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The Level Of Adulteration Of Honey Products And Their Mineral Content In Minna Town, Niger State Of Nigeria

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Abstract: *Honey samples collected from three different locations in Minna, Niger State (Farm, Supermarket, and Roadside) were analyzed to assess the level of adulteration by evaluating their physicochemical and Mineral properties, including moisture content, ash, glucose, sucrose, reducing sugar, Brix, pH, specific gravity, refractive index, and titratable acidity. The results indicated that most of the samples adhered to the Codex Alimentarius standards for parameters such as ash content, pH, specific gravity, refractive index, and titratable acidity, suggesting that the honey was relatively pure. However, variations were observed in moisture content, glucose, Brix, and sucrose levels, which may suggest potential adulteration or variations in processing and storage practices. Specifically, the moisture content of the Farm sample was higher than the recommended range, indicating possible improper storage conditions, while the Roadside sample exhibited low moisture content, which could suggest evaporation or over-concentration. The glucose content in the Supermarket and Roadside samples was significantly lower and higher, respectively, than the Codex standard, indicating potential dilution or adulteration with glucose syrup. Sucrose content was also higher in the Roadside sample, possibly indicating adulteration with sucrose syrup. Mineral analysis showed slight variations in sodium, potassium, phosphate, and calcium concentrations, which could be attributed to differences in nectar sources and environmental factors. Overall, the findings suggest some level of adulteration in honey products from Minna, Niger State, particularly in glucose and sucrose levels. These variations highlight the need for improved honey processing, storage, and quality control measures to ensure the authenticity and safety of honey products in the region.*

Keywords: Ash, Honey, Glucose, Moisture, pH, Specific gravity.

Introduction

Honey is a naturally produced sweet substance harvested by bees from the nectar of flowering plants. The honey produced by *Apis* species of bees, specifically *Apis mellifera*, is the most widely consumed and commercially available variety globally. While other bees, such as stingless bees, also produce honey, their output is generally smaller in volume and varies in composition and properties [1]. The process of honey production involves the collection of nectar, which bees regurgitate, mix with enzymes, and evaporate to reduce water content. The resultant substance is stored in wax honeycombs as a food reserve for the colony [2]. Honey is classified as a carbohydrate, with its primary constituents being the simple sugars glucose and fructose, which are easily absorbed by the human body without the need for further digestion. Unlike sucrose (table sugar), which must be broken down into simpler sugars before absorption, honey’s natural sugars are readily assimilated into the bloodstream, making it a more efficient source of energy [3]. Aside from sugars, honey contains a variety of other bioactive compounds, including vitamins, minerals, amino acids, and antioxidants, which contribute to its medicinal and nutritional, value [4]. Due to its rich composition, honey has been prized not only as a sweetener but also for its medicinal properties, including antibacterial, anti-inflammatory, and antioxidant effects [5]. However, the rising global demand for honey, coupled with economic pressures, has led to widespread adulteration practices, where honey is mixed with cheaper sweeteners such as glucose syrup, corn syrup, or cane sugar to increase production volume and reduce costs [6]. Such adulteration not only undermines the nutritional and therapeutic benefits of honey but also poses potential health risks to consumers [7]. Honey’s natural properties, such as its low moisture content and acidic pH, contribute to its preservation and resistance to microbial spoilage. However, honey can still be contaminated by microorganisms, particularly osmophilic yeasts and molds, which may affect its quality [8]. The adulteration of honey is a concern as it can affect both the product's quality and its shelf life, making the identification of pure honey essential for ensuring consumer safety and preserving its health benefits. This research work is aimed at investigating the level of adulteration in honey product from Minna.

MATERIALS AND METHODS

Collection of Samples

Commercially made honey samples were collected from three different locations in Minna, Niger State. The honey samples were stored in clean bottles and stored in the refrigerator until further needs for analysis.

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Physiochemical Properties

Determination of Specific Gravity

The specific gravity was determined by carefully measuring 50cm^3 of honey samples into a thoroughly washed dried and weighed 50cm^3 pycometer bottles. Another pycometer bottle was filled with water and weighed after which the bottle was dried and filled with oil sample and weighed. The specific gravity was calculated using the formula [9].

$$\text{Specific gravity} = \frac{\text{weight Xml of oil}}{\text{Weight of Xml of water}}$$

Determination of Refractive Index and Sugar Content (Brix)

The refractive index and sugar content of the honey samples was determined using abbe's refractometer. Few drops of the samples were mounted on the lower prism of the instrument and closed. The refractive index and sugar content was taken and recorded [10]**.**

Determination of the Sucrose, Glucose and Reducing Sugar Concentrations

The sucrose, glucose and reducing sugar concentrations in the honey sample were determined using the digital automatic saccharimeter model-Dr. kernchen) [11].

Determination of Moisture Content

The moisture content of each sample was determined as follows; 5g of the samples was weighed and placed into a pre-weighed alumni drying dish. The sample was dried to constant weight in an oven at 105ºc for four hours under vacuum [12].

$$\text{Moisture content} = \frac{M_1 - M_2}{M_1 - M_O}$$

Where

Mo= weight of the aluminium dish

M1= weight of the fresh sample + dish

M2= weight of the dried sample + dish

Determination of Ash Content

5g each of the samples was separately weighed out into a porcelain crucible previously ignited and weighed. Organic matter was charred by igniting the sample on a hot plate in a fume cupboard. The crucible were then placed in the muffle furnace and maintained at 600oc for 6 hours. They were then cooled in a desiccator and weighed immediately [12].

$$\text{Ash (\%)} = \frac{\text{(weight of crucible ash) - (weight of empty crucible)}}{\text{Sample weight}}$$

Determination of pH

The pH of the honey samples were determined by carefully measuring 10cm^3 of each sample into a clean beaker and its pH was determined using a pH meter (unicam, 9450 model) [12].

Determination of Total Titratable Acidity

25cm^3 of each sample (diluted) was titrated against 0.1N NaOH using 0.25ml phenolphthalein as an indicator. The relative amount of lactic acid was determined using the mathematical formula [12].

$$\text{Lactic Acid (\%)} = \frac{\text{Titre Value X Normality X 9}}{\text{Volume of Sample}}$$

Determination of Optical Rotation

The optical rotation of the honey samples was determined using a polar meter, model Bellingham + Stanley R94038 [12].

Mineral Analyses

One gram of each honey sample was measured and placed into a digestion tube. 10 ml of nitric acid and a single selenium catalyst tablet were combined and heated to 350°C until the solution became transparent. Following cooling, the mixture was mixed with 20 ml of distilled water and strained into a 100 ml volumetric flask. The filtrate was brought to the mark and utilizes to do mineral analysis according to AOAC [12], using atomic absorption spectrophotometer (AAS).

Results and Discussion

Results

Table 1; Physic-chemical properties of the honey samples from various locations in Minna

Parameters	Farm	Supermarket	Roadside	Codex Standard
Moisture	24.64±0.63	16.62±0.42	12.02±0.51	15.70-26.70
Ash	0.74±0.09	0.84±0.08	0.64±0.06	0.04-0.93
Glucose	32.49±0.20	7.89±0.20	61.57±0.26	22.8-40.70
Sucrose	2.70±0.02	0.75±0.02	5.69±0.01	0.25-7.570
Reducing sugar	60.88±0.51	60.45±0.50	59.85± 0.50	61.4-85.70
Brix	84.15±1.71	86.76±0.08	87.32±1.20	25-40
pH	4.4±0.08	4.4±0.08	4.25±0.07	3.6-5.6
Specific gravity	1.47±0.02	1.44±0.02	1.49±0.03	
Refractive index	1.49± 0.02	1.50±0.03	1.49±0.02	
Titratable acidity	0.18±0.03	0.14±0.02	0.18±0.03	0.03-0.19

Values are expressed in mean ± SD (n=3).

Honey samples from Minna Niger state had pH values of 4.4, 4.3 and 4.2 respectively.

The total titratable acidity calculated as % lactic acid of the honey samples showed that honey sample had percentage latics acid of 0.16, 0.13 and 0.17 respectively.

The honey sample also had percentage ash content 0.72, 0.82 and 0.63 respectively.

The percentage moisture content of the honey sample was 24.20, 11.78 and 16.32 respectively.

The specific gravity results for the honey samples showed values of 1.4718, 1.4425 and 1.4947 respectively.

While the relative density of the honey were 0.9938, 0.9113, and 1.0055 respectively.

The refractive index of the honey samples were 1.49973, 1.50467 and 1.4981 respectively.

While the sugar/ brix content were 84.6%, 87.6% and 86.42% respectively.

The sucrose content of the honey sample were 2.85, 5. 25 and 0.70 respectively.

The glucose (%) of the honey sample was 35.5, 61.5 and 8.00 respectively.

The reducing sugars (%) were 60.19, 60.14 and 59.63 respectively.

Table 2: Mineral properties of the honey samples from various locations in Minna

Elements (µg/ml/100g)	Farm	Super market	Roadside
Na	0.79±0.1	0.78±0.2	0.72±0.12
K	1.78 ±0.3	1.03±0.1	0.62±0.2
P	0.084±0.03	0.085±0.01	0.087±0.02
Ca	1.17±0.2	1.04±0.16	2.98±0.12

Values are expressed in mean ± SD (n=3).

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The honey samples (farm, Super market and Roadside) has Mineral content such as, sodium to be 0.79, 0.78 and 0.72, Potassium 1.78, 1.03, and 0.62, Phosphate, 0.084, 0.085 and 0.087. Calcium, 1.17, 1.04 and 2.98 respectively.

Discussion

Moisture content is one of the most critical factors influencing honey's shelf-life and susceptibility to fermentation. Honey with excessive moisture is prone to spoilage by yeast and molds, which can cause fermentation [13]. According to the Codex Alimentarius, the moisture content of honey should fall within the range of 15.70% to 26.70% [14]. The moisture content of the samples was Farm**:** 24.64 ± 0.63%, Supermarket**:** 16.62 ± 0.42% and Roadside: 12.02 ± 0.51%. The **Farm** sample exhibited moisture content at the higher end of the acceptable range, which could suggest improper storage conditions, such as exposure to high humidity, leading to higher moisture absorption [15]. In contrast, the **Roadside** sample had a much lower moisture content, which might indicate excessive evaporation, adulteration, or the use of overly concentrated honey [16]. The **Supermarket** sample showed moisture content within the standard range, indicating proper handling and storage, aligning with industry norms for quality control.

Ash content in honey is an indicator of the mineral content, and it can be used to assess the purity of honey. Pure honey typically has low ash content, and values above the standard range might indicate contamination or adulteration [17]. The ash content values observed in this study were: **Farm**: 0.74 ± 0.09%, **Supermarket**: 0.84 ± 0.08% and **Roadside**: 0.64 ± 0.06%. These values fall within the Codex Alimentarius standard range of 0.04% to 0.93% [14], suggesting that the honey samples analyzed are relatively pure with no significant signs of contamination. The differences in ash content may reflect variations in the nectar sources or environmental factors affecting mineral absorption [18].

Glucose is a major carbohydrate found in honey and contributes to its sweetness, crystallization behavior, and energy content. The Codex Alimentarius sets the glucose content in honey between 22.8% and 40.7% [14]. The glucose content in the samples was **Farm**: 32.49 ± 0.20%, **Supermarket**: 7.89 ± 0.20% and **Roadside**: 61.57 ± 0.26%. The **Farm** sample's glucose content falls within the Codex standard, indicating that it is likely pure honey. However, the **Supermarket** sample showed significantly lower glucose content, which may suggest dilution or adulteration with cheaper sugars, such as corn syrup or sucrose [19]. The **Roadside** sample, with a high glucose level, could indicate a concentration of glucose due to low moisture content or adulteration with glucose syrup [16]. Elevated glucose content is also associated with rapid crystallization, which could affect the quality and texture of the honey [13].

Sucrose content is another indicator of honey's purity. Pure honey should have less than 5% sucrose [18], and higher sucrose levels may suggest adulteration with sucrose syrup or other sweeteners [19]. The sucrose content in the samples was **Farm**: 2.70 ± 0.02%, **Supermarket**: 0.75 ± 0.02% and **Roadside**: 5.69 ± 0.01%. All values were within the acceptable Codex standard range of 0.25% to 7.57%, but the **Roadside** sample had the highest sucrose content, which may suggest adulteration [15]. The **Farm** and **Supermarket** samples both had sucrose levels that are typical for natural honey, suggesting that these samples are likely not adulterated.

Reducing sugars, primarily glucose and fructose, are the principal carbohydrates in honey, and their content is an important indicator of honey's quality. The Codex standard for reducing sugars is between 61.4% and 85.7% [14]. The reducing sugar content observed in the samples was **Farm**: 60.88 ± 0.51%, **Supermarket**: 60.45 ± 0.50% and **Roadside**: 59.85 ± 0.50%. These values are slightly below the standard range, which could indicate dilution or adulteration of the honey. However, this could also be due to natural variations in nectar composition or processing methods [13]. The reduction in reducing sugars could be indicative of honey being mixed with other substances, reducing the overall concentration of these sugars.

Brix is a measure of the total dissolved solids, primarily sugars, in honey. The Brix value serves as a good indicator of the concentration and authenticity of honey [16]. The Codex standard for Brix in honey is between 25% and 40% [14]. The Brix values for the samples were **Farm**: 84.15 ± 1.71%, **Supermarket**: 86.76 ± 0.08% and **Roadside**: 87.32 ± 1.20%. The **Farm**, **Supermarket**, and **Roadside** samples all exhibited much higher Brix values than the Codex standard, suggesting that these samples may have been concentrated or adulterated with sugars [13]. High Brix values can also result from improper storage, leading to increased evaporation of moisture, which in turn concentrates the sugars in the honey [19].

The pH of honey is typically acidic, which contributes to its antimicrobial properties and preservation. The Codex standard for pH in honey is between 3.6 and 5.6 [14]. The pH values for the samples were **Farm**: 4.4 ± 0.08, **Supermarket**: 4.4 ± 0.08 and **Roadside**: 4.25 ± 0.07. The pH values of all samples fall within the acceptable range, which is consistent with the natural acidic nature of honey. The acidity of honey plays an essential role in inhibiting the growth of pathogens and ensuring its long shelf-life [17]. The pH values observed in this study suggest that the honey samples are microbiologically stable.

Specific gravity and refractive index provide important information about the density and sugar concentration in honey. The refractive index is particularly useful in determining the level of adulteration in honey [16]. The specific gravity and refractive index values for the samples were **Farm**: Specific gravity = 1.47 ± 0.02, Refractive index = 1.49 ± 0.02, **Supermarket**: Specific gravity = 1.44 ± 0.02, Refractive index = 1.50 ± 0.03 and **Roadside**: Specific gravity = 1.49 ± 0.03, Refractive index = 1.49 ± 0.02. These values are consistent with those expected for pure honey, indicating that the samples are not diluted with significant amounts of water or other adulterants. The refractive index values around 1.5 suggest high sugar concentrations typical of natural honey [15].

Titratable acidity reflects the concentration of organic acids in honey, which contributes to its flavor, preservation, and antimicrobial activity. The Codex standard for titratable acidity is between 0.03% and 0.19% [14]. The titratable acidity values for the samples were **Farm**: 0.18 ± 0.03%, **Supermarket**: 0.14 ± 0.02% and **Roadside**: 0.18 ± 0.03%. These values are consistent with the Codex standard, indicating that the honey samples have an adequate level of acidity to preserve their quality and prevent microbial contamination [17].

The mineral content of honey (table 2) varies depending on several factors, such as the source of nectar, geographical location, and environmental conditions. In the present study, the mineral content of honey samples from different locations in Minna (Farm, Supermarket, and Roadside) revealed variations in key elements such as sodium (Na), potassium (K), phosphate (P), and calcium (Ca). These minerals play crucial roles in the nutritional and physiological benefits of honey.

Sodium levels in the honey samples ranged from 0.72 to 0.79 µg/ml/100g. Sodium is an essential electrolyte that contributes to the regulation of fluid balance and blood pressure in the body. While honey contains low amounts of sodium, its presence is important for maintaining osmotic balance in cells and tissues. Generally, honey is considered a low-sodium food, which aligns with its role as a sweetener in the diet without contributing significantly to sodium intake [20]. This aligns with findings that honey is naturally low in sodium but contributes to essential biological functions in small amounts [21].

The potassium content ranged from 0.62 to 1.78 µg/ml/100g, with the highest concentration found in the honey sample from the farm. Potassium is another essential mineral that supports proper cellular function, nerve signaling, and muscle contraction. It is also crucial for maintaining healthy blood pressure levels. The varying potassium levels in the honey samples suggest that the mineral composition of honey can be influenced by the plants visited by bees, which may vary in their potassium content [21]. Previous studies have highlighted that honey derived from certain nectar sources, such as fruit-bearing plants, tends to have higher potassium content [22]. Potassium's role in supporting cellular processes is critical, and its presence in honey further reinforces its nutritional value [23].

Phosphate levels in the honey samples were relatively consistent, ranging from 0.084 to 0.087 µg/ml/100g. Phosphate is essential for the formation of bones and teeth and plays a key role in energy metabolism and cellular functions. The concentration of phosphate in honey can be influenced by the nectar sources and the mineral content of the soil in which the plants grow [24]. In the present study, the phosphate levels were within the typical range for honey, as it is generally a minor component in the mineral profile of honey. Consistent with findings by Barros et al. [25], phosphate concentrations are often small but still significant for its health-promoting effects.

The calcium content varied significantly, with roadside honey showing the highest concentration of 2.98 µg/ml/100g, compared to 1.17 µg/ml/100g and 1.04 µg/ml/100g in farm and supermarket samples, respectively. Calcium is essential for bone health, nerve transmission, and muscle function. The higher calcium content in roadside honey could indicate a greater influence of certain plant species in the local environment, which may be richer in calcium. Variability in mineral content, particularly calcium, can be attributed to the differing nectar sources and soil mineral content in different regions [25]. Calcium is typically present in trace amounts in honey, and its concentration can vary based on the bee's foraging behavior and environmental factors [23].

Conclusion

In conclusion, the study suggests that honey samples from Minna, Niger State; exhibit some level of adulteration, particularly in terms of glucose and sucrose content. The variations observed in the physicochemical properties can be attributed to differences in honey processing, storage, and environmental factors. Further research is needed to explore the factors influencing honey adulteration in this region, and measures should be taken to ensure the quality and authenticity of honey products. Mineral analysis revealed slight variations in sodium, potassium, phosphate, and calcium content among the samples, with the Farm sample showing the highest potassium content, while the Roadside sample had the highest calcium concentration. These differences can be attributed to the varied nectar sources and environmental factors in the respective locations, which influence the mineral composition of honey. Regular monitoring and adherence to established standards are crucial to protect consumer health and maintain the integrity of honey as a natural product.

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