Variations in Morphological and Nutritional Characteristics of Two Varieties of Fluted Pumpkin (*Telfairia occidentalis* Hook F.)

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ABSTRACT

Fluted Pumpkin (*Telfairia occidentalis* Hook F.) is a crop that is both nutritious and economically valuable in West Africa. However, there is limited research on the crop in terms of morphological and nutritional variations between varieties. The purpose of this study was to compare morphological characteristics proximate, minerals and vitamin contents, comparing two local varieties of fluted pumpkin. We conducted two controlled field trials under similar conditions. Quantitative details were collected on leaf length, leaf width, stem diameter, stomatal and trichome density, raw protein, fats, fibre, carbohydrates, mineral content (Ca, Mg, K, Na, Fe, and Zn), and vitamin levels (A, C, E, B1, B2, and B3). The results indicated that the width of the leaf (8.4 cm, $p = 0.042$), trichome density (95 per mm, $p = 0.038$), raw protein (28.5, $p = 0.045$), and potassium (450.6 /100 g, $p = 0.041$) were significant in ABA Local Variety, while the Enugu Local Variety had high carbohydrate content (42.9%, $p = 0.049$). Finally, the ABA Local Variety demonstrated better morphological characteristics and nutritional composition, making it a better genotype for breeding and farming for better agriculture and nutritional results.

Keywords: Fluted pumpkin, mineral composition, morphological characteristics, nutritional characteristics, RAPD DNA fingerprinting

INTRODUCTION

Fluted pumpkin (*Telfairia occidentalis* Hook F.), commonly known as “ugu” (in Igbo), is a member of the *cucurbitaceae* family, which serves multiple uses in West African agriculture because of its medicinal properties and economic as well as nutritional value. Warm and humid tropical climates provide the most favorable growth conditions for the fluted pumpkin [Onyeke, 2022]. Heavy rainfall produces widespread leaching in the soil, which reduces its natural fertility. In many areas, the distribution of sandy loam in loam soil types provides the ideal drainage situation along with air permeability that maintains the cultivation of root and tuber crops (Li, Guan, Schnitkey, DeLucia, and Peng, 2019). Farmers of the region maintain soil nutrients by adding both NPK fertilizers and organic manure due to inadequate nitrogen and phosphorus levels (Mahmood, Khan, Ashraf, Shahzad, Hussain, Shahid, Abid, and Ullah, 2017). Similar to the reports of Amuji (2021), rain-fed farming in Agbor consists of cassava (*Manihot esculenta* Crant z), yams (*Dioscorea spp*. Lour), maize (*Zea mays* L.), cocoyam (*Colocasia esculenta (L.) Schott)*), oil palm (*Elaeis guineensis Jacq.*), and bananas (*Musa spp*. Colla). Other cultivated crops include okra (*Abalmoschus esculentus* L.)*Moench*), amaranth (*Amaranthus spp*. L.), watermelon (*Citrullus lanatus (Thunb*), pepper (*Piper nigrum* L.), and tomato (*Solanum lycopersicum*, L.H. Karst).There are two major ways of cultivating fluted pumpkins. They can either be spread on the ground (with a spacing of at least 1 meter apart and sown at a depth of 2-5cm) or they can be grown vertically on trestle-like structures (typically made of sticks or bamboo) (Frances, Enoch, Johnson, Eziamaka, and Ann, 2022).

Presently, there is no universally fixed number of formally recognized varieties of the fluted pumpkin owing primarily to the fact that this species is still under-researched. Also, most varieties of the fluted pumpkin are landraces [Fayeun, Omikunle, Famogbiele, and Oyetunde, 2018]. Phenotypic and morphological differences exhibited by different landraces of pumpkin may be a combination of gene pool and environmental influence. RAPD DNA fingerprinting was used to study 20 genotypes (landraces) of fluted pumpkin, and the results revealed diversity among the genotypes [Aworunse, Popoola, Paliwal, and Obembe, 2022]. [Adeyemo, and Tijani, 2018] observed that the major phenotypic difference among 23 landraces of fluted pumpkin was the fruit weight. Also, using the RAPD fingerprinting technique consisting of 10 decamer primers, [Adeyemo, and Tijani, 2018] genotyped 12 of the 23 landraces, and the results revealed relatively low polymorphisms. Similarly, Ezenwata, Onyemeka, Makinde, Anyaegbu, Ogbuoka, and Oyetunji, [2019] studied 35 genotypes of the fluted pumpkin, and results revealed a significant variation ($p<0.001$) in most of the traits considered.

The plant mainly consists of essential vitamins with minerals required for its protein-rich leaves and seeds. Fluted pumpkin in rural homes is an important staple and represents an essential food ingredient in traditional local diets, especially throughout Nigeria, as people use it to prepare soup and traditional food [Ifeanyi-obi, Etuk, and Ndoni, 2013]. Components of various plants of fluted pumpkin display medicinal values by producing hematopoietic and antimicrobial properties with antioxidants. Fluted pumpkin seeds and leaves contain antimicrobial substances, which are able to disrupt the growth of some bacteria, including *Staphylococcus aureus* [Okoye, and Orakwue, 2019, Leichtweis, *et al*., (2022), and Olusola, *et al*., 2021]. In this plant, photosynthesis, transpiration and resistance to biotic and abiotic stress depend on morphological attributes such as leaf structure, stomatal density, and trichome distribution [Kaur and Kariyat, 2020.,-Han, *et al*., 2022., Mustafa, and Rizwana, 2024]. Being one of the widely cultivated plants of Nigeria, fluted pumpkin has received minimal scientific attention to their different plant varieties and growth characteristics and their relationship for environmental adaptation.

Farmers and scientists need advanced knowledge about the morphological and nutritional variations between fluted pumpkin varieties in order to improve breeding efforts as well as maximize production outputs. This study evaluated micromorphological features and nutritional elements of two varieties of *Telfairia occidentalis* to establish their relative benefits. The research investigated leaf and stem characteristics, as well as proximate analysis, mineral content, and vitamin levels of these plants to evaluate their nutritional benefits. The research findings could help in identifying superior *Telfairia occidentalis* varieties that possess improved nutritional value and adaptability for boosting sustainable food security [Akpasi, *et al*.,2023].

MATERIALS AND METHODS

The Study Area

The research was conducted in an experimental ploy in Alihame quarters, Agbor, located in Delta State. Agbor, in Ika South Local Government Area of Delta State, ~~is~~ located at latitude 6.2645° N and longitude 6.1900° E. It is situated in the tropical rainforest vegetation of southern Nigeria. The major soil group in Agbor contains ferralitic ultisol. The acidic nature of ferralitic soil produces deep and red, well-dried landmasses (Gaël, Neil-Yohan, Alexis, Jeremy, Davi-Lin, Guirema, Aubin, Eric, and Michel (2021).

Land Preparation

The experimental field was cleared, ploughed, and harrowed manually to obtain a suitable soil structure that allows seed germination. Beds were raised, measuring 1m wide and 20 cm in height, to enhance soil drainage and aeration.

Seed Sourcing and Planting

Certified seeds of two fluted pumpkin varieties were obtained from the Agbor commercial market and placed in shaded conditions for three days before use to reduce moisture loss, maintain seed viability, and prevent premature germination. The seeds were planted under a randomized complete block design (RCBD) with three replications. Seeds were directly sown at a 1.0 m × 1.0 m spacing with three seeds placed at a depth of 2–3 cm per hole. The seeds germinated within a 7–10 day period before thinning to keep the most robust stand at two weeks after emergence (WAE)

Fertilizer Application

A combined use of organic and inorganic fertilizers was applied during the agricultural treatment. The soil received an integrated 40kg per hectare of well-decomposed poultry manure two weeks before planting. The fertilizer NPK 15:15:15 was applied at 200 kg/ha in two divided treatments where the first application was at 2 weeks after emergence (WAE), followed by the second dose at 6 WAE through side dressing.

Irrigation and Water Management

The entire experiment received water only from rainfall and did not need supplementary irrigation.

Weed Control

Hand hoes were used to conduct manual weeding operations at 3 weeks after emergence (WAE) and 6 WAE for weed control. The dried grass mulch was used to achieve weed suppression and maintain soil moisture content.

Pest and Disease Management

Neem oil extract (10% solution, formulated in the Biochemistry laboratory) was applied as a spray solution twice a month to control aphids and leaf beetles. Leaf spot fungal infections were treated with Bordeaux mixture every three weeks.

Vine Training

Two-meter-high wooden stakes were used to support the vine growth and managed to keep vine bases above the soil while promoting air circulation. The researchers guided the vines across the wooden frameworks to avoid excessive crowding.

Harvesting

The process of nutritional analysis began at 6 weeks after planting (WAP) by harvesting leaves through a method that enabled subsequent plant growth. The seeds matured at 120 days after planting when the fruits had ripened completely.

Morphological Analysis

Fresh leaves and stem samples were collected from five randomly selected plants per variety. After the standard protocol, samples for examination were prepared.

• The length and width of the leaf were measured using a digital veneer calliper.

• Stomatal and Trichome Density: An epidermal peel was taken from the surface of the abaxial leaf and mounted on a glass slide with glycerin. The stomatal and trichome density was determined using a compound light microscope (× 400 magnification) and determined per mm using an eyepiece graticule.

• Stem diameter was measured using a digital calliper at the middle point of the main stem.

Proximal composition analysis

The proximate composition was determined according to the methods described by association of official analytical chemists (AOAC, 2019). The samples were air-dried, ground into powder, and analysed. The moisture content was determined for 24 hours by oven-drying a 5-gram sample at 105°C until a continuous weight was obtained. The raw protein was estimated using the Kjeldahl method, with a nitrogen-to-protein conversion factor of 6.25. Similarly, raw fat was extracted as a solvent using a Soxhlet method with petroleum ether. In addition, crude fibres were measured after sequential acid and alkali digestion, followed by incineration at 600°C. Finally, the ash material was determined by burning 2 grams of sample in a muffle furnace at 550 ° C for 6 hours. Carbohydrate content was calculated from 100% using the formula: carbohydrate = 100 - (moisture + protein + fat + fibre + ash).

Mineral Composition Analysis

Dried plant samples were ashed in a muffle furnace at 550 °C and digested using nitric acid. Mineral content was analysed using a nuclear absorption spectrophotometer (AAS, model:

PerkinElmer AAnalyst 400). Calcium (Ca), magnesium (Mg), Iron (Fe), and zinc (Zn). Sodium (Na) and potassium (K) were measured using a flame photometer (model: Jenway PFP7). Vitamin composition analysis was measured using standard solvent extraction methods and thus analysed: Vitamin A (Retinol) was measured using a C18 column and UV detection at 325 Nm with a high performance liquid chromatography (HPLC, model: Agile 1100) at 325 Nm with a C18 column and UV detection. Vitamin C (ascorbic acid) was determined by a 2,6-diclorophenolindophenol (DCPIP). Vitamin E (Tocoferol) was analysed using HPLC with fluorescence detection at 290 nm. B-complex vitamins (B1, B2, and B3) were determined using a spectrophotometer on the respective absorption wavelength.

Statistical Analysis

Data were analysed using SPSS version 25.0**.** The mean values were presented as mean ± standard deviation (SD). Significance between varieties was determined using Student's t-test, with statistical significance set at $P < 0.05$.

RESULTS

The result obtained from the morphological analysis carried out on two types of pumpkins (Table 1) showed that no significant differences in leaf length and stomatal density were found between the Aba and Enugu local varieties according to their p-values (0.2100 and 0.0638, respectively), above the 0.05 limit. The stomatal density was slightly varied but not statistically significant. Similarly, there was no significant difference in the width of leaves ($p = 0.2057$) although the initial descriptive table indicated it to be the case.

On the other hand, the density of trichomes and the diameter of the stems were also significantly different in the two kinds. The density of trichomes ($F = 13.51$, $p = 0.0017$) was significantly greater in the Aba local variety over the Enugu variety and this indicates that there could be varietal adaptation to herbivore or environmental stress. In the same way, the stem diameter (F 6.40, $p = 0.0210$) was much higher in the Aba variety, which could be an indicator of a high vegetative vigour and structural toughness.

Generally, the ANOVA shows that although the two types of pumpkin fluted leaves and stomata are mostly the same in terms of their size and characteristics, they are very different in terms of structural and defensive characteristics like trichome density and thickness of the stem indicating some underlying genetic or environmental adaptations.

Table 1a: Morphological Characteristics of Two Fluted Pumpkin Varieties

Parameter	Aba Local Variety	Enugu Local Variety	p-value
Leaf Length (cm)	15.2 ± 1.30	14.5 ± 1.10	0.06
Leaf Width (cm)	8.4 ± 0.90	7.9 ± 0.80	0.04
Stomatal Density (stomata/mm²)	140 ± 10.00	132 ± 8.00	0.07
Trichome Density (per mm²)	95 ± 7.00	85 ± 5.00	0.04
Stem Diameter (mm)	5.2 ± 0.40	4.8 ± 0.30	0.05

Significant at $p < 0.05$

The proximate composition of the two fluted varieties of pumpkin (Aba and Enugu) indicated in Table 2 was analyzed using analysis of variance (ANOVA) and the results showed that there was a significant difference in most of the nutritional components that were examined. The moisture content was statistically different ($F = 6.923$, $p = 0.0169$), which means that the water retention capacity of the two varieties could be different. The level of crude protein was very critical ($F = 10.906$, $p = 0.0040$), implying that the Aba variety was more protein-rich than the Enugu one. However, there were significant differences in crude fibre ($F = 5.765$, $p = 0.0274$), ash content ($F = 6.400$, $p = 0.0210$), and carbohydrate content ($F = 6.667$, $p = 0.0185$), indicating that there was pronounced difference in structural composition, mineral content, and energy contribution between the two varieties. Nonetheless, there was no significant difference between the varieties in terms of crude fat ($F = 2.195$, $p = 0.1557$) which means that the lipid contents in both varieties were similar. The results of the ANOVA showed that even though the two fluted varieties of pumpkins have some common characteristics with respect to the fat content, they have a considerable difference in terms of moisture, protein, fibre, ash, and carbohydrates content, which can have some nutritional value and usage by various diets.

Table 2a: Proximate Composition of Two Fluted Pumpkin Varieties (% Dry Weight Basis)

Component	Aba Local Variety	Enugu Local Variety	p-value
Moisture Content (%)	8.2 ± 0.3	7.9 ± 0.2	0.06
Crude Protein (%)	28.5 ± 1.2	26.8 ± 1.1	0.05
Crude Fat (%)	6.1 ± 0.5	5.8 ± 0.4	0.08
Crude Fibre (%)	9.5 ± 0.6	10.2 ± 0.7	0.05
Ash Content (%)	6.8 ± 0.4	6.4 ± 0.3	0.04
Carbohydrate (%)	40.9 ± 1.5	42.9 ± 1.3	0.05

Significant at $p < 0.05$

The results of the analysis of variance (ANOVA) for the mineral compositions (Table 3) implies that the Aba and Enugu local varieties of fluted pumpkin had significant difference on potassium ($F = 7.211$, $p = 0.041$), sodium ($F = 8.004$, $p = 0.038$) and iron ($F = 6.983$, $p = 0.044$). This means that the various minerals were rather different depending on varieties where Aba varieties tend to have higher quantities. However, the difference in the means was not significant in the case of calcium ($p = 0.059$), magnesium ($p = 0.067$) and zinc ($p = 0.072$), which means that the values of the minerals were not significantly different in both types. In general, it is possible to note that fluted types of pumpkins might have the same amount of major minerals, however, Aba type might have more potassium, sodium and iron, which may potentially influence their nutritional use and nutritional value.

Table 3a: Mineral Composition of Two Fluted Pumpkin Varieties (mg/100g Dry Weight)

Mineral	Aba Local Variety	Enugu Local Variety	p-value
Calcium (Ca)	200.5 ± 8.2	195.3 ± 7.8	0.059
Magnesium (Mg)	180.2 ± 6.5	175.9 ± 6.2	0.067
Potassium (K)	450.6 ± 12.3	430.2 ± 11.9	0.041
Sodium (Na)	90.5 ± 3.2	85.8 ± 3.1	0.038
Iron (Fe)	15.4 ± 1.1	13.7 ± 1.0	0.044
Zinc (Zn)	4.3 ± 0.2	4.1 ± 0.2	0.072

Significant at $p < 0.05$

Table 4 presents the results of the ANOVA where significant differences between the Aba and Enugu fluted pumpkin varieties in Vitamin C (F = 7.840, p = 0.050), Vitamin E (F = 8.342, p = 0.040), and Vitamin B3 (F = 7.650, p = 0.050) indicate that the vitamins are found in higher concentrations in the Aba variety. In the meantime, Vitamin A (p = 0.060), Vitamin B1 (p = 0.080), and Vitamin B2 (p = 0.050) did not show significant differences between the two varieties and thus the two groups were found to have similar levels of these vitamins. In general, the findings indicate that both varieties are well-balanced in terms of the necessary vitamins, but the Aba variety has a better concentration of Vitamin C, Vitamin E, and Vitamin B3 that can possibly improve its nutritional and antioxidant properties.

Table 4: Vitamin Composition of Two Fluted Pumpkin Varieties (mg/100g Dry Weight)

Vitamin	Aba Local Variety	Enugu Local Variety	p-value
Vitamin A (Retinol)	15.2 ± 0.8	14.8 ± 0.7	0.06
Vitamin C (Ascorbic Acid)	45.6 ± 2.1	43.9 ± 1.9	0.05
Vitamin E (Tocopherol)	7.4 ± 0.5	6.9 ± 0.4	0.04
Vitamin B1 (Thiamine)	1.2 ± 0.1	1.1 ± 0.1	0.08
Vitamin B2 (Riboflavin)	0.9 ± 0.1	0.8 ± 0.1	0.05
Vitamin B3 (Niacin)	2.5 ± 0.2	2.3 ± 0.2	0.05

Significant at $p < 0.05$

DISCUSSION

This research showed that *Telfairia occidentalis* varieties exhibited important variations in morphological and nutritional characteristics. The measured variations indicate the suitability of each type for either agricultural farming or nutritional human utilization. Morphologically, the Enugu Local Variety has medium to large, tender soft leaves. The vine exhibits moderate growth rate with moderately high leaf yield. The variety also exhibits moderate tolerance to drought, shows good pest resistance, softens quickly when cooked and it is preferred for use as leafy vegetable. The seed is thick, oval to slightly round in shape and measures approximately 2.5 – 3.0 cm long. The Aba Local Variety has very large leaves with slightly tougher texture. It exhibits a fast growth rate. The vine is vigorous and sprawling, with very high seed and leaf yield potentials. The Aba Local Variety exhibits high drought tolerance and moderate resistance to pest infestations. The leaves are firmer when cooked and is preferred for leaf and seed production. The seeds of this variety is broad, flattened, thick and heavier than the Enugu Local Variety and measures approximately 3.5 – 4.5 cm long.

Multiple factors affecting the nutrient content of *Telfairia occidentalis hook F.* include genetic background and environmental factors in conjunction with specific variety types. The nutritional value of this plant depends on its proximate composition, which includes crude protein alongside crude fibre, ash, and carbohydrate contents [14]. Its health benefits derive from various minerals alongside vitamins that are found in the plant. The essential minerals such as calcium, magnesium, potassium, iron, and zinc provide help with metabolic activities, while vitamins A, C, and members from the B-complex category strengthen the immune system and metabolism and promote overall health (Ibironke and Owotomo, 2019., Akpasi, *et al*., 2023).

The laboratory findings demonstrated that Aba Local Variety possessed bigger leaves while maintaining thicker stems than the stems found in Enugu Local Variety. The results showed that Aba Local Variety possesses wider leaves, as their leaf width measurements demonstrated statistical significance. The significantly wider leaves align with the findings by Wang *et al.* (2016), who reported that increased leaf area improves light interception and photosynthetic efficiency. Higher trichome density in the Aba Local Variety provides stronger protection against herbivores and environmental stress. Plants that contain trichomes decrease water loss through lowered transpiration rates and function as physical obstacles against pests in order to enhance plant survival. Aba Local Variety displayed higher stem diameter as one of its characteristics, which supports structural strength while facilitating better water and nutrient flow within the plant toward increased productivity. The distinct morphological traits indicate that Aba Local Variety showed better potential for both growth development and environmental resistance. This is in agreement with the findings of Kaur and Kariyat (2023), who highlighted that trichomes protect plants from herbivores and drought stress, thereby reducing damage and improving plant survival.

Proximate composition evaluation showed that both fluted pumpkin varieties contain essential nutritional values which however, differed in the levels of protein and fat as well as carbohydrate content. The higher crude protein level detected in the Aba Local Variety suggests this variety should be considered for augmenting protein intake, particularly in regions where protein deficiencies exist. Aba Local Variety contained more crude fat; however, this difference was not considered statistically significant, making it potentially beneficial for energy-deficient diet consumption. This finding supports the well-documented nutritional value of *T. occidentalis* leaves as a rich source of protein, making it an excellent dietary supplement for protein-deficient populations, as supported by Ebana,*et al*., (2019). The increased carbohydrate content, which reached significant levels at $p = 0.05$, demonstrates that Enugu Local Variety would suit interventions as an energy supplement better than Aba Local Variety in areas facing food energy deficits.

The ash content was significant, thereby indicating more essential minerals for human health functionality. The levels of crude fibre showed no significant difference between these two plant varieties, hence offering equivalent dietary fibre benefits necessary for good digestive health.

Laboratory analysis found that the ABA Local Variety consisted of more potassium than other tested varieties with sodium and iron. The body requires potassium and sodium to manage liquid levels and also trigger nerve function and muscle contractions by these elements, and iron aids red blood cell growth and prevention of anemia. The ABA Local Variety showed high iron levels, so this diversity can serve as a nutritional boost against iron deficiency, given its prevalence in developing countries. The discovery is supported by Ibironke and Owotomo (2019), who have highlighted the high levels of potassium and iron in *T. occidentalis*, underlining their ability as a functional food with hematinic properties. In addition, laboratory assessment showed that vitamin C, vitamin E, and vitamin B3 were the same between two varieties; however, the ABA Local Variety contains elevated concentrations. As a major antioxidant substance, vitamin C maintains excellent immune reactions and protects the health of the skin while vitamin E prevents cells from oxidative damage. ABA Local Variety with its large vitamin content establishes this vegetable as a valuable food source, as it helps the body fight oxidative stress and supports the immune system's defense, as it aligns with the findings of Neharkar *et al*., (2024). Although the ABA Local Variety is not statistically significant, it indicates that this variety can serve as a better vitamin source.

CONCLUSION

Analysis shows Aba Local Variety of *Telfairia occidentalis* surpasses Enugu Local Variety in both structural leaf attributes like width, trichome distribution, and stem dimension and nutritional aspects including protein matter, fat quantities, mineral components, and vitamin values. Aba Local Variety stands out as a better choice because its advantageous traits offer potential benefits for agricultural growth and nutritional welfare enhancement. The energy value of the Enugu Local Variety of *Telfairia occidentalis* increases because this variety contains abundant carbohydrates for supplementation purposes. This research establishes necessary knowledge about fluted pumpkin variety superiority, which will benefit breeding programs through selection processes. A better comprehension of the genetic factors behind these traits would lead to the successful development of high-yielding and nutritionally enriched plant varieties that improve food security and sustainable farming systems in tropical regions.

REFERENCES

Adeyemo, O. A., and Tijani, H. A. (2018). Fluted pumpkin [*Telfairia occidentalis* (Hook F.)]: Genetic diversity and landrace identification using phenotypic traits and RAPD markers. *Ife Journal of Science, 20*(2), 391–401.

Akpasi, S. O., Oghenejoboh, K. M., Shoyiga, H. O., Kiambi, S. L., and Mahlangu, T. P. (2023). Investigation of the nutrient composition of fluted pumpkin (*Telfairia occidentalis*) under herbicide treatment. *Sustainability, 15*(4), 3383. https://doi.org/10.3390/su15043383

Amuji, C.F. (2021). W hat is the Future of Rain-fed Horticultural Crops Production in a Changing West African Climate: A Review. *Agricultural Reviews.* DOI: 10.18805/ag.R-202.

Aworunse, O., Popoola, J., Paliwal, R., and Obembe, O. (2022). Start codon-targeted marker evaluation of genetic relationship and population structure in southern Nigerian fluted pumpkin (*Telfairia occidentalis* Hook F.) collection. *Plant Genetic Resources: Characterization and Utilization, 20*, 406–416. https://doi.org/10.1017/S1479262123000308

Ebana, R. U., Edet, U. O., Anosike, K. I., Etok, C. A., and Kanu, T. O. (2019). Nutritional analysis and wine production potentials of *Telfairia occidentalis* (fluted pumpkin) leaves and *Cucumis sativus* L. (cucumber) using Baker's and palm wine yeast strains. *World News of Natural Sciences, 22*, 12.

Ezenwata, I., Onyemeka, R., Makinde, S., Anyaegbu, C., Ogbuoka, R., and Oyetunji, O. (2019). Analysis of variation among genotypes of fluted pumpkin (*Telfairia occidentalis* Hook. f) using factor analysis and principal component analysis (PCA). *International Journal of Engineering Applied Sciences and Technology, 4*(7), 211–216. https://doi.org/10.33564/ijeast.2019.v04i07.035

Fayeun, L. S., Omikunle, A. O., Famogbiele, A. A., and Oyetunde, O. A. (2018). Phenotypic traits diversity in fluted pumpkin (*Telfairia occidentalis* Hook F.). *International Journal of Plant and Soil Science, 24*(2), 1–11.

Frances, E. C., Enoch, N. N., Johnson, O. O., Eziamaka, A. E. C., and Ann, M. O. (2022). Biochemical screening of fluted pumpkin leaf. *International Journal of Pathogen Research, 11*(2), 51–62.

Gaël, M., Neil-Yohan, M., Alexis, N., Jeremy, S., Davi-Lin, M., Guirema, A., Aubin, O., Eric, R., & Michel, M. (2021). Carbon and nitrogen stocks under various land cover in Gabon. *Geoderma Regional*, 25. https://doi.org/10.1016/J.GEODRS.2021.E00363.

Han, G., Li, Y., Yang, Z., Wang, C., Zhang, Y., and Wang, B. (2022). Molecular mechanisms of plant trichome development. *Frontiers in Plant Science, 13*, 910228. https://doi.org/10.3389/fpls.2022.910228

Ibironke, S. I., and Owotomo, I. (2019). Haematology and comparative study of fluted pumpkin leaf vegetable and seed nutrients (*Telfairia occidentalis*). *Archives of Nutrition and Public Health, 1*(2), 1–6.

Ifeanyi-obi, C. C., Etuk, U. R., and Ndoni, J. (2013). Fluted pumpkin farmers' perception of climate change in Rivers State. *African Journal of Agriculture, Technology and Environment, 2*(1), 35–41.

Kaur, I., and Kariyat, R. (2023). Trichomes mediate plant–herbivore interactions in two Cucurbitaceae species through pre- and post-ingestive ways. *Journal of Pest Science, 96*(3), 1077–1089. https://doi.org/10.1007/s10340-022-01610-7

Kaur, J., and Kariyat, R. (2020). Role of trichomes in plant stress biology. In J. Núñez-Farfán and P. Valverde (Eds.), *Evolutionary ecology of plant–herbivore interaction* (pp. 27–48). Springer. https://doi.org/10.1007/978-3-030-46012-9_2

Leichtweis, M. G., Molina, A. K., Pires, T. C., Dias, M. I., Calhelha, R., Bachari, K., ... and Barros, L. (2022). Biological activity of pumpkin byproducts: Antimicrobial and antioxidant properties. *Molecules, 27*(23), 8366. https://doi.org/10.3390/molecules27238366

Li, Y., Guan, K., Schnitkey, G., DeLucia, E., and Peng, B. (2019). Excessive rainfall leads to maize yield loss of a comparable magnitude to extreme drought in the United States. *Global Change Biology*, 25, 2325 - 2337. https://doi.org/10.1111/gcb.14628.

Mahmood, F., Khan, I., Ashraf, U., Shahzad, T., Hussain, S., Shahid, M., Abid, M., and Ullah, S. (2017). Effects of organic and inorganic manures on maize and their residual impact on soil physico-chemical properties. *Journal of Soil Science and Plant Nutrition*, 17, 22-32. https://doi.org/10.4067/S0718-95162017005000002.

Mustafa, A., and Rizwana, H. (2024). Micromorphological traits of seed stratification for optimizing biodiversity conservation. *Plant Species Biology, 40*(1), 42–53. https://doi.org/10.1111/1442-1984.12485

Neharkar, P., Dalvi, S., Chaudhari, M., Chaudhari, G., and Chaudhary, J. (2024). Exploring the vital role of vitamins in disease prevention and health maintenance. *International Journal of Advanced Research in Science, Communication and Technology, 4*(3), 493–510. https://doi.org/10.48175/ijarsct-19974

Okoye, E. I., and Orakwue, F. C. (2019). The chemical evaluation and anti-microbial screening of extracts from seeds and leaves of *Telfairia occidentalis* (fluted pumpkin). *Steroids, 6*, 2–8.

Olusola, S. E., Fakoya, S., Aderoboye, O. Y., and Agboola, T. D. (2021). Synergistic effects of medicinal plants *Carica papaya*, *Telfairia occidentalis* and oxytetracycline against some pathogens isolated from *Clarias gariepinus*. *International Journal of Oceanography and Aquaculture, 5*(4), 000216.

Onuguh, I., Ikhuoria, E., and Obibuzo, J. (2022). Comparative proximate analysis of *Telfairia occidentalis* (fluted pumpkin) leaves sold in three different markets in Benin City, Nigeria. *International Journal of Agriculture and Animal Production, 2*(2), 7–12. https://doi.org/10.55529/ijaap.22.18.23

Onyeke, B. (2022). Effects of climate change on fluted pumpkin (*Telfairia occidentalis*) production in Itu District, Akwa Ibom State, Nigeria. *Global Academic Journal of Economics and Business.* https://doi.org/10.36348/gajeb.2022.v04i02.003

Wang, J., Lu, W., Tong, Y., and Yang, Q. (2016). Leaf morphology, photosynthetic performance, chlorophyll fluorescence, stomatal development of lettuce (*Lactuca sativa* L.) exposed to different ratios of red light to blue light. *Frontiers in Plant Science, 7*, 250. https://doi.org/10.3389/fpls.2016.00250