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Evaluation of some physicochemical properties of honey from Northern and Southern Guinea Savanah Zones of Niger State, Nigeria

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ABSTRACT: Honey is a naturally occurring sweet material made by honeybees from plant nectar and honeydew. Different regions might produce honey with varying qualities due to differences in floral, climate, and management practices. Evaluating honey from both zones ensures that it meets quality standards and adheres to safety regulations. The study was conducted to assess the bioactive properties of honey from Niger State's Southern and Northern Guinea Savannah Zones, Nigeria. Purposive sampling was used to gather the honey samples from the two ecological zones because we understood where to get samples. Samples were collected from nine Local Governments. The parameters assessed were pH, sugar concentration, and hydroxymethylfurfural content. The results show a pH range of 3.75–5.37, sugar 1.58–2.70%, hydroxymethylfurfural 20.20–29.96 mg/100g, and total reducing sugar of 72.15-84.73%. The pH, sugar content, and hydroxymethylfurfural were significantly different ($p>0.05$) between the Northern and Southern Guinea Savannah samples. Similar variations in pH and total reducing sugar were noted in honey samples that had been processed, retailed, and unprocessed. The honey's quality was deemed acceptable, falling within the internationally recognized standard (CODEX, 2019) of (pH 3-3.5, HMF less than 40, sucrose 5 and TRS greater than 60) based on the characteristics that were examined.

Keywords: Honey's quality, Niger State, physicochemical properties, reference standard.

INTRODUCTION

Honey is a naturally occurring sweet material that honeybees make from nectar blossoms or the secretion of living plant parts (Ebrahimi *et al*., 2023). The honeybees collect nectar, process it, mix it with other substances, store it, and then let to ripen and mature in the honeycomb (CODEX, 2001; Ma *et al*., 2019; Singh, 2022; Walker *et al*., 2022). The honeybee, or *Apis mellifera*, is responsible for processing it (Přidal *et al*., 2023). Due to its ability to pollinate and produce honey, this social insect is regarded as the most valuable insect in terms of economic value (Adeyemi *et al*., 2021). Honeybees have been described as the most useful of all insects because of their ability to provide the honey necessary for the survival of humans and other forms of life (Khalifa *et al*., 2021; Brant *et al*., 2022).

Honey has a higher percentage of carbohydrates (82.3%) than any other animal food (Puranik *et al*., 2023). The main monosaccharide sugars in honey are fructose and glucose. Moreover, it contains a wide variety of other sugars, including sucrose and maltose, which account for

more than 7% of its makeup (Puranik *et al*., 2023). Furthermore, honey comprises oligosaccharides, which are carbohydrates, such as fructooligosaccharide and raffinose (Tedesco *et al*., 2020). Additionally, a variety of elements are included in it, such as proteins, minerals, vitamins, enzymes, free amino acids, and a wide spectrum of volatile chemicals (Adadi and Obeng, 2017). Without additional processing, honey can be utilized as a natural "sweetening agent" (Ibrahim *et al*., 2021).

In Nigeria and around the world, honey is regarded as one of the tastiest natural foods because of its nourishing and healing qualities (Ame *et al*., 2022). It has multiple uses, including food, religious rituals, and medicinal purposes for both people and animals (Hossain *et al*., 2021). In addition, it is used to sweeten children's medication and feed animals (George and Shuaib, 2009; Ibrahim *et al*., 2021).

Honey adulteration may outweigh the advantages of honey ingestion (Adadi and Obeng, 2017; Hidalgo *et al*., 2020). Honey can become adulterated by adding other substances. It has been documented that honey can contain foreign materials such as molasses, starch solution, glucose, sucrose, water, and inverted sugar (Damto, 2021). Honey can become microbiologically contaminated when certain foreign materials such as sweetener or sugar syrup are added (Naila *et al*., 2022). High quality honey should be free from pathogenic bacteria that cause gastrointestinal disorders (Majtan *et al*., 2021).

Some chemical and physical features of Nigerian honey, as well as its ability to heal burns and wounds, have been documented (Mokhtari *et al*., 2019; John-Isa *et al.*, 2019; Nweze *et al*., 2020; Hossain *et al*., 2020; Ja'afar-Furo *et al*., 2020; Ajobiewe *et al*., 2022; Adeyemi *et al*., 2023). Global studies on the physicochemical, microbiological, and therapeutic qualities of honey abound (Nguyen et al., 2019; Zarei *et al*., 2019; Bobis *et al*., 2020, Berhanu *et al*., 2022). Honey use as a meal has significantly increased in Nigeria in recent years. As a result, the goal of the current study is to evaluate some physicochemical characteristics of local honey samples.

METHODOLOGY

Study area

The study was conducted in Niger State, located in the North-Central part of Nigeria with Minna as its capital. It is bounded to the South by the River Niger and by the States of Kebbi and Zamfara to the North, Kaduna to the Northeast, Kogi to the Southeast, Kwara to the South and Abuja to the Eastern border. Niger State lies on the geographical coordinates of 3˚35′ 7.33″ N 7˚23′17.41″ N and 8˚10′58.82″ E 11˚ 22′ 23.87″ E covering an estimated land area of 76,363 km^2 (29,484 m^2) and has twenty-five (25) Local Government Areas having two vegetation zones. The Northern Guinea Savannah vegetation is characterized by annual rainfall of 1,200 mm, open woodland and grass plains.

Honey sampling

A total of 81 honey samples were collected of which 36 samples were from the Northern Guinea savannah zone with 9 each from four Local Government Areas (Borgu, Agwara, Rijau and Magama) while 45 samples were collected from the Southern Guinea savannah zone of which 9 each were obtained from five Local Government areas (Shiroro, Bosso, Chanchaga, Lavun and Lapai). At each sample collection location, three samples of unprocessed and processed honey were obtained directly from the beekeepers while three processed samples were obtained from retailers that purchased their honey directly from the farmers (June, 2018-Febuary, 2019). The honey samples were collected in sterile bottles and kept in the dark at ambient temperature (25 – 28ºC) until they were needed for analysis (Omafuvbe and Akanbi, 2009).

Physicochemical properties of honey from the Northern and Southern Guinea Savannah Zones

pH

The pH of honey samples was measured with a digital portable pH meter (HANNA model). Ten millilitres (10 ml) of each honey sample was taken and mixed in a beaker with 10 ml of distilled water, shaken for 20 minutes and allowed to stand for 15 minutes before the electrodes were inserted. In between the readings of different samples, the electrode was washed with distilled water and dried with tissue paper. Occasionally, thick samples were diluted twice before inserting the electrode. Readings were taken for all honey samples in triplicates to allow for statistical analysis (Adenekan *et al*., 2012; Mesele, 2021).

Hydroxylmethylfurfural (HMF)

The HMF content in 81 honey samples was determined using a spectrophotometric method (White, 1979) elaborated by Keppy and Allen (2009). For each honey sample, 5 g of honey was dissolved in 25 ml of double distilled water. Then 0.5 ml of Carrez solution I (150 mg/ml Potassium ferrocyanide) were added to the sample and mixed well. Thereafter, 0.5 ml of Carrez solution II (300 mg/ml zinc acetate) was added and mixed well. Each sample was brought to a final volume of 50 ml in volumetric flasks using double distilled water. Samples were then filtered using Whatman filter paper No.1 in funnels. The first 10 ml of filtrates were discarded. Aliquots of 5 ml of the remaining filtrates were put in two test tubes; to one tube, 5 ml of distilled water was added (test sample

Table 1. Physicochemical Properties and sugar concentration of Honey from the Northern and Southern Guinea Savannah Zones of Niger State.

Sample and Source	pH	HMF mg/100g	Sucrose %	TRS%
Unprocessed				
NGS	3.75± 0.21^{c}	20.50 ± 0.17^{c}	1.63±0.07^{b}	84.36±1.52^{a}
SGS	4.08±0.03^{b}	20.20±0.99^{c}	1.58±0.05^{b}	83.73±1.54^{b}
Processed				
NGS	4.41 ± 0.22^{b}	25.50 ± 0.89^{b}	2.35±0.39^{a}	75.33±1.99^{b}
SGS	4.16±0.04^{b}	25.21±0.97^{b}	2.25±0.11^{a}	77.97±2.71^{b}
Retailed				
NGS	5.31 ± 0.12^{a}	29.96 ± 1.42^{a}	2.70±0.27^{a}	72.15±2.05^{b}
SGS	5.37±0.29^{a}	28.81±0.19^{a}	2.25±0.10^{a}	75.51±1.43^{a}
P-value	0.001	0.000	0.000	0.000
CODEX Reference Value	3.5-4.5	≤40	5	>60

Superscript $^{a–c}$: Means with the same letter(s) in a column are not significantly different p≥0.05. Keys: NGS= Northern Guinea Savannah, SGS= Southern Guinea Savannah, HMF=Hydroxymethylfurfural, TRS=Total Reducing Sugar.

solution); and to the second, 5 ml of 0.2% sodium bisulphite solution was added (reference solution). The absorbance of the test sample was measured against the reference sample at 284 and 336 nm using a spectrophotometer. The HMF content was calculated using the following equation (Bogdanov *et al.,* 2004.

HMF (mg /100g of honey) = {A_{284} x A_{336} / W} * Factor

Where W = weight of sample in gram of the honey sample

Factor =126*1000*1000 /16830=748.66 (Constant)

126 = Molar weight of HMF

16830 = Molar absorptivity of HMF

Sugar concentration of honey from the Northern and Southern Guinea Savannah Zones

The phenol-sulphuric acid method of Maynard (1970) was used. Ten millilitres (10 ml) of each honey sample ultra-pure water in a calibrated and centrifuged to obtain a supernatant solution for the analysis. One millilitre of diluted solution was pipette into the test tube and 1 ml of 52% phenol was added to each test tube. Five milliliters (5 ml) of 96% H_2SO_4 was also added in drops. The test tube was allowed to stand for 10 minutes before the content was transferred into clean grease-free cuvettes. Stock glucose was prepared as standard. The value of the reducing sugar present in each honey sample was read on a spectrophotometer at a wavelength of 490 nm (Adenekan *et al*., 2012).

RESULTS AND DISCUSSION

Table 1 show the results of the physicochemical properties and sugar concentration of honey in the study area. There were significant differences ($p<0.05$) in pH values of unprocessed (3.75) honey samples, processed (4.41%) and retailed samples (5.31). The content of HMF (mg/100g) of unprocessed (20.50) honey differed significantly ($p<0.05$) from that of processed (25.50) and retailed honey samples (29.96). The sugar content of unprocessed honey samples was significantly lower (1.63%) than the processed samples from farmers (2.25%) and retailers (2.25%). The Total Reducing Sugar (TRS) content in the unprocessed sample was significantly higher ($p<0.05$) compared to the processed sample (75.33%) and the retailer sample (72.15%). However, there was no significant difference ($p>0.05$) in the pH levels between the unprocessed (3.75) and processed samples (4.41), indicating similar properties among the samples.

There was a significant difference in retailed samples (75.51). The HMF content (Mg/100g) in unprocessed (20.21%), processed (25.21%), and retailed honey samples (28.81%) differed significantly ($p<0.05$). The unprocessed honey (1.58%) had a significantly lower sugar level ($p<0.05$) compared to the processed and retailed honey samples (2.25-2.70%). Similarly, the sucrose contents of processed honey did not differ significantly amongst the sampling locations. The unprocessed sample for the Northern Guinea Savannah was slightly higher 84.36% than that of unprocessed honey of Southern Guinea Savannah.

The analysis of the honey samples showed that the pH of the unprocessed and processed samples was low

enough to slow down or prevent the growth of many species of microbial pathogens but this acidity may be neutralised in the body by the buffering liquid fluid (Olaitan *et al.,* 2007), while the retailed samples were slightly higher than the CODEX (2001) standard and may be due to adulteration of the honey samples with sugar or water (Damto *et al*. 2024). Acidity is also important in honey because it has been shown to promote wound healing (Olaitan *et al.,* 2007). The pH values for samples obtained from the Northern Guinea Savannah zone ranged from 3.15-4.03 in the unprocessed samples, 4.13-5.05 in the processed samples and 4.97-5.50 observed in this study were within the limit of 3.50-5.50 of the optimum range for honey pH as cited by CODEX (2001). pH range from the Southern Guinea Savannah zone was 4.02-4.17 for the unprocessed samples, 4.30-4.30 for the processed samples and 4.90-5.60 for the retailed sample. The observed pH might be as a result of the plant source(s) from which the bees obtain nectar to produce the honey and the soil type can also affected the pH (Tomczyk *et al*., 2020). Similar values of 4.31-6.02 were recorded by Adebiyi *et al*. (2014) for some South, West and Eastern Nigerian honey samples and 4.46-4.48 recorded by Ibegbulem *et al*. (2018) for some honey samples from Zaria and Yelwa. Hydroxymethylfurfural content is indicative of the level of honey deterioration following the standard established by the Codex (2001) setting a maximum value of 40.00 mg/kg for processed honey. Hydroxymethylfurfural is formed during acid-catalyst dehydration of hexoses and it is connected to chemical properties of honey, like pH, total acidity, and mineral content (Zahedi *et al*., 2018). The HMF of the honey studied showed a significant difference ($p \geq 0.05$) in the value obtained from the studied honey samples (20-29 mg/100g). Based on the HMF values obtained, the samples were within the standard recommendation for any honey sample in the world. This is further supported by an earlier finding in Niger State by Osuagwu *et al*. (2020) and in Turkey by Terzo *et al*. (2020). The percentage of sucrose and reducing sugars in this study fell within acceptable limits, indicating that the sources and production methods of the honey yielded a product with a sugar content that meets the required quality standards (CODEX, 2001).

Conclusion

This study evaluates some physicochemical properties of 81 honey samples collected from the Northern and Southern Guinea Savannah Zones of Niger State, Nigeria. The HMF, reducing sugar and sucrose contents of the honey analysed are within the range of recommended values by the Codex Alimentarius (2001) and European Directive (2001) in both zones. The pH values were within the Codex standard in the processed and unprocessed samples from both zones, but slightly higher than the Codex Alimentarius standard in the retailed honey samples from both zones. Therefore, the honey samples collected directly from the honey farmers indicated that the honey from Niger State is a good quality honey.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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