Biometric Edaphological Assessment: The role of soil properties on the synthesis of essential molecules in Nigerian *Gnetum* species.

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Abstract

The effect of soil properties on the synthesis of essential molecules in habitats densely populated with Gnetum africana and Gnetum bulchozianum were studied Uyo, L.G.A. of Akwa Ibom State. Ten Plant samples each for the different species and soil samples at the stalk of the sampled plants were collected and taken to the laboratory for physiological, proximate and physic-chemical parameters. Correlation analysis between plant and soil parameters revealed significant (P<0.05) relationships. The study showed that the while the synthesis of chlorophyll and Phytate was dependent on Available phosphorus, Carbohydrate synthesis was dependent upon the synergistic effects from organic carbon and pH. Also, pH and total Nitrogen seems to have been responsible for the crude protein content of these species while Calcium was associated with the concentration of oxalates in these species. Again, Total nitrogen significantly (P<0.05) affected the concentration of tannins in the plant. These results have serious implications in Phytochemistry, nutrition science and drug formulation.

Keywords: *Carbohydrate, Gnetum, Hydrogen-Cyanide, Oxalate, Phytate and Soil.*

INTRODUCTION

Gnetum africana and *Gnetum bulchozianum* commonly known as Afang (Efik), Okazi (Ibo) and Eru (Cameroun) grows naturally in humid forest is from the family Gnataceae. It is widely distributed in Nigeria through Cameroun, Central Africa Republic, Equitorial Guinea and Gabon (Etukudo, 1985).This vegetable is important ingredients in preparing tasty soup in many homes in the South-south and Southeast of Nigeria. According to Okafor and Okoro (2004), vegetable is fresh edible portion of a plant consumed in either raw or cooked form. Omokanye, Isula and Udoma (2001) reported that food value of fresh vegetables varies from species to species and also from age to age owning to the large amount of mineral nutrients and water present in each species. In the rural areas where the popularly eaten food is mainly carbohydrate, indigenous vegetables play useful role in promoting food quality with proteins, minerals, vitamins and fats, also roughage part of the vegetable aids in digestion. Onyeagocha (1995) reported that the most important feature of some fresh vegetables is that they contain the nutritional value of economic importance. There has been serious efforts and proper documentation of the molecular properties of edible and medicinal plants but such informationin relation to the effect of habitat (soil) influence on the accumulation of these bioessential molecules is lacking (Ekop, 2012, Antia, et al. (2006).

Pedology is the branch of science which studies soil as an entity while edaphology is an aspect pedology which reveals the effect of edaphic factors on plants and animals. Literature has confirmed that most often than not, there is a complex interrelationship between the soil and the vegetation it supports. Selective absorption of nutrients by different plant species and their capacity to return these to the soil brings about changes in the biochemical properties of both soil and plants (Mbong and Ogbemudia, 2013., Brady and Weil, 1999). To this end, this research is aimed at defining the effect of some edaphic indices on the synthesis of protein, carbohydrates, chlorophyll and other essential molecules in common *Gnetum* species in Nigeria.

Generally, information(s) on the essential molecule (protein, carbohydrate, chlorophyll *etc*) compositions of plants has been properly documented but identifying the effects of pedological indices on the synthesis of these molecules is lacking. Against this background this present research is indispensible.

MATERIALS AND METHODS

Plant Materials Identification and Collection

The fresh leaves of *Gnetum africana and Gnetum bulchozianum* used for this research were obtained from Uyo (Akwa Ibom State), Ikom (Cross River State) and Ohafia (Abia State) Local Government Areas of Nigeria on 6th August, 2013. The plant samples were duly identified at the Department of Botany and Ecological Studies Herbarium, University of Uyo.

Soil Sample Collection

Soil samples were collected in a ring form at a rooting depth of 1.35m at the base of the plants from which leaves were harvested and stored in black polythene bags before digestion and analysis.

Method of plant analysis

The Moisture content of powdered leaves determined using the Drying Method (African pharmacopeia, 1986), Ash value using the method described by British pharmacopeia (1980), Crude Protein, Crude Fibre, Carbohydrate and Chlorophyll were obtained by the methods of Pearson (1976) and AOAC (2000).

Physicochemical Analysis of Soil Samples

Soil samples were analyzed following the standard procedures outlined by the

Association of Official Analytical Chemist (APHA, 1998). Soil pH were measured using Beckman's glass electrode pH meter (Meclean, 1965). Organic Carbon by the Walkey Black wet oxidation method (Jackson, 1962), available Phosphorus by Bray P-1 method (Jackson, 1962). The total Nitrogen content was determined by Micro-Kjeldahl method (Jackobson, 1992). Soil particle size distribution was determined by the hydrometer method (Udo and Ogunwale, 1986) using mechanical shaker, and sodium hexametaphosphate as physical and chemical dispersant. Exchange Acidity was determined by titration with 1N KCl (Kamprath, 1967). Total Exchangeable Bases were determined after extraction with 1M NH_4OAc (One molar ammonium acetate solution). Total Exchangeable Bases were determined by EDTA titration method while sodium and Potassium were determined by photometry method. The Effective Cation Exchange Capacity (ECEC) was calculated by the summation method (that is summing up of the Exchangeable Bases and Exchange Acidity (EA). Base Saturation was calculated by dividing total Exchangeable Bases by ECEC multiplied by 100.

RESULT

Table 1 shows species molecular variation in Gnetum species found in Nigeria, Table 2 reveals the characteristics of soil on which this species grow while Table 3 relates soil-plant correlation matrix.

Table 1: Mean (±SE) of Molecular constituents of *G.* species.

Molecular Composition	***G. africanum***	***G. bulchozianum***
Crude Protein	48.19±3.76	15.02±2.7
Crude Fat	38.15 ±2.30	12.36±3.31
Carbohydrate	37.27 ±1.40	20.19±1.8
Crude fibre	26.22 ±2.81	43.17±6.2
Hydrogen-Cyanide	0.95±0.05	3.55±1.73
Phytate	1.37 ±0.94	5.12±1.3
Oxalate	2.13±0.60	7.23±0.97
Tannins	0.56 ±0.03	4.10±0.75

Table 2: Mean (±S.E) Physico-Chemical Properties of Habitat of *Gnetum* species

Parameter	**Unit**	***G. africanum***	***G. bulchozianum***
pH		5.81±0.063	5.77±0.55
Ec	Ds/m	0.114±0.010	0.06±0.0009
Organic matter	%	6.27±0.021	6.61±0.15
Total N	%	0.19±0.000	0.17±0.0003
Av. P	Mg/kg	12.41±0.820	14.29±1.49
Moisture content	%	10.07±0.025	10.65±0.103
Ca	cmol/kg	4.08±0.509	5.52±0.51
Mg	cmol/kg	1.40±0.070	1.85±0.18
Na	cmol/kg	0.18±0.003	0.12±0.0007
K	cmol/kg	0.18±0.000	0.28±0.04
EA	cmol/kg	2.33±0.049	2.41±0.06
E.C.E.C	cmol/kg	8.51±0.774	10.12±0.57
Base Saturation	%	72.06±3.120	75.91±1.95
Sand	%	82.60±0.282	80.60±0.28
Silt	%	6.00±0.707	5.85±0.67
Clay	%	11.4±0.42	13.55±0.389

Table 3: Soil-Plant Correlation Matrix for *Gnetum* species

	pH	Tot. N	Org. C	Av. P	Calcium	Sand	Silt	Clay
Chlorophyll	0.087	0.031	0.188	0.110*	0.137	0.176	0.053	-0.128
Carbohydrate	0.256*	-0.039	0.621*	-0.105	0.179	0.128	0.341	-0.174
Crude protein	0.371*	-0.86*	0.116	-0.091	0.310	0.351	0.003	-0.316
Crude fat	0.56	-0.222	0.157	0.106	0.218	0.319	0.233	0.409
Phytate	0.231	0.201	-0.198	0.45*	-0.187	0.137	0.423	0.039
tannins	0.031	-0.56*	-0.003	-0.51	0.083	0.132	0.138	-0.296
Cyanide	0.087	0.031	0.188	0.110	0.137	0.195	0.239	-0.010
Oxalates	0.256	-0.039	-0.160	-0.105	-0.179*	0.270	0.261	0.035

DISCUSSION

Comparing the chemical composition of the leaves of *Gnetum* species with other edible vegetables shows that these species are rich in food nutrients. Generally, the species recorded nutrient values that were higher than those reported for other vegetables (Antia et. al. 2006, Lola, 2009 and Kochar, 1981).The results show that crude protein, crude fat and carbohydrate were higher in *Gnetum africanum* than in *Gnetum* *bulchozianum.* The physicochemical properties were summarized in Table 2. The pH values in the habitats wherein these plants grow are weakly acidic soils. Ubom et al, (2012) while studying the soil-vegetation relationships in fresh water swamp forest had reported a similar pH of 5.12. The fair pH recorded seems to contribute favorably to the species growth and synthesis of essential molecules such as carbohydrate and proteins in the species. This assumption is based on the positive correlation coefficient obtained between pH and the essential molecules. The positivity of most of these coefficients shows that both soil and plant indices increase together. This expression is in synchrony with the views of Alloway and Ayres (1997) who reported that soil pH, nature of soil and climatic changes were a part of the cluster of factors which affect the rate of uptake of nutrients by plants. Also it bears alliance with Wilson, (2000) and Ademola, Omoluabi and Martin (2005). Their reports demonstrated that age, environmental factors such as rhizospheric nutrient level, competition within and between species etc could affect proximate composition of plants. These could contribute to the variations observed in the chemical profile of these species. According to Bowman and Russell (2001) Carbohydrates, one of the biochemical compounds found in *Gnetum* are group of organic compounds consisting of carbon, hydrogen and oxygen in the ratio of 1:2:1 of which many of them are indispensible to the existence of living organisms. It is also referred to as the chemicals of life as all organic foodstuffs are ultimately derived from the synthesis of carbohydrate through photosynthesis (Verma and Agrawal, 2007). The catabolism of Carbohydrates provides the major source of the energy requirement for maintenance of life and performance of work (Bowman and Russell 2001). The significant relationship between protein and Organic carbon and Carbohydrate is believed to have arisen on the premise that Carbon assimilation in plants is central to carbohydrate synthesis through photosynthesis (Pandey and Singh, 2001). This explains the similarity in variation pattern of these parameters.

As seen from this result, there is an indication that Crude protein in the leaves of *Gnetum* species increases with an increase in soil total nitrogen content and elevated pH values. Proteins are organic nitrogenous compounds (fifteen to twenty five percent) formed by the linkage of several amino acids held together by the long chains of polypeptide bonds. Proteins are generally regarded as beneficial, and are a necessary part of the diet of all animals. Humans can become seriously ill if they do not eat enough suitable protein, the disease *kwashiorkor* being an extreme form of protein deficiency (Drewnowski and Gomez-Carneros, 2000). The significant relationships between protein and Total nitrogen must have arisen on the premise that nitrogen assimilation in plants is central to protein synthesis in plant (Verma and Agrawal, 2007). Thus, both vary together. The correlation matrix also reveals that there exist positive insignificant relationships between the soil parameters and crude fat in the leaves. This interprets that the pedological status of these *Gnetum* dominated habitats is fair for synthesis of fats. Antia, et. al. (2006) opined that dietary fats function in increasing the palatability of food by absorbing and retaining flavours. They stressed that diets providing 1-2% of its caloric of energy as fat is said to be sufficient to human beings since excess fat consumption results in certain cardiovascular disorders such as atherosclerosis, cancer and aging. The negative and significant relationship existing between total nitrogen and leaves tannin content is not unprecedented as it confirms the findings of Davidson *et al.*, (1975). These researchers attributed the inhibition or bioavailability of protein and minerals in studied plants to high tannin content. This is evident in this work as crude protein is significantly low especially in *G. bulchozianum* which has the highest tannin content. Also, the low protein content is not unrelated with the negative correlation index associated with the soil nitrogen status. The negative correlation portrays that nitrogen is a stress factor in the habitats wherein the species grow. Tannins are astringent, bitter plant polyphenols that either bind and precipitate or shrink protein which makes them useful in the production of leather. Tannins have diverse effects on biological systems because they are potential metal ion chelators, protein precipitating agents, and biological antioxidants (Khallouki *et al*., 2003; Odoemena, 2010).

The knowledge of phytate content is useful in calculating the quantity of phosphorus available out of the total phosphorus in food material or diet. This is why it is not surprising that available phosphorus varied significantly with the phytate content of the leaves in this study. Phytic acid in food materials is a major source of concern since literature has that its hydrolytic products are associated with inhibition of calcification in rats (Robert and Yudkin, 1961). Also, calcium and oxalates were found to vary together in the study area. Iwuoha and Kalu (1995) reported that some of the anti-nutritional and off-flavour problems (bitter and astringent taste and scratches in the mouth and throat) associated with cocoyam are caused by calcium oxalate (raphids). Dietary oxalate has been known to complex with calcium, magnesium and iron leading to the formation of insoluble oxalate salts and resulting in oxalate stone (Oke, 1969). Literature reports show that acute poisoning and kidney stones are related with perpetual and or large intake of oxalates.

CONCLUSION

Correlation analysis was employed to assess the influence of environmental (pedological) factors on the synthesis of Carbohydrate, protein, fats etc. This method confirmed that the soil pH of the area was fair enough to favour the synthesis of protein, carbohydrate and fats. Significant relationships were identified between pairs of these variables; Total nitrogen and crude protein, Total nitrogen and Tannins, Organic carbon and Carbohydrates, Phytates and Available phosphorus. The result of this work confirms that there is an intricate relationship existing between soil and plant with regards to synthesis of bio-essential molecules. These results are discussed in the light of current trends in Horticulture, food and nutrition studies and phytochemistry.

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