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Proximate composition and colour profile of honey from Northern and Southern Guinea Savannah Zones of Niger State, Nigeria

H. A. Aminuwa[1]*, I. H. Nock[1], I. S. Ndams[1], B. O. Otu[2], A. J. Natala[3], I. A. Abamhekhelu[4] and G. E. Lasisi[5]

[1]Zoology Department Ahmadu Bello University Zaria, Kaduna State, Nigeria.
[2]Department of Animal Production Federal University of Technology Minna, Niger State, Nigeria.
[3]Department of Veterinary Parasitology and Entomology Ahmadu Bello University Zaria, Kaduna State, Nigeria.
[4]Department of Microbiology, Federal University of Technology Minna, Niger State, Nigeria.
[5]Department of Psychology, Sociology and Politics Collegiate, Sheffield Hallam University, UK.

*Corresponding author. Email: haminuwa@lifesciences.abu.edu.ng

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ABSTRACT: This study evaluates the proximate composition and colour profile of honey harvested from the Northern and Southern Guinea Savannah zones of Niger State, Nigeria. The samples were gathered from nine Local Government Areas: four from the Northern Guinea Savannah Zone and five from the Southern Guinea Savannah Zone. The analysis included moisture, ash, protein, lipid, fibre, carbohydrate content, and colour composition of the honey samples. The samples showed that there were significant differences ($p>0.05$) in moisture content, crude protein and carbohydrate content between samples from the Northern and Southern Guinea Savannah zones of Niger State. However, there were no significant differences in the ash and fat content in the honey samples from both Northern and Southern Guinea savannah zones of Niger State. The honey had an amber colour value of 12 - 36.11%, carbohydrate content of 78.32-84.16%, crude protein of 0.16-0.20%, an ash content of 0.56-0.63% and fat content of 0.20-0.21%. The results of the proximate analysis indicated that all examined parameters fell within the codex standard, with the exception of the retailed samples, which had slightly lower carbohydrate contents in both zones. These findings suggested that geographical location within Niger State significantly influences the physicochemical properties of honey, which could impact its quality, marketability, and potential health benefits. Further research is recommended to explore the factors driving these regional differences and their implications for honey production and consumption.

Keywords: Colour profile, honey, proximate composition, Southern Guinea Savanna, Niger State.

INTRODUCTION

Honey is the naturally occurring sweet material that honey bees make from plant nectar, plant secretions, or plant-sucking insect excretions on plant parts. The bees gather this material, transform it by mixing it with other substances, deposit it, dry it out, store it, and then allow it to ripen and mature in the honeycomb (Codex Alimentarius, 2001). On the other hand, other insects, such as, mosquitoes contribute to global mortality, causing over one million deaths annually (Aminuwa *et al*., 2018). Because of the geographical and botanical origin of the nectar that bees graze, it is a complex mixture with wide variations in composition and characteristics (Soares *et al.,* 2017). Season, beekeeper management, botanical and floral origin, and environmental conditions are basic aspects that impact the market value of honey (Harianja et al., 2023).

Honey is a very nutritious food because of its high sugar content, low amounts of lipids, amino acids, and some

vitamins and minerals, as well as its long history of use for religious, medical, cultural, and economic purposes. For example, honey is employed for important religious activities in many Indigenous societies worldwide (Zambrano *et al*., 2022). The main components of honey are sugars, including oligo, dis, and polysaccharides as well as mono- and disaccharides. Enzymes like peroxidase, diastase, invertase, catalase, and glucose oxidase are found in it. According to Bogdanov *et al*. (2008), honey also includes organic acids, ascorbic acid, trace elements, vitamins, amino acids, proteins, and Maillard reaction products, among other bioactive components.

Honey was long utilized as a therapeutic solution for wound healing, treating skin problems, and treating numerous gastrointestinal diseases by ancient Egyptians, Assyrians, Chinese, Romans, and Greeks (White *et al*., 1962). According to recent studies, honey's secondary metabolites with antibacterial effectiveness have been linked to its potential to reduce inflammation and boost immunological responses in wounds (Gheldof *et al*., 2002). This study aimed at assessing the proximate properties and colour profile of some honey samples from Niger State, Nigeria.

MATERIALS AND METHODS

Study area

Niger State is 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. Trees are sparse and tend to be small and stunted, with scattered shrubs and herbs. Grasses are abundant and the most dominant species include Guinea grass, Rhodes grass, and red oat grass (Adenle *et al*., 2020). The Southern Guinea Savannah vegetation with rainfall of 1.600 mm is denser and consists of taller trees, shrubs, and herbs. The most dominant plant species include baobab, shea trees, locust bean, and leopardwood. Grasses are less abundant, but some of the common species include elephant grass, Guinea grass, and red oat grass (Adenle *et al*., 2020).

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 each of unprocessed and processed honey were obtained directly from the bee keepers while three processed samples were obtained from retailers that purchased their honey directly from the farmers (June, 2018 to Febuary, 2019). The honey samples were collected in sterile bottle and kept in the dark at ambient temperature (25 – 28ºC) until they were needed for analysis (Omafuvbe and Akanbi, 2009).

Honey colour analysis

Honey samples were heated to 50°C to dissolve sugar crystals, after which the colour was determined by spectrophotometric measurement of the absorbance of a 50% honey solution (W/V) at 635 nm. The honey samples were classified according to the Pfund scale after conversion of the absorbance values.

Mm Pfund = -38.70 + 371*Abs.

Where: Mm Pfund, is the intensity of honey colour in Pfund scale and Abs. is the absorbance of honey solution (White *et al*., 1962) modified by Rebiai and Lanez (2014).

Proximate analysis

Moisture content analysis

One-hundred grams (100 g) of honey sample each was weighed accurately in a pre-weighed platinum dish and gently heated in a muffle furnace at 105°C until the sample turned black and dried. This was allowed to cool in a desiccator and re-weighed again until a constant weight was obtained. The weight loss in respect of 100 g represented the moisture contents of the honey samples. The percentage moisture content (MC) was calculated for all samples using the formula below

$\% M_C = M_1 – M_2 \times 100 / M_1 – M_0$

Where: M_0 = wt (g) of dish; M_1 = wt (g) of dish of honey sample before drying; M_2 = wt (g) of dish of honey sample after drying (Adenekan *et al*., 2012).

Ash content

Determination of ash content was done according to the AOAC official methods (2001). Two grams (2 g) of each sample was put in a previously weighed porcelain crucible and dried in an oven at 110ºC for 4 hours. This was done

to remove moisture that would cause foaming of the honey during the early stages of ashing. After removing the crucibles from the oven, they were cooled in a desiccator for about 4 hours and weighed with the evaporated sample. The materials were then ashed in an electrical furnace at 600ºC for 6 hours, followed by cooling in a desiccator and then weighed. The ash content on dry basis was calculated according to the following equation:

% Ash = (Wt. of crucible + ash) – Wt. of empty crucible x 100/Wt. of honey sample (Adenekan *et al.*, 2012).

Where: A= weight of the crucible; B= weight of crucible and sample after evaporation; C= weight of crucible and sample after ashing.

Crude protein (CP)

The honey sample was analyzed for crude protein using the routine Kjeldahl nitrogen method (Joslyn, 1970). Ten grams (10 g) of the homogenous honey sample was weighed into a digestion flask and mixed with 10 ml of water. The diluent was transferred into the volumetric flask, while the Kjeldahl catalyst tablet (potassium sulphate) was added and thoroughly shaken. Twenty millilitres (20 ml) of concentrated H_2SO_4 was added and fixed into the digester. The flask was cooled and the digest was transferred into a 100 ml volumetric flask. Five drops of bromocresol (indicator) and 75 ml of water were added. Ten millilitres (10 ml) of the digest was pipetted into the Kjeldahl distillation flask and titrated with 0.05 N of HCl, while the percentage total nitrogen was calculated using the formula;

% Total nitrogen = (sample titre – blank titre) X N/10 x wt of sample

Where: N = normality of acid (Adenekan *et al.*, 2012).

Carbohydrate

The carbohydrate content was determined by subtracting the summed-up percentage compositions of moisture, protein, lipid, fibre and ash contents from 100 per cent (AOAC, 2001).

%Carbohydrate: = 100 – (%Protein + %Moisture + %Ash + %Fibre).

RESULTS AND DISCUSSION

The colour of the honey samples in the Northern and Southern Guinea savannah zones of Niger State showed that the most predominant honey colour was Dark Amber with 13 (36.11%) and 12 (26.67%) for the Northern and Southern Guinea Savannah zones respectively. Table 1 shows the colour of honey samples, in which the majority of the honeybees's honey samples (25 out of 81) had dark amber colour intensity in both Northern and Southern Guinea Savannah zones. Honey colours are a function of many factors including the type of vegetation from which the bees forage, soil, age of honey, storage factor and honey processing. In this study, the dominant tree species in the study area were *Nauclea folia* and *Entada abyssinica* which may account for the observed colour of the honey obtained. This is in line with the report of Lawal *et al*. (2009).

Nigerian honey is classified into eight colour categories, including extra white, extra white amber, extra light amber, light amber, amber, dark amber, white and water white by the USDA and CODEX alimentarus (Reference Table 1). In terms of agroecological zones, samples of honey from the Southern Guinea Savannah zone showed the highest level of colour variety, while samples from the Northern Guinea Savannah zone showed the lowest level of colour variation. Overall, it has been found that there are substantial relationships between the flavonoids and total phenolic contents of various foods, such as fruits, vegetables, and honey, and the colour variability of those foods (Mongi, 2013; González-Peña *et al*., 2013).

It has been claimed that the antioxidant actions of honey, as demonstrated in honey from Tanzania (Muruke, 2014; Shekilango *et al*., 2016) and the European Atlantic region (Escuredo *et al*., 2013) are directly linked to these flavonoids and phenolic substances. Light-coloured honey has lower levels of phenolic and flavonoid components as well as lower antioxidant qualities than dark-coloured honey. These chemicals, which are derived from the host plants that grow in these areas, are abundant in Savannah honey, which is frequently distinguished by its dark colour. Wesołowska *et al*. (2014) reported that the place of honey's origin can affect its anti-microbiological properties, even if the current investigation found overlaps in several places. It is important to note that the diversity of flora types in the locations with greater variance may have an impact on the food sources for bees.

The results of the proximate analysis of honey from the Northern Guinea Savanna zones of Niger State are shown in Table 2. The moisture content in the honey samples collected from the retailers (19.75%) was significantly higher ($p<0.05$) than that in the processed (18.77%) and unprocessed samples (14.88%) for both zones. The ash and fat contents did not differ significantly for Northern Guinea Savannah ($p>0.05$). The protein contents in the processed and retailed (0.20%) samples were significantly ($p<0.05$) higher than the unprocessed samples (0.16%). The carbohydrate content of the unprocessed sample (84.04%) was significantly ($p<0.05$) highest, followed by the processed sample (80.21%), while the retailer sample (79.28%) had the least.

Table 1. Honey colour from the Northern and Southern Guinea Savannah Zones.

Colour standard	Pfund scale	Northern (%)	Southern (%)	Total umber	t-value	p-value
Amber	>114	2 (5.55)	3 (6.67)	5	-2.47	0.13
Dark Amber	>85 and ≤114	13 (36.11)	12 (26.67)	25	1.15	0.35
Extra Light Amber	>70 and ≤85	3 (6.25)	5 (11.11)	8	-6.92	0.02
Extra White	>60 and ≤70	0 (0.00)	2 (4.44)	2	-17.32	0.00
Extra White Amber	>50 and ≤60	0 (0.00)	2 (4.44)	2	-34.64	0.00
Light Amber	>34 and ≤50	2 (4.17)	6 (13.33)	8	-6.92	0.02
White	> 17and ≤34	9 (25)	9 (20.00)	18	0.00	1.00
Water white	>8 and ≤17	7(19.44)	6 (13.33)	13	8.660	0.013
Total		36	45	81		

Table 2. Proximate analysis of honey from the Northern and Southern Guinea Savannah Zones

Sample and source	Moisture (%)	Ash (%)	Fat (%)	Crude protein (%)	Fibre (%)	Carbohydrate (%)
Unprocessed						
NGS	14.88±0.46^{c}	0.63±0.06^{a}	0.20±0.00^{a}	0.16±0.01^{b}	0.00	84.04±0.56^{a}
SGS	15.05±0.34^{c}	0.63±0.05^{a}	0.20±0.00^{b}	0.16±0.02^{b}	0.00	84.16±0.36^{a}
Processed						
NGS	18.77±0.31^{b}	0.60±0.08^{a}	0.21±0.01^{a}	0.20±0.00^{a}	0.00	80.21±0.30^{b}
SGS	18.10±0.22^{b}	0.61±0.11^{a}	0.20±0.00^{ab}	0.20±0.00^{a}	0.00	80.91±0.19^{b}
Retail						
NGS	19.75±0.59^{a}	0.56±0.08^{a}	0.21±0.01^{a}	0.20±0.02^{a}	0.00	79.28±0.56^{c}
SGS	20.24±0.22^{a}	0.63±0.02^{a}	0.21±0.01^{a}	0.20±0.01^{a}	0.00	78.32±0.50^{c}
P-value	0.00	0.25	0.10	0.00		0.00
CODEX Ref. value	<20	<0.6		0.20		≥83

Superscript $^{a–c}$: Means with the same letter(s) in a column are not significantly different p≥0.05. **Key:** NGS= Northern Guinea Savannah**, SGS**= Southern Guinea Savannah.

The fat value in retailed (0.21%) was significantly higher than fat in unprocessed (0.20%) but was comparable to processed (0.20). Protein levels in processed (0.20%) and retailed (0.21%) were significantly higher than unprocessed (0.16%). There was a significant (p<0.05) difference in carbohydrate content among the unprocessed (84.16%), processed (80.91%) and retailed (78.32%) samples and carbohydrate (81.51%) were slightly higher in the Northern Guinea Savannah.

The honey moisture content from the Northern Guinea Savannah zone ranged from 14.88±0.46 to 19.75±0.3% and the Southern Guinea Savannah zone from 15.05±0.3 to 20.24±0.22%, which all fall within the international standard for honey (Codex, 2001) meaning that the honey samples can remain stable and can resist spoilage by yeast fermentation during storage. The differences in the moisture content of honey could be based on composition, floral origin or adulteration of honey with water or sugar (Nanda *et al*., 2003, Malika *et al*., 2005). The honey sample from the Southern Guinea Savannah showed significantly (p>0.05) higher moisture content compared to the honey samples from the Northern Guinea Savannah. The differences might be because of the different sample sites, though the sample obtained from the retailers were higher in moisture content in both the Northern and the Southern Guinea savannah zones of Niger state. Another reason for the difference might be a result of the longer storage time practised by retailers who keep honey and await better sale periods. The study agrees with the report of Kumsa and Takele (2001) who obtained (14.13 - 14.61%) moisture content for honey from the Bauchi and Kaduna States, and Osuagwu *et al*. (2020) (11.13-16.16) honey from the Guinea savannah zones of Nigeria with 15.58% moisture content from the Niger State of Nigeria. Similarly, values in moisture content for honey from Iran and India were reported by Zahedi *et al*. (2018) (16.02 - 17.8) for Iranian honey and Indian honey 17.22 - 21.8% as reported by Anupana *et al*. (2003).

The ash content of 0.34± 0.06 to 0.56± 0.8% from the Northern, and 0.43± 0.05-0.63± 0.11% from the southern Guinea savannah zone of Niger State was statistically the same and were all within the international standard (Codex standard), giving certification to the quality of honey from the study area. High ash content in honey might reduce the sweetness and flavour and lead to discolouration or darkening of honey. In extreme cases, high ash content can cause honey to turn solid. However, ash content alone is not a reliable indicator of honey quality. This work agrees with the report of EC, (2010) that stated that the blossom honey (honey from nectar producing plants) has low ash content. This finding is consistent with other findings as reported by Ibegbulem *et al*. (2018) 0.13 - 0.51%; Adebiyi *et al*. (2004) 0.09-0.51%, Zahedi *et al*. (2018) 0.37-0.62 and lower ash content obtained by Lawal *et al*. (2009) 0.60-0.84% for Nigeria honey.

The protein content in honey samples from the Northern and Southern Guinea Savannah zones was not significantly different and within the accepted limit. However, significant differences were observed from within zones as the protein level in unprocessed, processed and retailed samples. Differences may be due to pollen content variations in honey from the unprocessed, processed and retailed samples which was not assessed as protein content in honey is linked with the pollen content. Findings from this study corroborate the work by Osuagwu *et al*. (2020) but vary with the protein values obtained by Adenekan and Augustus (2020), from the tropical rainforest Agro-ecological zones of Nigeria.

One of the constituents of honey is the carbohydrate which constitutes about 95% of honey dry weight (Osuagwu *et al*., 2020). Honey is a high-energy carbohydrate food; the sugar content in honey is digestible similar to the sugar found in fruits. Also, honey with carbohydrate content greater than 83%, moisture content less than 17.0% and storage temperature less than 11˚C will not ferment (European Union Commission, 2001)
The carbohydrate content of the studied honey samples was within the International limit of ≥83% (European Union Commission, 2001). The result obtained is comparable with that by Ndife *et al*. (2014), who reported 80.00±2.96 to 82.71±3.10% carbohydrate content of imported U.S.A honey, Osuagwu *et al*. (2020) recorded 97.94% in the comparative studies of the physiological properties and mineral elements of honey produced in the Guinea savannah zones of Nigeria and Leticia *et al*. (2013) reported 98.95±019% carbohydrate content in the study of *Melipona subnitida* and *Apis mellifera* from Brazil.

Food with a higher fat content stands the risk of rancid spoilage during storage (Estevinho *et al.,* 2012). The high content of 0.2 and 0.21% obtained in the Southern and Northern Guinea savannah zones respectively, correlated with the pollen content. Honey should be devoid of fat (Martin *et al*, 2021). However, the higher values obtained suggested that the honey may become rancid during storage. The result of this study is consistent with the previous report by Ndife *et al*. (2014) who recorded 0.12±0.01 to 0.20±0.03% in the comparison study with an imported USA honey, and in contrast with Leticia *et al*. (2013) report who obtained higher values (0.37% to 0.39%).

Conclusion

This study evaluated the physicochemical properties of some honey samples from Niger State, Nigeria. Results of the parameters; moisture, ash, fat, crude protein, fibre and carbohydrate contents which were used in determining the honey quality, however, indicated that all the honey samples studied recorded values within the international standard described by Codex Alimentarius; the U.S. Department of Agriculture and European Regulation Commission for bee honeys, except for the fat content which is slightly higher in both zones. The highest moisture content of all the studied honey samples is 20% and this confers on the sample stability against bacteria activities and long periods of preservation. The colour analysis showed that the most predominant honey colour from the study area was dark amber coloured. Therefore, honeys from both zones in Niger State are of good quality.

CONFLICT OF INTEREST

The authors declared that no competing interest exists.

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