were detected, including catechin, epicatechin, flavanones, rutin, and naringenin, with catechin and flavanones showing the most prominent peaks. Other bioactive compounds such as steroids, anthocyanins, proanthocyanins, saponins, and cardiac glycosides were also present. Minor amounts of alkaloids and antinutritional compounds including phytate and oxalate were identified, while ephedrine was detected only in trace quantities.

The control honey sample exhibited a broader phytochemical profile. Flavonoid-related constituents detected included flavan-3-ol, flavanones, rutin, naringin, naringenin, kaempferol, epicatechin, and resveratrol, most of which gave strong chromatographic responses. Additional bioactive compounds such as proanthocyanins, anthocyanins, cardiac glycosides, cyanogenic glycosides, steroids, and saponins were also present. Alkaloids such as Lunamarin, ribalinidine, sparteine, and ephedrine were identified in market and control samples by HPLC, but were absent in qualitative tests.

Overall, peak areas were generally higher in the control sample, which also contained naringin, kaempferol, and resveratrol not detected in the market samples. This suggests possible degradation or dilution of phytochemicals during handling and storage. These findings are in agreement with Natasha et al. (2023) and Moniruzzaman et al. (2014), who used HPLC to profile alkaloids and flavonoids in honey.

The findings of this study demonstrate the potential application of the obtained data in the food industry where honey is utilized as an ingredient. The established profiles of nutritional composition, heavy metals, and phytochemical constituents provide reference values that may be used for setting quality standards for honey in both local and international trade. Additionally, the data reflect the current safety and phytochemical status of honey sold in open markets, and therefore contributes to the body of scientific information available for product characterization and consumer awareness.

5. CONCLUSION

This study demonstrates that the quality of honey sold in Enugu urban markets varies significantly. Phytochemical and HPLC analyses revealed that both market and control samples contained beneficial compounds such as flavonoids, tannins, glycosides, saponins, and phenolics, with the control sample exhibiting a broader profile and higher concentrations. Alkaloids such as lunamarin, ribalinidine, sparteine, and ephedrine were detected in both market samples and the control by HPLC, but were absent in the qualitative screening. Trace elements of heavy metals were detected in market samples but were not detected in the control sample, and all were within safe and acceptable limits. The data generated from this study provide reference values that may be used for quality assessment and standardization of honey in the food industry and local markets.

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