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METEOROLOGICAL INFLUENCES ON SOME MELLIFEROUS PLANT SPECIES: NECTAR NUTRITIONAL COMPOSITION AND HONEY YIELD IN MANGROVE VEGETATION ZONE OF AKWA IBOM STATE, NIGERIA.

UFFIA, I. D., AKACHUKU, C. O., UDOFIA, O. E AND NSIEN, I. B.

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ABSTRACT

Meteorological influences on the nutritional composition of the nectar of selected melliferous plant species and impact on honey yield were studied for 36 months in the mangrove vegetation in Akwa Ibom state Nigeria. Nectar of selected melliferous plants was collected randomly for three years (2015-2017) and from the vegetation zone during dry and rainy seasons. Climatic factors such as Maximum Temperature, Minimum Temperature, Solar Radiation (mm), Mean Daily Evaporation (mm), Wind speed (ms^{-1}) Rainfall (mm) and humidity) data of the study area were also recorded from Nigeria Meteorological Agency (NIMET) station in Eket LGA. Samples were taken in the early and later stages of flowering and the plants selected for the study were Helicteres ixora, Musa paradisiaca, and Costus afer. Nectar was extracted from the flowers directly, using a 10 µl capillary tube from the floral cup of 200-3000 flowers of melliferous plants. Finding from this study showed higher concentrations of vitamins and sugar in the nectar of melliferous plant species in the dry season than in raining season suggesting a possible impact of high temperature and radiation on increased nectar production.

KEYWORDS: Nectar, Nutritional Composition, Melliferous plants, Climatic factors

1.0 INTRODUCTION

Plants play an important role, as sources of food and maintenance of good health (Ben, 2004). In Nigeria and most African countries, indigenous people traditionally use a wide range of plants (particularly non-timber forest products) as food and medicine (Etukudo, 2000). Ruiz and Arnold (1995) explained that plants contain a wide variety of compounds that exhibit some medicinal and nutritive properties which are used as spices, food or medicinal plants. West Africa is endowed with rich varieties of melliferous plant species. These melliferous plants provide the environment for the production of high-quality honey by the typical West African honeybee (Apis mellifera adansonii) (Akachuku and Onyenso, 2009). The honeybee, Apis mellifera, depends largely on plant resources for food. Akachuku (2002) explained that honeybee workers make thousands of visits to flowers of melliferous plant species to collect nectar and pollen.

They pollinate these flowers during visits, thereby helping to increase fruit and seed-setting in wild and cultivated plants. The implication of this is that honeybees contribute immensely to the maintenance of ecosystems, agricultural production and production of important products such as honey. Akachuku (2002) defined melliferous plant species as plants that are visited by the bees and produce substances that can be harvested by honeybees and turned into honey. Akachuku and Onyenso (2008) explained that man has sought the honey produced by bees from the earliest times; therefore, the honey collection is a traditional activity in Africa. Honey, a high sugar concentration (greater than 0.8) fluid, is made by honeybees from flower nectar, a lower sugar concentration liquid (0.1–0.5), collected from numerous flowers of melliferous plant species sometimes at a considerable distance from the nest (up to 9 km) (Beekman and Patricks, 2000). This nectar is passed by the forager honeybee to another honeybee (unloader/storer) (Park, 1946), which

Uffia, I. D., Department of Genetic and Biotechnology, Akwa Ibom State University, Nigeria
Akachuku, C. O., Department of Forestry and environmental Management, Michael Okpara of Agriculture, Umudike, Abia State
Udofia, O. E., Department of Genetic and Biotechnology, Akwa Ibom State University, Nigeria
Nsien, I. B., Swamp Forest Research Station, Forestry Research Institute of Nigeria, Ibadan, Oyo, Nigeria.

then starts the desiccation process by selectively heating and aerating the nectar with their mouth parts while placing it in a honeycomb cell.

According to Allen and Platt (1990), climatic factors can affect the production and availability of flowers which in turn affect the production of nectar harvested by bees for honey production. Available data on nectar characterization of melliferous plant species and their influence on all aspects of honey production have received very limited consideration. The study therefore assessed the meteorological influences of some melliferous plant species nectar nutritional composition and honey yield in mangrove vegetation zone of Akwa Ibom State, Nigeria.

2.0 MATERIALS AND METHODS

The study was carried out in mangrove vegetation zone in Akwa Ibom State, Nigeria. Mangrove vegetation zone is located along the Atlantic Coast with Latitude 4°15 'N and 4°55' N and longitude 6° 10 and 8° 16'E (UNEP, 2007). According to Ukpong (2007), the mangrove forest is known to be rich in both aquatic and terrestrial biodiversity, as such, a major source of rural life sustenance not only in Akwa Ibom States but also in many other regions in Niger Delta and elsewhere (Meteorological services, 1980: Metrological Station, National Root Crop Research Institute (NRCRI) Umudike, Nigeria).

The determination of honeybee plants was done through direct observation of foraging honeybee workers on its flowers. These observations were made during field trips, which lasted from dawn to dusk, organized periodically in both dry and wet seasons. Only plants with many sustained foraging for nectar and/or pollen were recorded.

Nectar of the selected melliferous plants (Helicteres ixora, Musa paradisiaca, Costus afer) was collected randomly from the vegetation in their early and later stages of flowering during dry and wet seasons for three years (2015-2017). The nectar was extracted directly, using a 10 µl capillary tube: a sterile technique according to Harrigan and McCane (1976) and Kearns and Inouye (1993) from the floral cup of 200-3000 flowers of melliferious plants, depending on the nectar yield of each plant. The tubes of the micropipettes and micro-syringes were used for extracting nectar of many plant species where floral nectar was highly viscous, or was produced in low volumes (<1 µl) (Corbet, 2003). Thus, the number of flowers in a tree species from which nectar was collected indicates the nectar quantity. Samples collected were transferred to a refrigerator at -4°C. It was then clean to remove less polar impurities by solid-phase extraction on C18 columns, and then dried in a vacuum centrifuge for analysis of various sugars (glucose, fructose, sucrose) from extracted nectar of melliferious plants, it is then diluted with 200 µl distilled water, and filtered using a WATERS™ high performance carbohydrate column to avoid contamination. Samples were injected directly after filtration. The injection volume was 10 µl, and elution took place with an acetonitrile–water mixture (71: 29) at a flow rate of 1·4 ml min−1 and a temperature of 40 °C. Glucose, fructose, and sucrose were detected with a refraction index detector and quantified with the WATERS Millenium Software™. Concentrations were converted from µg µl−1 to sucrose-equivalent, percentage weight per total weight (Weast, 1969: AOAC, 2003: Čižmárik, 2004).

Vitamins (A-C) contents were determined using Ultra-performance liquid chromatography (UPLC) which is an easy and accurate way to qualify and quantify specific sugars and other chemicals within a nectar sample. After centrifugation and filtration (with a 0.20 µm syringe filter), the sample was analyzed using a UPLC system (Waters, USA), an Acquity UPLC® HSS T3 (2.1 x 100 mm, 1.8 µm) column, and a PDA detector (Waters, USA) set at a wavelength of 254 nm. The mobile phase used was 99% methanol and 1% distilled water with 0.1% formic acid solution at a flow rate of 0.3 mL min-1. Authentic vitamins standard was used for identification and quantification of the peak (Kearns and Inouye, 1993: Spinola et al. 2012). Climatic factors (Maximum Temperature, Minimum Temperature, Solar Radiation (mm), Mean Daily Evaporation (mm), Wind speed (ms-1), Rainfall (mm) and Humidity) data of the study area were also recorded from the Nigeria Meteorological Agency (NIMET) station in Eket LGA respectively.

3.0 RESULTS

Results in Table 1 summarized the results in the levels of vitamin and sugar contents in nectar of Helicteres ixora in dry and raining seasons in the mangrove vegetation zone in Akwa Ibom State, Nigeria. The results indicated a variation in vitamin and sugar contents in nectar of Helicteres ixora in dry and rainy seasons in the mangrove vegetation zone. The results recorded significant difference ($p<0.05$) in vitamin A, vitamin B1, vitamin B3 contents between dry and raining seasons. Dry season recorded significantly higher ($p<0.05$) values in vitamin A, vitamin B1, vitamin B2 than values recorded in the raining season.

Table 2 revealed variations in vitamin and sugar contents in dry and raining seasons in nectar of Musa paradisiaca flowers in mangrove vegetation zone in Akwa Ibom State, Nigeria. However, the results recorded a significant difference ($p<0.05$) in vitamin B2 contents only while no significant difference existed in the rest of the studied parameters. Dry season had significantly higher values than rainy season in vitamin B2 contents.

Table 3 indicated the variations in vitamin and sugar contents in nectar of Costus afer in mangrove vegetation zone in Akwa Ibom State, Nigeria. A Significant difference ($p<0.05$) existed only in vitamin C contents between dry and raining seasons. Vitamin C contents was significantly higher ($p<0.05$) in the dry season than in the rainy season.

Table 4 showed variations in climatic factors in mangrove zone in Akwa Ibom State, Nigeria. Significant difference ($p<0.05$) existed in the maximum temperature, Solar Radiation, Mean Daily Evaporation, rainfall and humidity levels. No significant difference ($p>0.05$) existed in the minimum temperature and wind speed levels. Maximum temperature, solar radiation, mean daily evaporation had significantly higher values ($p<0.05$) in the dry season than in the raining season. However, rainfall and relative humidity had significantly higher values ($p<0.05$) in the raining season than in the dry season.

Spearman's rho correlation coefficient (ρ) values for climatic factors with nectar parameters in mangrove vegetation zone are presented in Table 5. The correlation coefficient showed some significant ($p<0.05$) relationships amongst themselves. There was a positive significant correlation between rainfall and Vitamin B3 ($\rho=0.19$) while negative significant correlation existed between mean daily evaporation and vitamin B3 ($\rho= -0.27$. No significant correlation existed in the rest of the measured parameters.

Table 1: Variations in vitamins and sugar contents of nectar of Helicteres ixora in dry and raining season in Mangrove vegetation zone of Nigeria

	Seasons		
Nectar parameters Vitamins and sugar)	**Dry season**	**Rainy season**	**Significant**
Vitamin A (mg/100g)	$0.20\pm0.00_a$	$0.17\pm0.11_b$	Yes
Vitamin B1 (mg/100g)	1.14±0.01	1.13±0.01	No
Vitamin B2 (mg/100g)	$0.08\pm0.013_a$	$0.06\pm0.03_b$	Yes
Vitamin B3 (mg/100g)	$1.48\pm0.11_a$	$1.46\pm0.01_b$	Yes
Vitamin C (mg/100g)	83.40±1.39	83.62±0.61	No
Glucose (mg/100g)	202.22±0.17	202.00±0.17	No
Fructose (mg/100g)	199.64±0.46	199.20±0.42	No
Sucrose (mg/100g)	202.43±0.06	202.20±0.09	No

Means with different subscripts along the same row are significantly different (Duncan's test) $p<0.05$

Table 2**: Variation of vitamin and sugar contents in nectar of Musa paradisiaca flowers in dry and raining season in Mangrove zone of Nigeria**

	Seasons		
Nectar parameters (Vitamins and Sugar)	**Dry season**	**Rainy season**	**Significant**
Vitamin A (mg/100g)	0.14±0.011	0.13±0.013	No
Vitamin B1 (mg/100g)	1.11±0.01	1.09±0.01	No
Vitamin B2 (mg/100g)	$0.09\pm0.01_a$	$0.06\pm0.01_b$	Yes
Vitamin B3 (mg/100g)	1.41±0.02	1.39±0.01	No
Vitamin C (mg/100g)	40.93±0.80	38.20±1.88	No
Glucose (mg/100g)	26.68±1.92	24.87±1.63	No
Fructose (mg/100g)	26.71±1.55	25.86±1.57	No
Sucrose (mg/100g)	27.97±1.79	26.17±1.50	No

Means with different subscripts along the same row are significantly different (Duncan's test) $p<0.05$

Table 3: Variations in vitamin and sugar contents in dry and raining in nectar of Costus afer in Mangrove vegetation zone in Nigeria

	Seasons		
Nectar parameters (Vitamins and sugar)	**Dry season**	**Raining season**	**Significant**
Vitamin A (mg/100g)	0.26±2.09	0.16±0.01	No
Vitamin B1 (mg/100g)	1.18±0.05	1.12±0.01	No
Vitamin B2 (mg/100g)	0.06±0.011	0.07±0.03	No
Vitamin B3 (mg/100g)	$1.47\pm0.01_a$	$1.43\pm0.01_b$	No
Vitamin C (mg/100g)	91.04±1.06	87.96±1.11	Yes
Glucose (mg/100g)	199.58±0.38	198.21±0.73	No
Fructose (mg/100g)	199.42±0.79	196.45±1.44	No
Sucrose (mg/100g)	198.00±0.94	198.11±0.65	No

Means with different subscripts along the same row are significantly different (Duncan's test) $p<0.05$

Table 4: Variations of climatic factors in dry and raining seasons in Mangrove vegetation zone of Akwa Ibom State, Nigeria

	Seasons		
Climatic factors	**Dry season**	**Raining season**	**Significant**
Max Temperature (°C)	32.37±0.19a	30.40±0.27b	Yes
Min Temperature (°C)	23.18±0.21	23.41±0.13	No
Solar Radiation (w/m^2)	13.61±0.23a	11.23±0.32b	Yes
Mean Daily Evaporation (mm)	3.32±0.19a	2.09±0.15b	Yes
Wind speed (ms-1)	1.78±0.22	1.45±0.19	No
Rainfall (mm)	94.19±17.13b	398.10±30.88a	Yes
Humidity (%)	83.16±1.36b	88.69±0.58a	Yes

Means with different subscripts along the same row are significantly different (Duncan's test)

Table 5: Spearman's rho correlation coefficients (r) of Climatic factors with Nectar Parameters in Mangrove Vegetation Zone in Nigeria

	Nectar Parameters							
Climatic factors	**Vitamin A**	**Vitamin B1**	**Vitamin B2**	**Vitamin B3**	**Vitamin C**	**Glucose**	**Fructose**	**Sucrose**
Max Temperature (^{0}C)	0.08	-0.04	0.00	-0.07	0.00	0.09	0.08	0.08
Min Temperature (^{0}C)	0.10	-0.06	0.00	0.11	-0.11	0.03	0.02	0.01
Solar Radiation (mm)	0.06	-0.09	-0.01	-0.01	-0.10	-0.05	-0.06	-0.06
Mean Daily Evaporation (mm)	0.07	-0.01	0.00	**-0.27**	0.01	0.11	0.10	0.10
Wind speed (ms^{-1})	0.15	-0.10	0.00	0.03	0.01	0.03	0.03	0.02
Rainfall (mm)	-0.06	0.03	0.00	**0.19**	0.02	0.02	0.02	0.02
Humidity	-0.06	0.04	0.00	0.05	-0.03	-0.08	-0.08	-0.08

Values in bold are different from 0 with a significance level alpha=0.05

4.0 DISCUSSION

Rainfall and relative humidity are relatively high in this zone, with significantly higher values ($p<0.05$) in the rainy season than in the dry season. The annual rainfall lasts seven months: wet season from April to October and a dry season November to March. Similar data from the Niger-delta by International Institute for Tropical Agriculture (IITA), Onne, Rivers State, Nigeria has been reported by Abowei and George (2009). The high rainfall and high relative humidity recorded in this study area guaranteed constant availability of water needed for (melliferous) plants' growth and viability and increased honey yield (Akachuku, 2006). Finding from this study showed higher concentrations of vitamins and sugar in nectar of melliferous plant species in dry season than in raining season suggesting a possible impact of high temperature and radiation increased nectar production. Peat and Goulson (2005) also revealed that weather had a great influence on whether bees collected nectar and nectar quantity. Finding is in line with work of Junior et al. (2010) who indicated that bees return flights with nectar increased in frequency during the day at all seasons. Higher temperatures recorded in the dry season were expected since the heat from sunlight increases the maximum temperature. Similarly, the drop in the maximum temperature in the wet season is attributed to heavy rainfall experienced during the period. This is in line with the work of Ukpuoho (2005) who affirmed that the diverse nature of the mangrove vegetation and fast growth of plant species has been attributed to the always high temperature during the day and balancing cool temperature at night which is a characteristic of the area. The correlation between the climatic factors and sugar concentrations in identified melliferous plant species in this study, affirmed observations of Carroll et al. (2012) that the inter-play between temperature and relative humidity has an impact on nectar production and that the periodicity of nectar secretion is temperature-dependent. High nectar production suggests that the different climatic factors such as annual rainfall, temperature and relative humidity, interacting with the different melliferous plant species (Schweitzer, et al., 2013). This affirmed the observation of Okeke and Amaliko, (1992) that the high sunshine, temperature, rainfall and relative humidity all combine to meet the needed requirement for plant species growth, timely flowering and viability as well as to keep the ecological system functioning optimally. Dyer et al. (2006) affirmed that floral temperature can serve as an additional reward for pollinator insects when nutritional rewards are also available. Quality nutritional composition which is a function of better nectar sources correlated positively with higher external temperature for increased honey yield. Work of Leza et al., (2016) lead to the same conclusion suggesting that if the average rainfall is much lower or higher than the ideal, it could lead to significant problems, from drowned plants to poor flowering of melliferous plants thus impacting negatively on honey yield. This is also in line with work of Schweitzer et al., (2013) who affirmed that the rate of moisture loss (via transpiration) from nectar is greatly reduced under conditions of high relative humidity. High humidity in the study area suggests high moisture content in nectar from melliferous plants. These affirmed observations of Akachuku (2006) and Park (1946) that nectar commonly contains 50 percent or more of water which is passed by the forager honeybee to another honeybee (unloader/storer), which then starts the desiccation process by selectively heating and aerating the nectar with their mouth parts while placing it in a honeycomb cell, while after being changed to honey only 15 to 20 percent water remains. If the moisture level is not reduced, it will lead to fermentation and spoilage of nectar (Akachuku, 2006).

5.0 CONCLUSION

Plant species has shown specific nectar characteristic with high values in glucose, fructose, sucrose and ascorbic acids. By understanding the effect of high sunshine, temperature, rainfall and relative humidity on plant species growth, timely flowering and viability as well as it impacts on nectar characteristics and honey yield in the mangrove vegetation zone are essential in guiding prospective beekeepers in the choice of suitable sites/seasons for locating apiaries for sustainable honey production all year round.

REFERENCES

Abowei, J. F. N. and George, A. D. I., 2009. Some Physical and Chemical Characteristics in Okpoka Creek, Niger Delta, Nigeria. Research Journal of Environmental and Earth Science, 1 (2): 45-53.

Akachuku, C. O., 2002. Plant species of some wetlands in Nigeria visited by honeybees for nectar and pollen collection. Journal of Dev. Studies, 4, pp.68-80.

Akachuku, C. O., 2006. Assessment of housing architecture, Colony Content and physico-chemical properties of honey of Hypotrigona species. A Stingless honeybees species. Prod. Agric. Technol., 1: 161-169.

Akachuku, C. O. and Onyenso, A. I., 2009. Honey yield in different hives used in modern beekeeping in the rainforest area of Nigeria, Journal of Tropical Forest Resources, 25, pp.17-24.

Allen, R. B and Platt, K. H., 1990. Annual Seedfall Variation in NothofagusSolanderi (Fagaceae), Canterbury, New Zealand, Oikos, vol. 57, pp. 199-206.

AOAC (Association of Official Analysis Chemists) 2003. Official Methods of Analysis of the Association of Official Analysis Chemists. 15th edn. Atomic Absorption Method for Nectar" Washington, D. C. pp, 60-62.

Beekman M. and Ratnieks FLW. 2000. Long-range foraging by the honey-bee, Apis melliera L.Funct. Ecol. 14, 490-496.

Ben, C. B., 2004. Conservation and Management of Forest and Wildlife Resources in the Tropics, League of Researchers in Nigeria (LRN) Bauchi, Nigeria, pp. 122-141.

Carroll, M., Milakovsky, B., Finkral, A., Evans, A. and Ashton, M.S., 2012. Forest management and climate change: A position statement of the society O American foresters 2014 ed SAF, forest resources community America, pp. 23-45.

Čižmárik, J., Hroboňovňá, K. and Lehoytay, J., 2004. Determination of Monosaccharides and Disaccharides in Honey by Ion-Exchange High Performance Chromatography', Acta facultatis Pharmaceuticae Universitatis Comenianae, 51

Corbet, S. A., 2003. Nectar sugar content: estimating standing crop and secretion rate in the field. Apidologie, 34, pp.1–10.

Dyer, A. G., Whitney, H. M., Arnold, S.E.J., Glover, B. J. and Chittka, L., 2006. Bees associate warmth with floral colour. Nature, 442, 525.

Etukudo, I. G., 2000. Forests our divine treasure, Doround Publishers Uyo, Nigeria, pp. 54-65.

Harrigan, W. F. and McCane M. E., 1976. Laboratory methods in food and Diary Microbiology. 1st Edn. Academic Press. London, UK pp. 452-459.

Junior N T F, Blochtein B and Moraes J F de 2010. Seasonal flight and resource collection patterns of colonies of the stingless bee Melipona bicolor schencki Gribodo (Apidae, Meliponini) in an Araucaria forest area in southern Brazil.

Revista Brasileira de Entomologia 54(4): 630–636.

Leza M. M., Miranda-Chueca M. A., Purse B. V., 2016. Patterns in Varroa destructor depend on bee host abundance, availability of natural resources, and climate in Mediterranean apiaries. Ecol. Entomol

Kearns C A. and Inouye D W., 1993. Techniques for the pollination biologist, University Press of Colorado, USA, pp. 12-34.

Schweitzer, P., Nombré, I. and Boussim, J. I., 2013. Honey Production for Assessing the Impact of Climatic Changes on Vegetation, Tropicultura, 2013, 31, 2, 98-102.

Meteorological service 1980. Soil-vegetation interrelationships of mangrove published by Geoderma, An International Journal of Soil Science. 64, 1, pp.167-181.

Okeke, A. L. and Omaliko, L., 1992. Nutrient accretion to the soil via litterfall and through fall in Acida barteri stands at Ozala, Nigeria. Agro-forestry system, 16: 23-32.

Park , O. W., 1946. Activities of honey bees. In The hive and the honey bee (ed. Grout R), Chicago, IL: Dadant and Sons. pp. 125-205.

Peat J. and Goulson, D., 2005. Effects of experience and weather on foraging rate and pollen versus nectar collection in the bumblebee, Bombus terrestris. Behavioral Ecology and Sociobiology, 58(2), 152-156.

Ruiz, P. M. and Arnold, J. E. M., 1995. Current issues in non-timber forest products research. CIFOR and ODA. PP. 81-90.

Schweitzer, P., Nombré, I. and Boussim, J. I., 2013. Honey Production for Assessing the Impact of Climatic Changes on Vegetation, Tropicultura, 2013, 31, 2, 98-102.

Spinola, V., Mendes, B., Camara., J. S. and Castilho, P. C., 2012. An improved and fast UHPLC-PDA 388 methodology for determination of L-ascorbic and dehydroascorbic acids in fruits and vegetables. 389 Evaluation of degradation rate during storage. Analytical and Bioanalytical Chemistry, 403, pp.1049–1058.

Ukpong, I. E., 2007. Mangrove Forest under Threat? An evaluation of the integrity of Mangrove Ecosystem Functioning. The 17th Inaugural Lecture. University of Uyo, pp. 23-56.

Ukpuoho, E. I., 2005. The effects of litter and woodash on the recruitment/regeneration of plant species under a pine plantation in Umuahia, Abia State unpublish B.Sc. Project. Michael Okpara University of Agriculture, pp. 102-112.

UNEP., 2007. Mangroves of Western and Central Africa. UNEP-Regional Seas Programme/UNEP-WCMC, pp. 88-102.