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Varietal Characterisation and Taxonomic Evaluation of Sweet Potato (*Ipomoea batatas*) Using Macro- and Micromorphological Evidence

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Abstract

Taxonomic audit was carried out on three varieties of sweet potato (*Ipomoea batata*) in north central part of Nigeria. Ten (10) tubers of the representative samples of three varieties of sweet potato (Purple, Yellow and White varieties) were collected from different locations within the north central part of Nigeria and planted in the research farm of the University of Agriculture, Makurdi, Nigeria. At full maturity, they were characterized using gross macro- and micromorphological features. Mean values of all quantitative parameters were computed for each variety. Qualitative and quantitative data generated were analysed by using SPSS software 20.0 version. Box plots and charts were constructed to reveal level of variations at a glance. Dendrogram was generated using furthest neighbor method to reveal the phylogenetic relationships among the varieties. Statistical test of significance was performed on major variable characters. From the results, the three varieties varied significantly in their epidermal characters such as stomatal types, stomatal indices and number of epidermal cells. Stomata types were tetracytic, anisocytic, and paracytic in all but the Purple variety had an additional stomatal type (anomocytic). Macroscopically, variation was observed with respect to some qualitative characters (leaf apices, leaf shape, leaf margins, leaf bases, leaf colour, stem colour and root colour) and quantitative characters (leaf sizes, petiole length, stem diameter, root sizes and plant height) at significant levels ($p < 0.05$). As a result, dendrogram classified the three varieties where the yellow and purple types were widely divergent as two separate species under the Genus *Ipomoea*. The white type could be seen as a variety of the yellow type based on their close relationship. The synergistic information obtained from both morphological and anatomical sources of evidence in this report has yielded a reliable result that may call for appropriate nomenclatural assignments. Hence, the authors suggest the following nomenclatures: *Ipomea batatas* var *makurdi* (Yellow variety); *Ipomoea batatas* var *lafia* (White variety) and *Ipomoea aguoru* (Purple variety).

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Keywords

***Ipomoea batata*, Varieties, Variation, Characters, Phylogeny, Nomenclature**

Subject Areas: **Plant Science**

1. Introduction

Sweet potato (*ipomoea batatas*) is a dicotyledonous plant that belongs to the family of convolvulaceae [1]. It is popularly known for its starchy and edible tubers as root vegetable [2]. According to [3], the young leaves and shoots are sometimes eaten as greens. The plants are herbaceous perennial plants bearing alternate heart-shaped or palmately lobed leaves and medium sized sympetalous flowers with a smooth skin whose colours range among yellow, orange, red, brown, and purple. Sweet potato varieties with white or pale yellow flesh are less sweet and moist than those with red, pink orange flesh [4]. Sweet potato is a stable food crop that is widely cultivated in most parts of Africa, most especially in Nigeria though it's believed to have originated from Central America or South America. In Nigerian markets, three varieties are in popular demands: the purple, yellow and white potato. Abundant evidence shows that sweet potatoes are spread widely through the migration roots of people in the new world tropics before the discovery of America [5] [6].

Sweet potato (*Ipomoea batatas*) is the world's eleventh most important food crop after wheat, rice, maize, potato, barley and cassava and has different varieties within the series batatas. There are thirteen wild species related to sweet potatoes [7] [8]. It is cooked or used to make cakes, chapattis, mandazia, bread, buns and cookies [9]. The young leafy shoots which are eaten as a green vegetable in some countries has high protein of about 20% dry weight and are good source of b-carotene, thyamine (Vitamin B1), riboflavin (B2), folic acid [10]. The primary centre of diversity of sweet potatoes is located in North Western and South America (Colombia, Ecuador, and Peru) and parts of Central America (such as Guatemala) where a great diversity of native sweet potatoes, weeds and wild ipomoea exists. Secondary centres of sweet potato diversity outside of the Americas are in China, South East Asia, New Guinea and East Africa [11] [12]. Though some varieties are popularly known as the Irish potato by indicating their non nativeness, the crop is widely cultivated and has formed a staple food in all parts of Nigeria.

Within the series batatas there are 13 wild species that are considered to be related to sweet potatoes [7] [8]. According to [13], there are about six thousand five hundred (6500) sweet potatoes' varieties, including wild accessions, farmer varieties and breeding lines. The skin colours of sweet potatoes come in various shades yellow-orange skins, creamy white, tan, reddish purple and red. *Ipomoea batatas* is not known in the wild and plants found growing in the wild are remnants from abandoned cultivated fields or coming from sweet potato seeds, which continue growing by vegetative propagation. Several wild ipomoea species having some morphological resemblance to *Ipomoea batatas* have been considered as potential wild ancestors of the sweet potato [14].

Sweet potato has so many varieties, including wild accessions, farmers' varieties and breeding lines. This study is to reveal the anatomical (Leaf epidermal) and morphological similarities and differences of three varieties of sweet potato (*Ipomoea batatas*). The aim is to establish the degree of relatedness or divergence among three varieties of sweet potato and establish the phylogenetic relationship that exists amongst them.

2. Materials and Methods

Ten (10) tubers of the representative samples of three varieties of sweet potato (Purple, Yellow and White varieties) were collected from different locations (Mararaba, Masaka, Keffi, Lafia, Makurdi, Gboko, Jos and Suleja) within the north central part of Nigeria and planted in the research farm of the University of Agriculture, Makurdi, Nigeria. At full maturity, they were characterized using macroscopic and microscopic taxonomic sources of evidence.

2.1. Microanatomical Evidence

Epidermal peels of the leaves were prepared for microscopic studies following standard protocols [15]. 20 slides

consisting of 10 abaxial and 10 adaxial surfaces were prepared from the leaf of each variety. The slides were appropriately labelled and examined under low and high power objective lenses. Ten (10) fields view were observed per slide. All epidermal structures were comparatively studied and photomicrographs of the anatomical features were taken using installed digital camera. The stomata index was calculated based on the formula derived by [16]. The mean was derived by adding up the total number of stomata index and dividing it by 10.

$$SI = \frac{S}{E+S} \times 100$$

SI = Stomata index;
S = Number of stomata per unit area;
E = Number of epidermal cells in the same unit area.

2.2. Macromorphological Evidence

The macromorphological characters which include leaf length, leaf breath, petiole length, plant height, root length and stem diameter were assessed using a meter rule while the leaf weight was assessed by using a digital weighing machine with tarring function. The leaf type, leaf shape, leaf apex, leaf margin, leaf venation, leaf arrangement, leaf base, leaf colour, stem colour and root colour (storage and fibrous roots) were physically examined.

2.3. Statistical Operations

Mean values of all quantitative parameters were computed for each variety. Qualitative and quantitative data generated were analysed using SPSS software 20.0 version. Box plots and charts were constructed to reveal level of variations at a glance. Dendrogram was generated using complete linkage and furthest neighbor methods to reveal the phylogenetic relationships among the varieties. Statistical test of significance was performed on the two sources of taxonomic evidence used.

3. Results and Discussion

The mean values of stomata, epidermal cells and stomata indices of each variety (abaxial and adaxial surfaces combined) are presented in **Table 1**. The lowest number of stomata was recorded in the Purple variety (21.25) but possessed the highest number of epidermal cells (54.4). Consequently, the Purple variety had the lowest stomatal index (28.09%) which varied widely from the indices obtained in the Yellow and White varieties (40.06% and 41.5%) as revealed in **Figure 1**. Therefore, the purple type differed from others in terms of stomatal indices and number of epidermal cells (**Figure 2**). It is also worth noting to discover that only the Purple variety has hexagonal shaped epidermal cells apart from the polygonal and irregular shapes common to all the varieties. Stomata types were tetracytic, anisocytic, and paracytic in the three varieties but the Purple Variety had an additional stomatal type (anomocytic).

Macroscopically, wide variation was observed with respect to some qualitative characters (leaf apices, leaf shape, leaf margins, leaf bases, leaf colour, stem colour, root colour) and quantitative characters (leaf sizes, petiole length, stem diameter, root sizes and plant height) as shown in **Table 2**. Statistical significant differences were recorded in the two sources of taxonomic evidence used in this study ($p < 0.05$) as given in **Table 3**. As a result, dendrogram has clearly classified the three varieties (**Figure 3**). Therefore, the Purple (**Figure 4(a)**) and

Table 1. Micromorphological characterization of the three varieties of *Ipomoea batatas*.

Variety	Mean number of stomata	Mean epidermal cells	Epidermal cells shape	Stomata type(s)	Stomata indices (%)
Purple	21.25	54.4	Irregular Polygonal Hexagonal	Anomocytic Tetracytic Anisocytic Paracytic	28.09
Yellow	23.6	34.5	Irregular Polygonal	Tetracytic Anisocytic Paracytic	40.6
White	31.7	44.6	Irregular	Tetracytic Anisocytic Paracytic	41.5

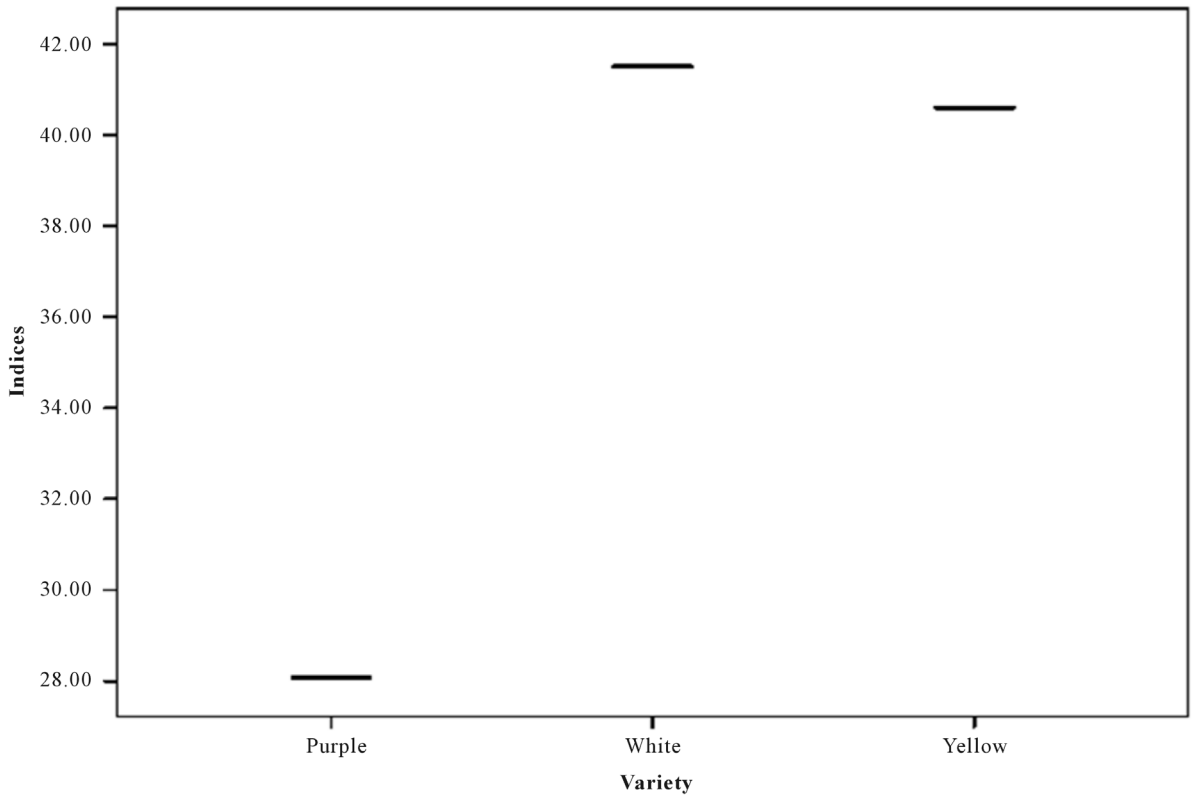


Figure 1. Stomatal indices of the three varieties (p = 0.014).

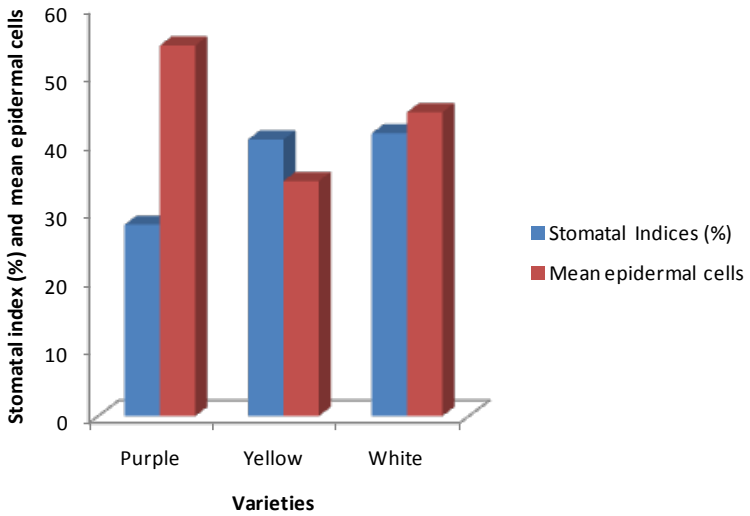


Figure 2. Epidermal partitioning of the three varieties of *Ipomoea batatas*.

Yellow (**Figure 4(b)**) varieties could be described as two separate species under the Genus *Ipomoea* while the White type (**Figure 4(c)**) could be seen as a variety of the Yellow type based on their close relationship. This is substantiated in their root colour differences (**Figure 4(d)**). Similar approach of classification was successfully adopted by [17] in the determination of phylogenetic relationship in eggplant molecular studies in north central Nigeria. The present study generally agrees with the views of most plant taxonomists that microanatomical features in plants are of huge taxonomic values [15] [18]-[20].

Accoding to [11], a common feature of *Ipomoea batatas* is the formation of complexes through infraspecific

Table 2. Macromorphological characterization of the three varieties of *Ipomoea batatas*.

Characters	Purple variety	Yellow variety	White variety
Leaf type	Simple	Simple	Simple
Leaf shape	Cordate	Deltoid	Cordate
Leaf apex	Acuminate	Cuspidate	Acute
Leaf margin	Repand/serrate	Sinuate	Entire
Leaf venation	Palmately netted	Palmately netted	Palmately netted
Leaf arrangement	Alternate	Alternate	Alternate
Leaf base	Cordate	Hastate	Cordate
Leaf colour	Purple/green	Green	Green
Stem colour	Purple/red	Green	Green
Root colour	Purple/green	Yellow/green	White/green
Leaf length (cm)	8.5	10.3	8.1
Leaf breadth (cm)	7.4	12.1	9.4
Leaf weight (g)	11.7	16.3	12.3
Petiole length (cm)	5.9	16.3	14.4
Plant height (cm)	45.3	50.9	46.9
Stem diameter (mm)	3.2	2.2	3.5
Root length (cm)	12.3	18.7	16.7

Table 3. Test of Significance of demarcating characters.

Characters	t	df	Sig. (2-tailed)	Mean difference	95% Confidence interval of the difference (Lower)	95% Confidence interval of the difference (Upper)
Stomatal indices	8.487	2	0.014	36.73000	18.1090	55.3510
Epidermal cells	7.746	2	0.016	44.50000	19.7819	69.2181
Petiole sizes	4.082	2	0.055	11.56667	−0.6242	23.7575
Root sizes	8.411	2	0.014	15.90000	7.7666	24.0334

hybridization. Hence, polyploidy as a combination of new chromosome may lead to sympatric speciation where new species of distinct character may likely evolve. The same type of hybrid complexes was reported in eggplant (Solanaceae) which continuously gives rise to new species because of their interfertile nature [17]. Mechanism of unreduced pollen formation was proposed by [21] as responsible for the polyploidization of sweetpotato. Sweet potato, as a genetically diverse economic crop, offers huge genetic resources that should be explored, maintained, utilized and conserved [11] [13]. In the view of [3], the crop could be described as an untapped food resource. Therefore as new species emerge, a continuous taxonomic review is pertinent to ensure accurately named germplasm for efficient communication in all aspects of the biology of the crop.

The synergistic information obtained from both morphological and anatomical sources of evidence in this report has yielded reliable results that may call for appropriate nomenclatural assignments. Hence, the authors suggest the following nomenclatures: *Ipomea batatas* var *makurdi* (Yellow variety); *Ipomoea batatas* var *lafia* (White variety) and *Ipomoea aguoru* (Purple variety). The first two are named based on location of collection while the third is named based on the author's name. In conclusion, it can be inferred that macro- and morphological and microanatomical features are relevant taxonomic tools in separating sweet potato varieties.

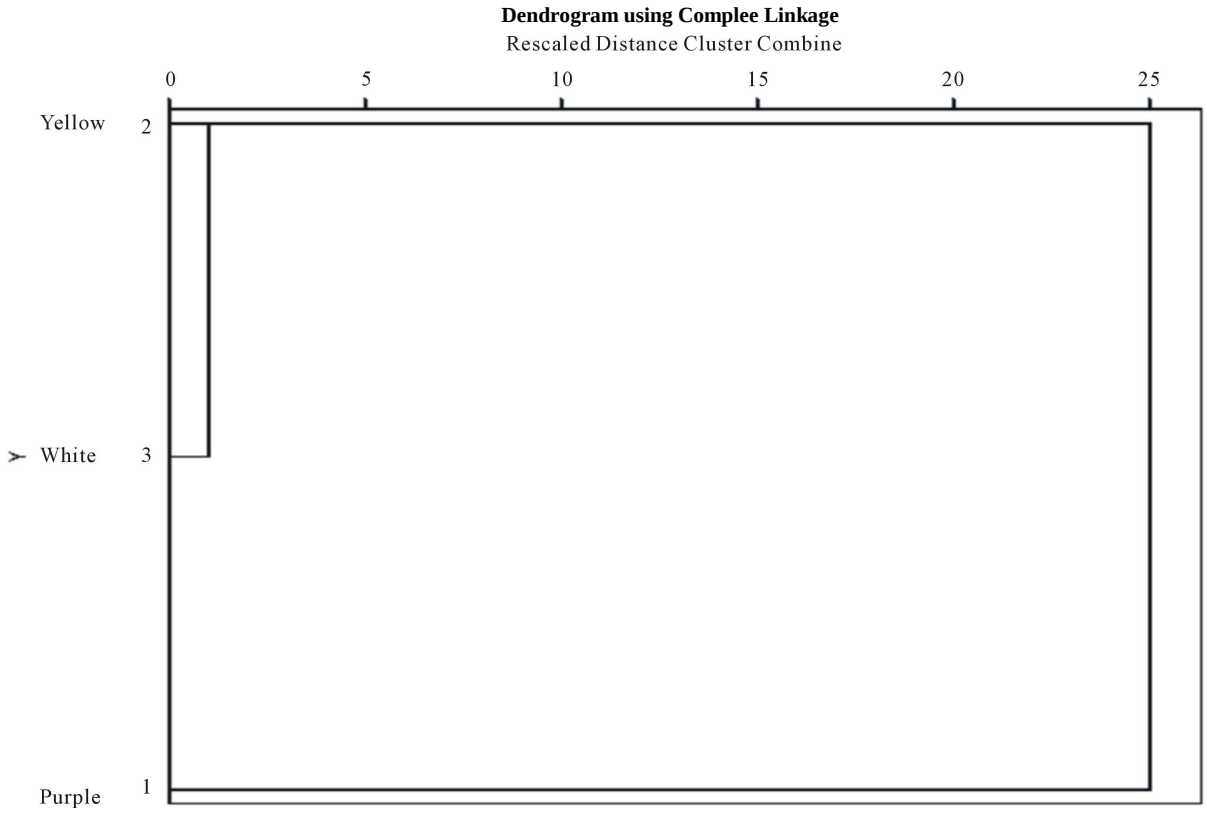
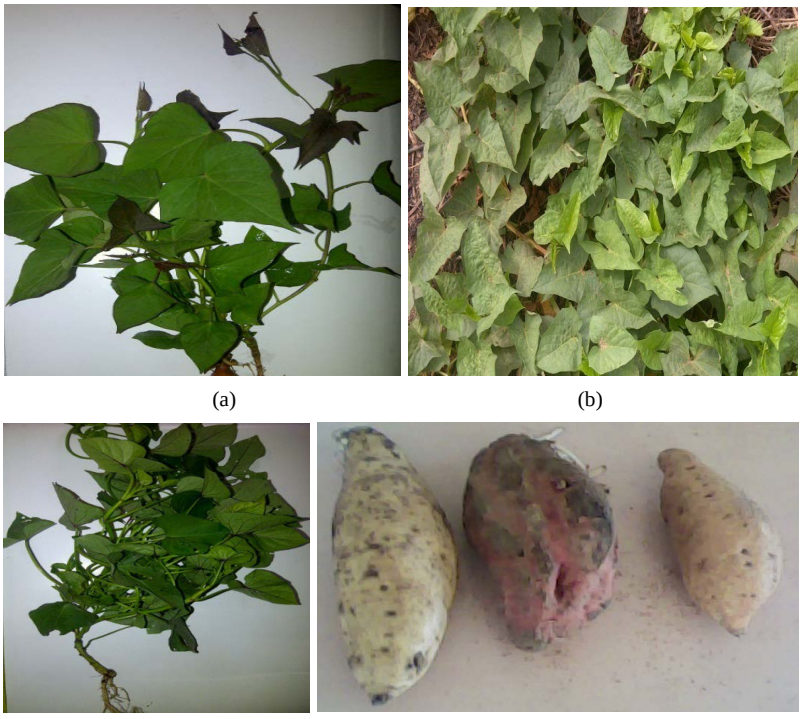


Figure 3. Dendrogram of the three varieties.



(a) (b)

(c) (d)

Figure 4. (a) Purple variety; (b) Yellow variety; (c) White variety; (d) (L-R) root of white, purple and yellow varieties.

Therefore, variability in sweet potato may be explored by plant breeders for crop improvement. This outcome thus calls for more taxonomic audit of the *Ipomoea batatas* complexes through cytogenetic and molecular systematic studies.

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