CHAPTER ONE

INTRODUCTION

1.1 The background of the study

Musa species commonly known as bananas and plantains are giant humid tropical and subtropical giant perennial herbs of the Eumusa section, Order Zingiberales, family Musaceae and genus *Musa* (Christenhusz and Byng, 2016*)*. Bananas and plantains are highly valued commodity due to their social, cultural and economic importance. In 2013, banana ranked 4th among the main world fruit crops in financial values (Holmes, 2013). Bananas are used in many aspects of human life. Bananas are used as food, fibres and ornamentals. The leaves, fruit and stems are used in herbal medicine for treating ailments such as dysentery, diarrhoea and digestive disorders (Morton, 1987). Rubbing of banana peels on mosquito bites has a good effect of stopping the stinging sensations (Morton, 1987). Banana fruit contains vitamin B_6 which regulates blood glucose levels (Waston, 2004). Bananas and plantains vary in proportions of their sugar and starch contents. Bananas are varieties of *Musa* species with high sugar content and are eaten fresh or cooked, while plantains are those with high starch content and are eaten after cooking (Constantine and Rossel, 2001). Bananas and plantains (*Musa* spp.) originated in Southeast Asia. Their natural distribution is mainly restricted to the humid and sub-

humid tropics of Asia, Africa and the Americas (Heslop-Harrison and Schwarzacher, 2007). It is extensively grown in many countries like Mexico, Egypt, Israel, South Africa, Indonesia, Philippians, Brazil, Nigeria and Sri Lanka (Wells, 2002).

Musa spp. originated mainly from intra- and interspecific hybridizations between two wild diploid species, *M. acuminata* Colla ('A' genome) and *M. balbisiana* Colla ('B' genome) (Simmonds and Shepherd, 1955). Therefore, the cultivated varieties can present different genomic combinations as follows: AA, AB, AAA, AAB, AAAA, AAAB, AABB and ABBB indicating diploids, triploids and tetraploids (Dina *et al.,* 2009). Plantains belong to BB genotype and their hybrids are polyploids and genome is ABB group while banana belong to AA genotype. Banana hybrids are triploids and their genomic group include AA, AB, AAA and AAB. The bananas are the most diverse of *Musa* subgroups. The species with triploid genotypes are virtually or completely sterile and develop their fruits by vegetative parthenocarpy.

The botanical classification of plantains and bananas is so complicated that plantain is variously viewed as a subspecies of the banana, and the banana as a subspecies of plantain (Encyclopaedia Britanica, 2010). All banana and plantain taxonomists seem to agree that no single scientific name can be given to all the

edible bananas. There have been existing difficulties in the taxonomic classification of banana plants due to enormous variations evident in banana plants. Morphological description has been very useful for the identification of the large diversity of banana varieties that exist in the tropics (Jarret and Gawel, 1995; Tezenas, 1987). The great diversity among bananas and plantains resulted from reccurrent somatic mutations, close genetic relationships among varieties and morphological changes due to environment, and human selections for their tasty fruit. Wide diversity and variation of forms and uses occur among plantains and bananas ('ABB' *Musa* varieties) (Simmonds, 1985). There are approximately 500 varieties of bananas and plantains. About 150 of these are primary clones, the rest are somatic mutants (Sachter-Smith and Gerei**,** 2011). Consequently, the use of only morphological parameters could result in over estimation or underestimations of the degree of relatedness among banana varieties (Daniells *et al.,* 2001; Kaemmer *et al.,* 1992; Swennen, 1990). Several factors including, the sterility, ancient domestication and hybrid origins of the cultivated varieties and the unwillingness of many to adopt newer, correct names are responsible for difficulties in classification of *Musa* species (Daniells *et al.,* 2001). The problem emanated from the simplistic description of bananas as *Musa paradisiaca* for plantain and *Musa sapientum* for dessert banana, by Linnaeus, the father of modern botanical nomenclature. This was attributed to the very limited specimens available

to him in Europe where the original names were given. Phonetic variation associated with tonal language in Asia often resulted to differences in spelling (Karamura, 1998). Conventionally, identification and classification of edible bananas and their wild relatives have been based on their morphological characters and their similarity to the two progenitor species, *M. acuminata* and *M. balbisiana*. In 1955, Simmonds and Shepherd devised a new genome-based nomenclature system for the edible fruit bearing bananas based on their genotype (Daniells *et al.,* 2001). They have listed various features that were characteristic of *M. acuminata* and *M. balbisiana* and gave them arbitrary numerical values. They scored plants based on the visual assessment of these characters and assigned them with various genome groups. This system of classification has been primarily referred to in banana genotyping.

Several qualitative and quantitative morphological characters including features of inflorescence, features of male flowers and fruit characters were very useful for identification and classification of *Musa* species (Amorim *et al*., 2012). Morphological characteristics alone are not enough as criteria for classification of banana varieties (Stover and Simmon, 1987; Robinson, 1996). Scientific techniques that can supply additional information not available from the examination of morphological characteristics alone are therefore necessary for easy and accurate identification of banana varieties (Jarret and Gawel, 1995). Crouch *et*

al. (2000) suggested that the traditional designations of banana landraces based on morphotype do not provide a true reflection of overall genetic divergence. Similarly, they further stated that classification systems using phenotypic indices based on agronomic characters may not provide accurate taxonomic differentiation.

This state of affairs as regards the taxonomy of banana is not abating especially as the species naming is concerned. Banana is known by different names in various countries of the world. In order to describe various banana varieties, names that may reflect local uses or characteristics are often used. The binomial Latin nomenclature for edible varieties, e.g. *Musa cavendishii* cultivar (var.) Williams, proved unsatisfactory. They are for example, referred to as, *Musa* spp. (AAA Group, Cavendish Subgroup) cv. Williams. Varieties have many local names making identification of specific clones difficult by common name.

1.2 Statement of the Problem

Musa taxonomy has for decades remained in a confused state. Several factors including, the sterility, close genetic relationships among varieties as well as frequent somatic mutation and morphological changes due to environment have resulted in the large number of varieties, ancient domestication and hybrid origins of the cultivars and the unwillingness of many to adopt newer, correct names are

responsible (Danniells *et al*., 2001). Identification of this wide variety of varieties is traditionally based on morphological criteria. Moreover, banana varieties have been named in different dialects resulting in numerous synonyms and homonyms (Shanmugavelu *et al.,* 1992). Phonetic variation associated with tonal language in Asia often resulted to differences in spelling (Karamura, 1998).

Morphological characteristics alone are not enough as criteria for classification of banana varieties (Robinson, 1996; Stover *et al*., 1987). Scientific techniques that can supply additional information not available from the examination of morphological characteristics alone are therefore necessary for easy and accurate identification of banana varieties (Jarret and Gawel, 1995). These authors futher suggested that the traditional designations of banana landraces based on morphotype do not provide a true reflection of overall genetic divergence. Similarly, the classification systems using phenotypic indices based on agronomic characters may not provide accurate taxonomic differentiation.

Identification and classification of *Musa* species pose serious problems to taxonomists and this is probably as a result of the fact that only morphological and cytological evidence have been used in classification of the species. Linnaeus classified and identified banana based on very limited species. The great diversity of species as it is now evident was not recognized at the time and further works

were based mainly on their local names, which are not always the same in different localities. The problem partly emanated from the fact that various banana varieties are morphologically identical, but have quite distinct fruit pulp characteristics which determine their uses. Another source of confusion is the existence of numerous varieties, names and synonyms in different languages and dialects of different regions. In most cases, the same varieties are known by different names in different communities, tribes and countries. Confusion also arises when varieties' appearances recorded in different geographical location differ in some characteristics such as pseudostem color which had been changed by the local environmental factors (Amorim *et al*., 2012), Mislabeling and typographical errors also cause confusion; some cultivar names are spelt differently from one publication to another (Swennen, 1990).

Researchers have not tried using other characteristics to differentiate and classify banana varieties and hence, banana varieties are only known by their local names which are not always the same in different localities. Since the confusion in classification of *Musa* plants has not been solved completely through morphological characteristics, the need to employ other parameters has arisen. It is possible that ascertaining the anatomical, genetical, proximate, mineral and phytochemical features of banana varieties could throw up important differences and similarities that will help in achieving a clearer classification of the many

banana varieties namely namely *Musa sapientum* var. ‘Egbela’, *Musa sapientum* var. ‘Unele Mmemme’, and *Musa sapientum* var. ‘Unele Ojii’ , *Musa sapientum* var.‘Unele Ocha ’, *Musa sapientum* var. ‘Akpupoike’ and *Musa sapientum* var. ‘Obuo odaa’.

1.3 Aim and Objectives of the study:

The aim of this work was to investigate the features of taxonomic values (similarities or dissimilarities) existing among different varieties of banana plant with a view to using such features in their taxonomic classification.

Specifically the objectives were to

1. determine the morphological characters of various varieties of *M. sapientum*
2. determine the anatomical characters of the various varieties
3. determine the genetical diversity of various varieties of *M. sapientum*
4. determine the phytochemical, proximate and mineral composition of various varieties of *M. sapientum*
5. Develop the taxonomic key for the identification of *Musa* varieties studied.

1.4 Significance of the Study

The results of this study may resolve the difficulties and confusion in the taxonomic classification of the of the banana varieties. Hence the differences and

similarities in the characteristics of the varieties could throw more light on their relatedness or otherwise, with a view to achieving clearer descriptions, delineation and possibly review the present identification and classification procedure. This research work will also serve as a resource material as well as provide information on the chemical constituents of various varieties of banana, so as to make use of informed knowledge in the choice of the banana cultivar for consumption, commercial purposes, ornamentation and ethnomedicine.

CHAPTER TWO

LITERATURE REVIEW

The review of literature which generates the theoretical framework for the study is organised as follows; description of banana, distribution of banana species, The role of banana in food and health, taxonomy of banana, the use of Random Amplified Polymorphic DNA (RAPD) markers in detection of Genetic variability, review of anatomy as means of classification of plants and chemotaxonomy of plants.

2.1 Description of *Musa sapientum* plant

Musa sapientum commonly known as plantains and bananas are tropical giant perennial herbs of the genus *Musa* and family Musaceae and Order Zingiberales (Christenhusz and Byng ,2016). The tall aerial shoots arise from swollen, fleshy underground corms. *Musa sapientum* (banana) plant attains heights of about 3-10 meters with a conical false trunk formed by the leaf sheaths of its spirally arranged leaves. The leaves are about 2.75 meters (nine feet) long and about 60 centimeters (two feet) wide (Morton, 1987). The fruit, which is green, is typically smaller and thiner than that of Plantain to which they are closely related (Hotsonnyame, 2008).

2.2 Distribution of banana species

Banana is tropical crop per excellence and is grown in all tropical and subtropical regions of the world. It is extensively grown in many countries like Mexico, Egypt, Israel, South Africa, Indonesia, Philippines, Brazil, Nigeria and Sri Lanka. Next to Brazil, India is the second largest banana producing country in the world (Ogazi, 1996). *Musa sapientum* (Banana) is widely distributed in Sub-Saharan Africa, Tropical America and parts of India (Wells, 2002).

2.3 Taxonomy of banana

At present the genus *Musa* consists of 30-40 species which are classified into five sections based on chromosome numbers and morphological characters; these are *Eumusa* (n =11), Australimusa (n =10), *Callimusa* (n =10) *Ingentimusa* (n =14) and *Rhodochlamys* (n =11) (Ude *et al.,* 2002). The majority of the cultivated species arose from the Eumusa section. Therefore the *Australimusa, Callimusa, Ingentimusa* and *Rhodochlamys* sections will not be discussed further. There are 13-15 species in the *Eumusa* section but most cultivated species are derived from the diploid wild ancestors of bananas, *Musa acuminata* Colla (A) and *Musa balbisiana* Colla (BB) or a hybridization of these two, leading to the formation of diploid, triploid and tetraploid varieties. The wild ancestors originally contained many hard seeds, making them virtually inedible. Through human intervention,

parthenocarpic mutants of these wild species were selected and cultivated. Female sterility is a characteristic for triploid varieties which evolved later resulting in seedless fruits even when pollinated (Simmonds, 1962). The terminology used to identify groups within the *Eumusa* section is based on the origin of the parents' chromosomal material (the A genome and / or the B genome) and the ploidy. For example, the triploid AAA genome (3n =33), derived solely from parent material of *M*. *acuminata*, designates many dessert bananas, like those of the Cavendish subgroup and also cooking bananas of the East African highland banana subgroup; the AAB genome, derived from the parent material of *M. acuminata* and *M. balbisiana*, designates dessert bananas (Danniells *et al.,* 2001).

There are three common species of *Musa*, which include *Musa cavendishii*, *Musa paradisiaca* and *Musa sapientum*. *Musa cavendishii* is pure triploid *acuminata* (AAA group) and is a type of dessert banana. Cavendish is one of the most important fruits grown commercially in large scale for world export trade. *Musa paradisiaca* is a type of banana, which is normally, cooked before eating while *Musa sapientum* known as true banana is usually eaten raw at maturity after ripening . Both *Musa paradisiaca* and *Musa sapientum* belong to AAB group (Stover and Simmonds, 1987) and are characterized by the higher starch concentration.

The family Musaceae contains three genera: *Musella, Ensete* and *Musa* (including bananas and plantains) (Kress *et al*., 2001). Plant sizes are classified into three groups, large, medium and small. However, it is difficult to apply this classification to actual field work conducted in rural areas, since the same cultivar expresses different sizes depending on the differences in growing environment. The height of pseudostem at flowering was classified into three ranges: shorter than 320cm; 320cm to 370cm; and taller than 370cm (De Langhe, 2005). On the other hand, De langhe, (1964) adopted the ranges around 225cm as small, 275cm as medium, and 350cm as large . Tezenas (1979) regarded those shorter than 400 cm as small, 400cm to 500cm (around 450cm) as medium, and those taller than 500 cm as large. Although the classification based on actual height of pseudostem may be possible when different varieties are planted on the experimental plot with identical conditions but it is difficult to apply the same criteria to studies conducted for actual fields with variable conditions in diverse geographical areas. A practicable criterion likely to be applied to field work is the number of leaves developed by the stage of flowering which shows a high correlation with the plant height in experimental plots (De Langhe, 2005). Moreover, the number of developed leaves is a trait relatively stable under variable environmental conditions (Rossel, 1998). While the criteria based on the size, that is large-medium-small, differ delicately depending on papers, they approximately correspond to those of

the number of leaves as follows: more than 40 (or 42) for large; 38 (or 40) to 32 for medium; and less than 30 for small. Use of fruit clusters' characters does exist. Other traits used for classification include the pseudostem colors, the shapes of finger apex, and the cluster orientation.

In recent years, studies on DNA of bananas have started. It has been proven that bananas and plantains include diverse types, which are also classified according to their end uses and according to genome groupings. The end use categories include dessert, cooking, roasting and beer bananas (Simmonds, 1962). Genome groupings of cultivated bananas include a range of diploids, triploids and tetraploids and are categorized on the basis of their ploidy levels and the genome they contain. Eastern Africa produces mainly 'Highland' bananas, which are triploid *Musa acuminata* (AAA). "EA" is usually appended to the genome designation to signify that they are East African (AAA-EA). These constitute one third of the total world output of bananas and plantains and are principally cooking and beer bananas (Crounch *et al*., 2000). On the other hand, the above described classification system based on morphological characteristics, inflorescence and plant size seemingly do not agree unequivocally with classification based on genetical differences. The studies by Crounch *et al*., (2000) have shown only very little correlation between the differences of varieties of banana and the morphological classification of them,

suggesting the existence of great diversity in the domains of genes that affect scarcely the cluster type and the plant size.

The genus *Musa* contains many species; several of which produce edible fruit, while others are cultivated as ornamentals (Leibling *et al.,* 2006).

Banana classification has long been a problematic issue for taxonomists due to the way Linnaeus originally classified banana as two species based only on their methods of consumption, *Musa sapientum* for dessert bananas and *Musa paradisiaca* for plantains (Skidmore and Smith, 2001).

However, this simplistic classification has proven to be inadequate to address the sheer number of varieties (a lot of them synonyms) existing in its primary center of diversity, Southeast Asia (Stephen and Corinna, 2007). In botanical classification, Plantain is variously viewed as a subspecies of the banana, and the banana as a subspecies of plantain (Encyclopedia Britanica, 2010). *Musa spp.* originated mainly from intra- and interspecies hybridizations between two wild diploid species, *M. acuminata* Colla (‘A’ genome) and *M. balbisiana* Colla (‘B’ genome) (Simmonds and Shepherd, 1955.). Therefore, the cultivated varieties can present different genomic combinations: AA, AB, AAA, AAB, ABB, AAAA, AAAB, AABB, and ABBB. Edible bananas are diploids, triploids and tetraploids with 22, 33, 44 chromosomes respectively, where the basic chromosome number is 11.

Musa accuminata Colla- This species exist as either a diploid (2n=22) or triploid (3n=33). These types are symbolized as AA and AAA, respectively, by geneticists and taxonomists (Palmer and McGlasson, 1971).

Musa balbisiana Colla – This is the seedy, fruited, inedible species from southern Asia used as a parent of several varieties, due to its disease resistance, drought tolerance and general hardiness to environmental factors. It is diploid and symbolized BB. Its natural range does not overlap that of *Musa accuminata*, but human migration in this region allowed these two species to hybridize in nature, many years ago, giving rise to three additional genotypes, AB, AAB and ABB. Hybrids (AB, AAB) are sometimes given the name *Musa paradisiaca*. Wide diversity and variation of forms and uses occur among plantains and bananas through genome origin, ploidy and somatic mutation (Simmonds, 1966). The inflorescence morphology has been solely utilized to distinguish the 'AAB' *Musa* varieties, otherwise known as plantains into four subgroups namely French, French horn, False horn and horn (Tezenas *et al*., 1983). Despite, the fact that Southeast Asia is the center of origin of *Musa* species (Simmonds, 1966), great genetic diversity has been reported for both plantains and highland bananas in sub-Saharan Africa (Swennen and Vuylsteke, 1991).

This state of affairs as regards the taxonomy of banana is sustained especially as the species naming is concerned. Banana is known by different names in various countries of the world. In order to describe various banana varieties, names that may reflect local uses or characteristics are often used (Oke *et al*., 1998). The total number of varieties of bananas and plantains has been estimated to be anything from around 300 to more than 1000. Names are highly confused, even within a single country. Many common names do not refer to a single cultivar or clone; for example 'Lady's Finger' or 'Lady Finger' has been used as the name for members of different genome groups, including AA and AAB. Many other names are synonyms of varieties grown in the same or different countries (Ploetz *et al.,* 2007). Attempts have been made to create lists of synonyms. In 2000, Valmayor *et al*., listed equivalent local names for 68 varieties across five Southeast Asian countries (the Philippines, Malaysia, Indonesia, Thailand and Vietnam), together with their internationally used names. They considered a further 81 varieties to be unique to one country (Valmayor *et al.,* 2000). Ploetz *et al*., (2007) listed more cultivar names and synonyms, with an emphasis on those grown in the islands of the Pacific and including some grown in areas such as India, Africa and South America. As an example, for the widely grown cultivar 'Dwarf Cavendish', they gave 58 synonyms from 29 different countries or geographical areas.

Cheesman (1947) first discovered that *Musa sapientum* and *Musa paradisiaca*, described by Linnaeus, were actually varieties and descendants of two wild and seedy species, *Musa accuminata* and *Musa balbisiana* (Stephen and Corinna, 2007). He recommended their abolition in favour of reclassifying bananas according to three morphologically distinct varieties – those primarily exhibiting the botanical characteristics of *Musa balbisiana*, those primarily exhibiting the botanical characteristics of *Musa accuminata*, and those with characteristics that are the combination of the two (Skidmore and Smith, 2001). Researchers like Simmonds and Shepherd (1955) proposed the genome-based nomenclature system. It classifies cultivated bananas into genome groups, according to the relative contribution of their ancestral wild species, and into subgroups, sets of closely related varieties and then gives varieties names in a currently spoken language, enclosed in single quotes, and organized them into "cultivar groups", also not given Latin names (Stover and Simmonds,1987).

Banana and plantain varieties derived from *M. acuminata* and *M. balbisiana* can be classified into cultivar groups using two criteria. The first is the number of chromosomes indicating whether the plant is diploid, triploid or tetraploid. The second is relationship to the two ancestral species, which may be determined by genetic analysis or by a scoring system devised by Simmonds and Shepherd. A cultivar is scored on 15 characters, chosen because they differ between the two

species. Each character is given a score between one and five according to whether it is typical of *M. acuminata* or of *M. babisiana* or is in between. Thus the total score for a cultivar will range from15 if all characters agree with *M. acuminata* to 75 if all characters agree with *M. balbisiana*. Intermediate scores suggest mixed ancestry: for example, 45 would be expected for diploids with equal genetic contributions from both species (Stover and Simmonds, 1987).

Groups are then named using a combination of the letters "A" and "B". The number of letters shows the ploidy; the proportion of As and Bs indicating the contributions of the ancestral species. The AAB Group, for example, comprises triploid varieties with more genetic inheritance from *M. acuminata* than *M. balbisiana*. A character score of around 35 is expected for members of this group. Within groups, varieties may be divided into subgroups and then given a cultivar name, e.g. *Musa* AAA Group (Cavendish Subgroup) 'Robusta'.

This system eliminates almost all the difficulties and inconsistencies of a taxonomy based on *Musa paradisiaca* and *Musa sapientum*. However, due to difficulties in assigning certain varieties to a subgroup, and to a lesser extent to a group, there are inconsistencies in the way the system has been applied. Adding to the confusion is the continued use of Latin binomials to classify cultivated bananas. Cultivated bananas are unusual in not having a Latin scientific name.

This system eliminated almost all the difficulties and inconsistencies of the nomenclature system of bananas based on *Musa sapientum* and *Musa paradisiaca*. Despite this *Musa sapientum* is still recognized by some authorities today, leading to confusion (Stephen and Corinna, 2007). Generally, modern classifications of Banana varieties follow Simmonds' and Shepherd's (1955) system. The accepted names for Bananas are *Musa acuminata, Musa balbisiana* or *Musa acuminata x balbisiana,* depending on their genetic ancestry.

Synonyms include:

- *Musa sapientum* L.
- *Musa x paradisiaca* L.
- *Musa paradisiaca* L.subsup. *sapientum* J.G Baker
- *Musa rosacea* N.J. von Jacquin
- *Musa violacea* J.G. Baker
- *Musa cliffortiana* L.
- *Musa dacca* P.F. Horaninow
- *Musa rosacea* N.J. von Jacquin
- *Musa paradisiacal* L. subsp. *sapientum(*L.) C .E.O. Kuntze
- *Musa paradisiaca var. dacca* (P.F. Horaninow) J. G. Banker ex K. M. Schumann

(Stephen and Corinna, 2007).

2.4 The use of Random Amplified Polymorphic DNA (RAPD) markers in detection of Genetic variability.

Traditional methods for testing genetic variability in fruit crops are based on morphological or time consuming physiological assays (Welsh *et al.,* 1990).Presently there exist biochemical and molecular techniques to improve the fruit crops (Williams *et al*., 1990). The assessment of genetic diversity may be done within and between populations at molecular level by using various techniques like allozymes or DNA analysis (Mondini *et al.*, 2009). During the past decades, use of molecular markers is gaining attention to reveal polymorphisms at the DNA level. Different marker based techniques are available for the identification of plants. Out of these, molecular marker based techniques is more accepted because it overcomes many of the limitations of morphological and biochemical techniques since they are not affected by the environmental or developmental stage and can detect a variation at the DNA level (Tingey and Tufo, 1993). Polymerase chain reaction (PCR)-based molecular markers were extensively used in many plant species for identification, phylogenetic analysis, population studies and genetic linkage mapping. Random Amplified Polymorphic DNA (RAPD) markers are markers of choice, because of its simplicity and low-cost nature, rapid, inexpensive and effective system for studying plant genetic relationships (Williams *et al*., 1990).

The RAPD technique has been successfully used in a variety of taxonomic and genetic diversity studies (Mcgrath *et al*., 1999; Nebauer *et al.,* 1999), and was found by Wolf *et al*.(1999), to be suitable for use with *Echinacea* species in its ability to reproducibly generate polymorphic markers. Wolf *et al.,* (1999) has published a report demonstrating the utility of the RAPD technique for the discrimination of *E. purpurea, E. angustifolia,* and *E. pallida* using two different primers. Kapteyn *et al.,* (2002) reported an additional 17 RAPD markers capable of distinguishing among the commercially relevant *Echinacea* species and *E. atrorubens*, and extend the application of those markers to the identification of the genetic relationships between those species and the diversity and structure present within those species. RAPD data was used to partition genetic variation between the within accession and among accession levels for the three commercial species and to identify *E. pallida* and *E.angustifolia* accessions which may serve as potential sources of unique genetic material. The sensitivity of the RAPD method also permitted the detection of *P. integrifolium* adulteration of *E. angustifolia* at levels down to 10%.

The RAPD markers could also be used in the study of genetic variability of species or natural populations (Lashermes *et al*., 1993 and Wilkie *et al.,*1993) and in the study of genotype identification (Koller *et al.,*1993 and Wilde et al.,) . Genetic variability studies in ginger collected from different geographical regions of India

have been carried out using RAPD markers. DNA was isolated by CTAB method. DNA extraction of ginger proved difficult due to the presence of secondary metabolites. A modified CTAB method by Doyle and Doyle (1990) proved to be fruitful. The modified method included higher incubation temperature (65 °C). Random amplified polymorphic DNA and related techniques require less DNA, but purity is necessary to ensure repeatability and confidence (Welsh and Mcclelland, 1990 and Willians *et al*., 1990) . The purity of DNA determined from the ratio of optical density of 260/280 ratio which ranged from 1.78 to 1.92 for the samples indicates the purity of DNA in all samples. Random amplified polymorphic DNA (RAPDs) finger printing has been used reliably as molecular makers in varieties characterization (Ortiz , 1997).

RAPDs have the advantage that the material is processed by an efficient and inexpensive technique without requiring prior knowledge of the genome (Bhat *et al*., 1995). RAPD assays has the advantage of being easy to use, requiring very small amount of genomic DNA without the need for blotting and radioactive detection (Da-Mata *et al*., 2009), and are moderately reproducible. The RAPD markers have been used for detecting genomic variations within and between varieties of sweet potato. A total of 160 primers were tested and eight showed consistent amplified band patterns among the plants with variations within and between varieties (Lin *et al*., 2009) of sweet potato. Genetic diversity was

evaluated by RAPD markers and morpho-agronomic characters for a total of 42 accessions of Barberton daisy (*Gerbera jamesonii*) employing a set of 12 primer pairs (Da-Mata *et al*., 2009). Germplasm accession of 80 *Plantago* spp. was studied by using RAPD with the help of 20 random primers (Singh *et al*., 2009). Recently, RAPD has been used for estimation of genetic diversity in various endangered plant species (Zheng *et al*., 2008).

A study of an optimization of primer screening for evaluation of genetic relationship among the twelve accessions of ginger through RAPD analysis was carried out by Kamran *et al*. (2013).The main emphasis of the study was assessment of the genetic diversity at intraspecific level among the 12 accessions of ginger of Indian subcontinent using RAPD markers. RAPD analysis indicated that there is a high level of polymorphism among different accessions. From the study, it was understood that each location varied with respect to environmental factors and genetic parameters. Results showed that the accessions whose cultivation regions are very close shows maximum similarity among them as compared to accessions which are farther apart. This outcome is supported by Nayak *et al*., (2006) who established that main cause of polymorphism could be intraspecific variation among different varieties.

Biodiversity of banana cultivar are caused by natural crossing or somatic mutation processes for a long time (Stover and Simmonds, 1987) or caused by the selection and vegetative propagation (Purseglove, 1979). The diversity of banana could be differentiated by the taste, shape and color of fruit. Molecular approach and chromosome caryotype have been used to determine the phylogenetic relationship among some species of bananas (Retnoningsih, 2009).

2.5 Review of Anatomy as means of classification of plants

It is believed that internal structure of plants can provide more information than external morphology. However anatomical features cannot by themselves constitute the basis of classification but can be used with advantage to supplement those morphological attributes on which classification has been based. The anatomical studies of organs of flowering plants can serve as an integral part of taxonomy. Anatomy knowledge is essential when vegetative propagation is used to identify important structural features necessary for propagation success (Silva-Lima *et al*., 2005). Information on anatomical structure is needed by breeder working on improvement for drought tolerance (Nassar *et al*., 2008). Anatomically the corm of banana is built of a central cylinder, consisting of parenchymatous cells and an outer cortex of 1-3cm thick. As the true stem is entirely below ground, meristematic tissues for root and shoot formations are located close to one another.

The meristematic region between the cortex and the central cylinder forms the roots and is also called the ‘Mangin.

The use of leaf epidermal features in systematics has become popular and distinctive and has been used as a great taxonomic tool at the levels of family, genus and species. An excellent review of the application of morphological features in systematic studies is shown in the works of Edeoga and Ikem (2001); and Gill and Mensah (2001)). Kantachok *et al.,* (2007) stated that leaf anatomical data support morphological evidence for separating taxa of Myrtaceae at the generic level. The taxonomic position of a number of families are made on the basis of leaf epidermis and is one of the most important taxonomic characters from the biosystematic point of view (Stace, 1984; Jones, 1986). With their exhaustive research work Prabhakar *et al*., (1984) described the structure and distribution of the elements of epidermal cell complex in angiosperms. Variation in epidermal cell characters viz. shape, anticlinal and perclinal walls, cytoplasmic contents, sculpturing of outer wall, arrangement and orientation were presented. Inceer and Ozean (2011) considered leaf anatomy as an additional taxonomic tool for 18 taxa of Asteraceea in Turkey. Adedeji and Jewoolao (2008) concluded that leaf epidermal characters are taxonomically important in twelve species of Asteraceae. Makbul *et al*. (2008) suggested that anatomical features are more important than palynological ones in explaining variation among the examined taxa.

Dube and Morisset (1987) reported that some of the significant morphological and anatomical characters can display the taxonomic position and the percent of similarity in Poaceae, especially in Aegilops species (Dube and Morisset, 1987; Baum and Gupta, 1990). Dube and Morisset (1987) illustrated that the occurrence of sclerenchyma and bundle sheaths (Kranz sheath), the width of sclerenchyma, the indumentum of leaves, and the length and frequency of epidermal hairs are important features that can identify relationships among the genera of Poaceae. Jarves and Barkworth (1992) mentioned that the tetraploid species of Aegilops have higher variation in anatomical characters than the diploid species; however, the frequency of stomata among the diploid species is higher than that of the tetraploid species (Aryavand *et al*., 1999).

Davis and Heywood (1963) emphasized the use of anatomical characters as these are fairly constant and reliable within a taxon. The epidermis have a number of important diagnostic characters that provide valuable clues for identification like size, shape and orientation of stomata, guard cells and subsidiary cells, distinctive or specialized form of trichomes, structural peculiarities of epidermal cell walls (Dickison, 2000). Qureshi *et al.* (2002) carried out taxonomic studies of six species of genus *Sonchus* (Asteraceae) from Pakistan. Ahmad (2005) conducted morphological and anatomical studies of 23 species of genus *Saussurea* (Asteraceae) from Pakistan. Hayat *et al*. (2009) found that foliar trichomes of

genus *Artemisia* are good taxonomic markers. Hayat *et al*. (2010) studied stomatal variation in 24 taxa of genus *Artemisia* which can be utilized to solve the taxonomic issues within the genus.

2.6 Chemotaxonomy of plants

Chemotaxonomy of plants may be defined as a scientific investigation of the potentialities of chemical characters for the study of problems of plant taxonomy and plant physiology. The chemotaxonomic characters are better than the morphological characters, because the material to be analyzed must not be fresh or complete materials but it uses only dried and crushed material. A hundred years old herbarium specimen can also be examined for their secondary metabolites accurately (Harborne, 1973). The advent of chemotaxonomy is closely linked to the introduction of chemical analytical methods, especially chromatography (Harborne, 1973). The application of chemical data to systematics has received serious attention of a large numbers of biochemists (Hegnauer, 1989).

The four prominent groups of compounds that exhibit a wide variation in chemical diversity, distribution and function are phenolics, alkaloids, terpenoids and non-protein amino acids (Smith, 1976). Chemotaxonomic principles are considered and some examples are provided to show the importance of chemical evidence in taxonomic revision (Hegnauer, 1986). The system of chemotaxonomic classification relies on the chemical similarity of taxon, it is based on the existence

of relationship between constituents and among the plants (Rasool *et al*., 2010). In traditional plant taxonomy the totality of morphological characters has always to be weighed and checked carefully when decisions with regard to delimitations and classification have to be made (Hegnauer, 1986). The role of chemistry in plant taxonomy has been explained by Iwashiana *et al*. (1995); Heywood (1973). The position of many taxa in natural system of plant is still highly uncertain, this applies to all levels of taxonomic categories like species in genus, genera in a family, families in an order and even orders in a class. Varying interpretation and evaluation of morphological characters very often result in disagreement regarding classification. In such instances taxonomists as a rule look for characters other than morphological ones as described by Thorne (1963) and Davis and Heywood (1963). Generally anatomical, embryological, palynological and cytological characters are considered first. Sometimes they produce convincing evidence and sometimes fail to do so. In such situations chemical characters may become very useful guides to taxonomists. At present one important task of chemotaxonomy consists of procuring additional evidence in all cases of obscure relationships of plants.

The chemical compounds present in some taxa can help in understanding their relations with other taxa. For example, Gottlieb *et al*., (1993a) found that the primitive members only of Hamamelididae, Dilleniidae and Rosoideae have

galloyl esters in their tissues. Chemistry and micromolecular studies in the Fabaceae by Gottlieb *et al*., (1993b) indicated a probable derivation from Sapindales.Works concerning phytochemical survey were done by Bohm and Chan (1992) on the flavonoids in the genus *Greyia*; the chemotaxonomy of three closely related genera of the Lamiales was done by Denton and Smith (1996). Von Poser *et al*., (2000) have studied the distribution of iridoids among the tribes of Bignoniaceae and the data obtained can help in the taxonomy of the family. Jensen *et al*., (2002) studied the chemotaxonomy of the Oleaceae and found that the biosynthesis and distribution of iridoid can be used as taxonomic markers. Albach *et al*., (2004) used the iridoid glucosides of *Paederota lutea* to understand the relationships between *Paederota* and *Veronica.* Pfister *et al*., (2000) has developed analytical and diagnostic methods for Larkspur (*Delphinium* spp.) alkaloids, including development of immunogenic alkaloid-protein conjugates and antibodies for a systematic approach to the taxonomic classification of the genus.

2.7 The role of banana in Nutrition and health

Banana species are important components of food security in the tropics and they also provide income to the farming community through local trade (Crounch *et al*., 1998). They are major sources of energy food in many parts of the world and notably in Southern India, Africa and Tropical America. Banana is useful in many

aspects of life. Bananas are used as food, fibres and ornamentals. Banana provides many health benefits in addition to its other economic importance. Bananas are excellent source of potassium which is very essential for muscle metabolism. Potassium also helps to reduce blood pressure in individuals who are potassium deficient and reduces the risk of stroke. Bananas are excellent source of vitamins A, B6, C and D (Morton, 1987).

Other uses of Bananas and Plantains include the burning of the peel to make soap, use of the fibres of the pseudostem to make ropes and fermentation of the pulp to make beer. The large leaves and fast growth of *Musa* spp. make them ideal for mixed cropping systems together with cash crops, like coffee and cacao (Nkendah and Akyeampong, 2003). According to Mota *et al*. (2000), green banana fruit contains higher hemicelluloses (6.08%) than most fruits and vegetables. Banana has characteristics that make it a favourite fruit. It is available all year round and affordable. It has varietal range, good taste, high nutritional and medicinal values. There are two varieties of Banana; the sweet banana and the plantain. Sweet Banana can be eaten raw when it turns yellow with a soft smooth creamy pulp, while Plantain has lower water content and more starch content. Plantain is eaten boiled, roasted, or stewed and made into porridge (Sampath, *et al*., 2012). The most commonly grown varieties within the savannah environment of Nigeria are sweet banana and cooking banana – Plantain (Obiefuna and Ndubuizu, 1982). The

value of sweet banana in Nigeria is high because it is nutritionally rich, economically viable and medically beneficial (Sampath *et al*., 2012).

Shanmugavelu *et al.* (1992), reiterated that banana is rich in carbohydrates (22.84g),protein (1.09g), vitamin A (which promote healthy teeth, heart, bones, soft tissu es); vitamin B (which is essential in the body immune system, promotes brain and heart health); vitamin C(which promotes healing, development of tissues and ligaments) and vitamin D (which promote the body calcium metabolism). They provide food for both urban and rural populations of developing countries (Obiefuna and Ndubuizu, 1982). According to Sampath *et al*. (2012), all parts of sweet banana plant have medicinal value. The flowers are used for the treatment of bronchitis, dysentery and ulcers. Plantains are very similar to the unripe dessert bananas outwardly in appearance. The fruit of plantain is larger, coarser and less sweet. Sweet dessert bananas are generally eaten raw while cooking bananas or plantains are boiled, steamed, fried or roasted for food. Banana provides energy primarily in the form of carbohydrate with minimal contribution to energy from fat. In unripe bananas the carbohydrates are mostly starches. In the process of ripening the starches are converted to sugars; a fully ripe banana has only 1-2% starch (Ploetz, *et al.,* 2007).

Phytochemical constituents are the basic source for the establishment of several pharmaceutical industries. The constituents present in the plant play a significant

role in the identification of crude drug. Phytochemical screening is very important in identifying new sources of therapeutically and industrially important compounds like alkaloids, flavonoids, phenolic compounds, saponins, steroids, tannins and terpenoids (Akindele and Adeyemi, 2007). Previously the drugs were identified by comparison only with the standard description available, but recently due to advancement in the field of pharmacognosy various techniques have been followed for the standardization of crude drugs (Savithramma, *et al*., 2010). The high level of natural self-defense compounds in the plant makes it highly resistant to insect and disease infestation (Peter, 1991).

Alkaloids are basic natural products occurring primarily in plants. They occur as one or more heterocyclic nitrogen atoms and are generally found in the form of salts with organic acids. Alkaloids are the most efficient therapeutically significant plant substances. Pure isolated alkaloids and their synthetic derivatives are used as basic medicinal agents because of their analgesic, antispasmodic and anti-bacterial properties (Farquar, 1996). Alkaloids are formed as metabolic byproducts and have been reported to be responsible for the antibacterial activity (Mantle *et al*., 2000).

Glycosides serve as defence mechanism against predation by many microorganisms, insects and herbivores (Dhar *et al.,* 1979). The demonstration of activity against both gram positive and gram negative bacteria by the plant may be

indicative of the presence of broad spectrum antibiotic compounds (Lans *et al*., 2001).

The optimal effectiveness of a medicinal Plant may not be due to the one main active constituent, but may be due to the combined action of different compounds originally present in the plant (Bhandarkar and Khan, 2003).

The phenolic compounds such as flavonoid, phenolic acids and tannins are considered to be major contributors to the antioxidant capacity of plants. Phytochemicals such as saponins, terpenoids, flavonoids, tannins, steroids and alkaloids have anti – inflammatory effects (Akhindele and Adeyemi, 2007; Orhan *et al*., 2007). Tannins are dietary anti-nutrients that are responsible for the astringent taste of foods and drinks (Chikezie *et al*., 2008). Tannins bind to both proteins and carbohydrates and this has several implications for commodities containing tannins. Their presence can cause browning or other pigmentation problems in both fresh foods and processed products. The presence of tannin in the plants implies they may have astringent properties and in addition, could quicken the healing of wounds and burns (Farquar, 1996). This justifies their usage in herbal medicine. Tannins play a major role as antihaemorrhagic agent and have been shown to have immense significance as antiper cholesterol, hypertensive and cardiac depressant properties (Price , 1987).

Saponin has the property of precipitating and coagulating red blood cells. Some of the characteristics of saponins include formation of foams in aqueous solutions, haemolytic activity, cholesterol binding properties (Eleazu *et al*., 2010) and bitterness (Sodipo *et al*., 2000). It has been reported that saponins possess hypocholesterolemic and anti diabetic properties. Flavonoids are potent water soluble antioxidants and free radical scavengers which prevent oxidative cell damage, have strong anticancer activity and protect against the different levels of carcinogenesis (Okwu, 2004). Flavonoids in the intestine lower the risk of heart diseases.

The antioxidant potentials of plants have been linked with their flavonoids contents. In addition, the therapeutic potentials of plants have been linked with their antioxidant potentials (Eleazu *et al*., 2011). As antioxidants, the flavonoids from these plants may provide anti-inflammatory activity. Thus the high alkaloid and flavonoid contents of these plants explain their therapeutic use in herbal medicine especially in the treatment of wounds, burns and ulcers.

Flavonoid compounds especially quercetin and genistein have antitumor activity. These compounds are cytotoxic to cancer cells (Pouget *et al*., 2001). It has been reported that flavonoid, epigenin holds great promise as a chemo preventive agent for a variety of cancers and exhibits significant activity against UV induced DNA damage and thus protect against skin cancer (Baliga and Katiyar, 2006). It also

inhibits the growth of a variety of human cancer cells including leukemia, Breast, colon, skin, thyroid and prostate cancers (Khan and Sultana, 2006). Flavonoids and tannins are phenolic compounds and plant phenolics are a major group of compounds that act as primary antioxidants of free radical scavengers (Polterait , 1997).

These phytochemicals found in the parts of banana plants are known to exist in large group of angiosperms and are responsible for the protection and disease resistance of this group of Angiosperm. Formally, it was taught that plants produces these chemicals to protect the plants only, but recently it was discovered that when eaten by humans that the chemicals can prevent or cure diseases in humans (Akunyili, 2000). Although there is sufficient information on the phytochemical constituents of the fruits, there is scarcity of such information on the leaves. The phytochemical compounds isolated from *G. kola* include oleoresin (Onayade *et al*., 1998), tannins, saponins, alkaloids, cardiac glycosides (Ebana *et al*., 1991). Other phytochemical compounds so far isolated from *G. kola* seeds are biflavonoids such as kola flavone and 2-hydroxybi-flavonols (Okunji *et al*., 2002; Terashima *et al*., 1999; Okunji and Iwu, 1991). However, there is paucity of such information on the leaves.

Phytochemical analysis of unripe banana flour showed that it contained significant quantities of saponins, flavonoids, alkaloids and tannins. Saponins are known to

possess both beneficial (cholesterol lowering) and deleterious (cytotoxic permeabilization of the intestine and paralysis of the sensory system) properties (Price , 1995). However, the levels of saponin in the flour are quite too low to cause any deleterious effect. Flavonoids, alkaloids and tannins are polyphenolic compounds with antioxidant properties. In addition, phenolic compounds existing in plants are also responsible for their contribution to color, sensory and antioxidant properties of food (Robinson, 1996). The chemical composition of banana varies with the variety, maturity, degree of ripeness and where it is grown (soil type). The water content in the green plant is about 61% and increases on ripening to about 68%. The increase in water is presumably due to the breakdown of carbohydrates during respiration. Green banana contains starch which is in the range of 21 to 26%. The starch in the unripe plantain is mainly amylose and amylopectin and this is replaced by sucrose, fructose, and glucose during the ripening stage due to the hydrolysis of the starch (Marriott *et al*., 1981). The carbohydrate content reduces to between 5 and 10% when ripe. The sugar content is between 0.9 to 2.0% in the green fruit but and is about twice that of sweet potato (Aurand *et al.,* 1987). Banana therefore has a high carbohydrate content (31 g/100g) and low fat content (0.4 g/100g). They are good sources of vitamins and minerals (Adeniji *et al.,* 2006), particularly iron (24 mg/kg), potassium (9.5 mg/kg), calcium (715 mg/kg), vitamin A, ascorbic acid, thiamin, riboflavin and

niacin. The sodium content (351 mg/kg) is low in dietary terms hence recommended for low sodium diets (Izonfuo and Omuaru, 1988). The amino acid components include alanine, aminobutyric acid, glutamine, asparagine, histidine, serine, arginine and leucine. As a starchy staple food, plantain supply about 1g protein/100 g edible portion (USDA, 2009). As a healthy adult requires about 0.75g protein kg/day_(Burton and Willis, 1976), plantain alone cannot meet adult protein needs. The fat content of plantains and bananas is very low, less than 0.5%, and so fats do not contribute much to the energy content. Although the total lipid content remains essentially unchanged during ripening, the composition of fatty acids, especially within the phospholipids fraction has been observed to change, with a decrease in their saturation (Ogazi, 1996). The energy value of a food derives from the sum of its carbohydrates, fat and protein content. In the case of plantain, the carbohydrate fraction is by far the most important. The sugar and starches that make up this fraction are present in varying concentrations according to the state of the ripeness of the fruit. The two main components of this are amylose and amylopectin, present in a ratio of about 1:5. Sugars comprise only about 1.3% of total dry matter in unripe plantains, but rises to around 17% in the ripe fruit (Ogazi, 1996). Plantains are considered palatable at lower water content than maize, thus boiled and mashed plantain may prove to be a higher energy staple than maize porridge (Chandler, 1995).

Although bananas do not provide a particularly good source of several important minerals in human nutrition, such as calcium, iron and iodine, they are notably high in potassium and low in sodium (USDA, 2009). Nonstarch polysaccharides (collectively known as fibres) include crude fibre, cellulose, pectic substances, hemicelluloses and other polysaccharides. Unripe plantain pulp has a total of 3.5% dry matter as cellulose and hemicellulose and therefore constitutes a good source of dietary fibre (Kirk and Sawyer, 1991). The fruit is a good source of energy (1 g = 1 kcal), vitamin B1, B2, C and potassium and is low in sodium. More vitamin A is found in bananas and plantains than in most other starchy staples (Sharrock and Lusty, 2000).

In Summary, it is evident from the literature reviewed that classification of banana from the time of Linnaeus to the present time has mainly been based on use of morphological features of banana. Linnaeus (1753) probably unaware of the immense diversity of banana species classified the limited specimen presented to him as *Musa sapientum* and *Musa paradisiaca* based on their uses as food. With time the diversity of species of banana became evident and the inadequacy of Linnaean binomial system in classifying the species came to the fore. The simple two-fold distinction was not useful and was not made in local languages.

To overcome the inadequacies of Linnaean binomial system of banana classification, Earnest Cheeseman (1947) proposed a Classification of *Musa* species with a system based on morphological characters of two wild progenitors of *Musa* species namely *Musa acuminata* and *Musa balbisiana* into 3 groups which are as follows:

Group1which include those with mostly features of *Musa acuminata*

Group2 which include those with mostly features of *Musa balbisiana*

Group3 which include those with features of both progenitors

To further improve on classification of banana species Simmonds and Shepherd (1955) proposed abandonment of traditional Latin based botanical names for cultivated bananas and introduced a genome based classification which still employed assessing of morphological characters of *Musa acuminata* and *Musa balbisiana* in the *Musa* variety to be classified in order to assign genome to the species and the give varieties names in a currently spoken language, enclosed in single quotes, and organizes them into "cultivar groups", also not given Latin names.

They are classified into genomic groups by scoring morphological features of *Musa acuminata* and *Musa balbisiana.* This system eliminated almost all the

difficulties and inconsistencies of a taxonomy based on *Musa paradisiaca* and *Musa sapientum*. However, due to difficulties in assigning certain varieties to a subgroup, and to a lesser extent to a group, there are inconsistencies in the way the system has been applied. Adding to the confusion is the continued use of Latin binomials to classify cultivated bananas. Cultivated bananas are unusual in not having a Latin scientific name. Despite these attempts at evolving a more reliable system of identification and classification of banana varieties, the confusion in the process of classifying banana species has persisted as a result of great diversity of banana species and due to use of mainly morphological characters. In the literature reviewed, various workers recommended that parameters obtained from anatomical, phytochemical, proximate, genetical and mineral analytical studies of plants could be combined with morphological parameters to evolve more reliable taxonomic keys for classifying plants.

In line with the above this study is focused on ascertaining anatomical, phytochemical, proximate, mineral, genetical and morphological parameters of six varieties of *Musa* species that are of discontinuous type (characters that are not affected by environment) to use in formation of more reliable taxonomic key for classification of banana varieties.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Area of study

The study area was Anambra State of Nigeria that situates between Latitudes 5° 32’ and 6°45’ N and Longitudes 6°43 ’ and 7° 22 ’E respectively. Anambra State is constituted of three ecological areas namely (1) riverine areas in the Anambra North senatorial zones (2) dry environment areas environment in the Anambra central senatorial zones and (3) mixed riverine and dry environment areas located in the both south and central senatorial zones (Figure 1). The towns from which the specimens were collected include Umueri, Aguleri and Ogbaru in the riverine area, Igboukwu, Ekwulobia, Awka- Etiti in dry environment area and

Agulu, Adazi- Nnukwu and Umuawulu from mixed riverine and dry environment area. The prevailing climatic conditions are high rainfall ranging from 1,400 mm in the north to 2,500 mm in the south with four months of dryness (November – February), constantly high temperatures and a mean atmospheric humidity of

30 %.

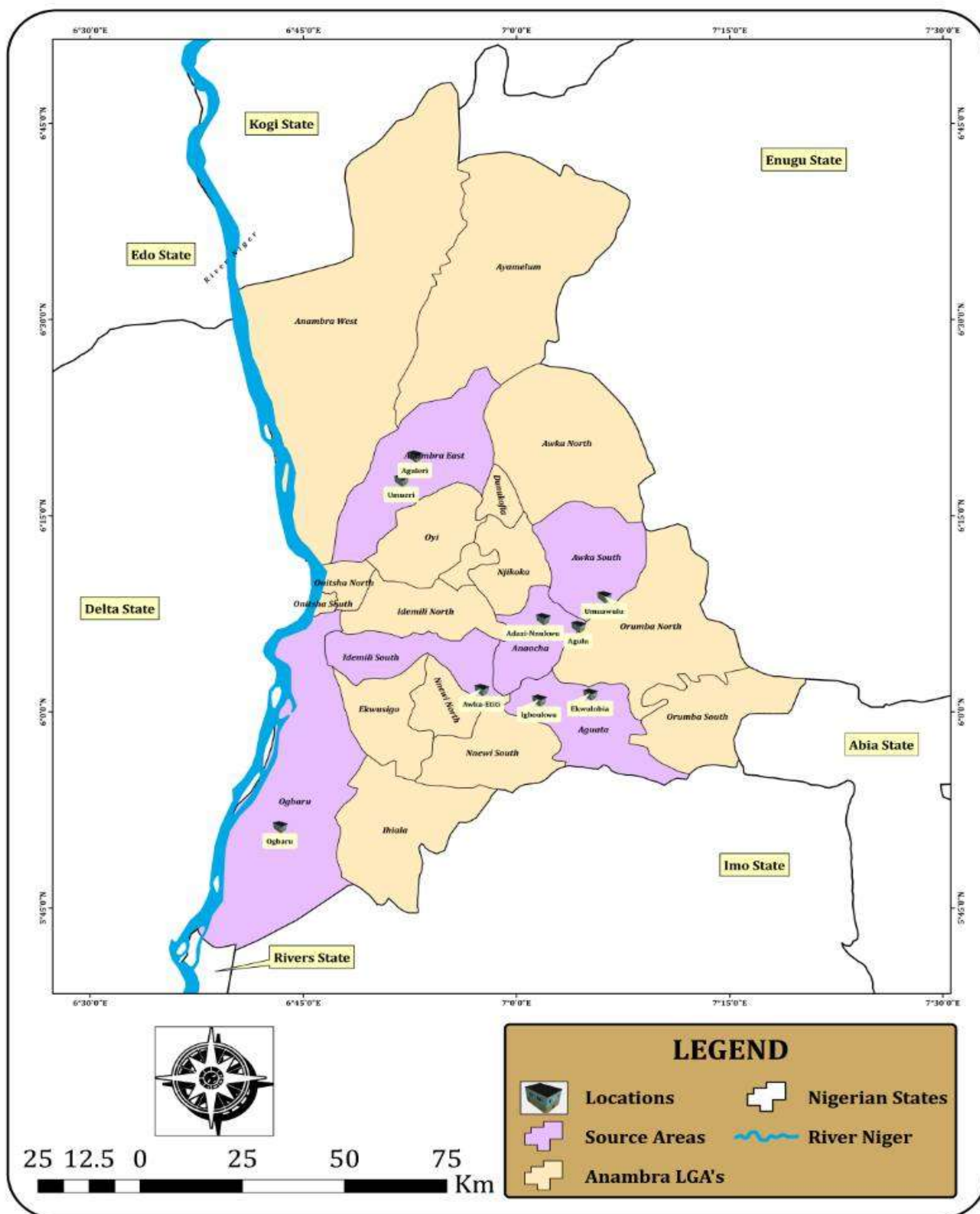

Fig. 1: Map of Anambra state indicating the towns where the specimens were collected.

3.2 Research Design

For each of the 6 varieties of *Musa sapientum* the leaves, flowers, fruits, pseudostems, rhizomes and roots were collected in triplicates from the towns ealier mentioned. The fresh banana plants used were harvested at physiologically mature stages of the fully developed (unripe) fruit. The third leaves from the tips of plants ready for harvest were used for the study. For fruit specimens, fingers of third hands of the bunches of fruits ready for harvest were collected.

The specimens used for the study were representative, matured, intact and undamaged. The sampling plan for gathering parts of different varieties of banana was purposive, meaning that specimens were selected to serve a specific purpose. The purpose of this sampling plan was to maximize the value of data for theory development by gathering data rich enough to uncover conceptual relationships.

3.3 Collection and identification of Samples of banana

The banana varieties namely, *Musa sapientum* var. 'Egbeala ', *Musa sapientum* var. 'Unele Mmemme', *Musa sapientum* var 'Unele Ojii' ,*Musa sapientum* var. 'Unele Ocha ', *Musa sapientum* var. 'Unele Akpukpoike' and *Musa sapientum* var. 'Unele Obuo odaa' were used in the study. Field trips were undertaken to visit farms and plantations in search of the six varieties of banana plant in the ealier mentioned towns. The six varieties parts were collected in triplicates from the

towns. Banana varieties parts were collected from plantations that are in the three ecological zones. The identification of varieties was made using a dichotomous key (Hutchinson and Dalziel, 2000). The identifications were later authenticated at the International Institute for Tropical Agriculture (IITA), Onne, by Dr Okechukwu Richardson. Vouchers of the banana varieties specimens were deposited at Herbarium of the Department of Botany, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.

3.4 Morphological examination of the samples

The six banana varieties were compared based on the morphological features of the roots, flowers, fruits, leaves and rhizomes. The morphological characterization was carried out by visual observation, physical assessment and metric measurements using 109 phenotypic traits, expressed by banana varieties as described in the Descriptors for banana (*Musa spp*) (International Plant Genetic Resources Institute -INIBAP, 1996).

3.5 Anatomical study

3.5.1 Temporary Staining

Cut sections of the root, rhizome, petiole and leaf of the varieties were prepared using paraffin method, while epidermis layer of leaf was processed using

modification of whole mount method (Ruzin, 1999). The stained sections were viewed under the microscope for identification of tissues of interest.

3.5.2 Permanent Staining

Sections of the root, rhizome, leaves of the varieties made were transferred into separate staining jars containing safranin and allowed to stand for ten minutes. The safranin was drained off and the sections were washed with distilled water to remove excess stain. The sections were then dehydrated in 97% ethanol and later in absolute alcohol for two minutes. The sections were then counter stained with fast green for ten minutes, washed three times with absolute alcohol for five minutes each, at five minutes interval, then washed in 50/50% alcohol and xylene three times at five minutes interval, cleared in pure xylene and mounted with Canada balsam.

3.6 Determination of genetic diversity

3.6.1 Genomic DNA extraction

The total DNA of the plants was isolated using cetyltrimethylammonium bromide (CTAB) method as described by Gawal and Jarrel (1991). A quantity of 0.5g of young banana roots was cut and ground in 600ml of extraction buffer and was incubated at 60˚C for 20 minutes. The sample was removed from the incubator and allowed to cool to room temperature and chloroform was added, the sample was

mixed by gentle inversion of the tube several times. Thereafter, the sample was spinned at 14,000rpm for 15 minutes and the supernatant was transferred into a new micrometre tube and an equal volume of cold Isopropanol was added to precipitate the DNA. The sample was kept in the freezer for 1 hour and later spinned at 14,000rpm for 10 minutes and the supernatant was discarded and the pellet was washed with 70% ethanol. Later the sample was air dried for 30mins on the bench. The pellet was resuspended in 100ml of sterile distilled water containing Ribonuclease A (RNase A). DNA concentration of all the samples was measured on spectrophotometer at 260nm and 280nm and the genomic purity were determined using Doyle and Doyle (1987) method. The genomic purity was 1.8-2.0 for all the DNA samples. The quality of DNA was detected by agarose gel electrophoresis and the size of fragment obtained was about 25kb for all the samples. The concentration of the DNA ranges within both the parental lines and progenies were within the purity level of 1.8-2.0. The genomic DNA was used in PCR_{22} amplification using RAPD makers.

3.6.3 Polymerase chain reaction mix

About 10ml of each DNA was taken into micrometer tube and 990 ml serial distilled water was added to make 1000 ml. The final concentrations become 20-50mg/ml. The reaction mix was carried out in 20 ml final volume containing

60mg-80mg genomic DNA, 1.0 mm of the primers, 2 mm $mgcl_2$, 125 mm of each Dntp and 1unit of Taq DNA polymerase. The thermocyler profiles were an initial denaturation temperature for 30 minuites at 94˚C, followed by 45 cycles of denaturation temperature at 94˚C for 20 seconds, annealing at 37˚C for 40 seconds and primer extension at 72˚C for 40 seconds, followed by final extension temperature at 72˚C for 5mins was added.

3.6.4 Agarose Gel electrophoresis

Agarose gel Electrophoresis was used to determine the quality and integrity of the DNA by size fractionation on 1.0% agarose gels. Agarose gels were prepared by dissolving and boiling 1.0g agarose in 100ml 0.5 × Tris-Borate-Ethylenediaminetetraacetic acid (TBE) buffer solutions. The gels were allowed to cool down to about 45˚c and 10ml of 5mg/ml ethidium bromide was added, mixed together before pouring it into an Electrophoresis Chamber set with the combs inserted. After the gel has solidified, 3ml of the DNA with 5ml sterile distilled water and 2ml of 6× loading dye was mixed together and loaded in the wall created.Electrophoresis was done at 80v for 2 hours. The integrity of the DNA was visualized and photographed on UV light source.

Polymerase Chain Reaction (PCR) amplicon electrophoresis was carried out by size fractionation on 1.4% agarose gels. Agarose gel was prepared by dissolving

and boiling 2.8g agarose in 200ml 0.5×TBC buffer solution. The gels were allowed to cool down to about 50˚C and 10 ml 0f 5mg/ml ethidium bromide was added, mixed together before pouring it into an electrophoresis chamber set with the combs inserted. After the gel has solidified, the PCR amplicon was loaded in the well created. Electrophoresis was done at 100v for 2 hours. The DNA was visualized and photographed on UV light source.

3.7 Phytochemical analyses of *Musa sapientum* parts

3.7.1 Preparation of the extracts

The method of Harborne (1998) was used for ethanolic extracts preparation. The plant leaves, stem, roots, fruits (matured and unripe), were washed, air dried and pulverized. To obtain the ethanolic extracts, 800 g of each of the plant materials (ground fruits, leaves, and roots of the six varieties of *M. sapientum* under study were soaked in 2 litres of ethanol for 48 hours. The residues were removed by filtration and the filtrates were concentrated under reduced pressure by a rotary evaporator at 40^{0}C and kept ready for use. Exhaustive extraction was carried out in duplicates.

3.7.2 Qualitative Phytochemical screening

Phytochemical screening was done by physical examination of the intensity of the color of reaction mixture compared with blanks (i.e. without plant samples) and the highest possible intensity of color type. The ethanolic extract of each sample was examined for the following compounds: Alkaloids, Phenols, Flavonoids, Saponins and Tannins using the standard laboratory techniques of Harborne, (1998).

3.7.3 Alkaloids

The presence of alkaloids in each sample was investigated using the method described by Harborne (1973). An alcoholic extract was used and obtained by dispersing 2g of the powdered sample in 10ml of ethanol. The mixture was thoroughly shaken before filtering using Whatman no. 40 filter paper. 2 ml of the filterate was placed in a test tube and 3 drops of pirovic acid was mixed with it. The formation of light green coloration indicates presence of alkaloid.

3.7.4 Flavonoid

The determination of the presence of flavonoid in the sample test was carried out using the acid alkaline test described by Harbone (1973). 2ml of the aqueous extract was added to a test tube and a few drops of bench concentrated ammonia (NH_4) were also added. The formation of a yellow coloration showed presence of

flavonoid. Confirmatory test was carried out by adding few drops of concentrated hydrochloric acid (HCl) into the yellow solution which turned colorless.

3.7.5 Phenols

The test for presence of phenols in the sample was carried out using the Harborne (1973) methods. The fat free sample was boiled with 50ml of ether for 15 minutes. 5 ml of the extract was pipetted into a 50 ml flask and 10ml of distilled water added into it. 2 ml of ammonia hydroxide solution and 5ml of concentrated amyl alcohol were also added. The mixture was allowed to react for 30 minutes for color development. . A dark green color indicated the presence of phenolic compounds.

3.7.6 Saponin

The presence of saponin in the test samples was investigated using the Harborne (1973) method. Two tests were involved in the investigation, the froth test and emulsion test. In the froth test, 2 ml of the aqueous extract was mixed with 6 ml of distilled water in a test tube. The mixture was shaken well and the formation of froth indicated the presence of saponins.

3.7.7 Tannin

The determination of the presence of tannin in the test sample was carried out using the ferric chloride test described by Harborne (1973). 2g of the powdered

sample was added into 10ml of distilled water. The mixture was shaken for 30 minutes in a mechanical shaker and filtrate used as aqueous extract. 2ml of the aqueous extract was added into a test tube and 3ml of distilled water added to it. After shaking to mix well, 2 drops of diluted ferric chloride (FeCl) was added to the mixture. The formation of a very dark precipitate indicated the presence of tannin.

3.8 Quantitative phytochemical determination

3.8.1 Alkaloid (%):

The determination of the concentration of alkaloid in the sample was carried out using the alkaline precipitation gravimetric method described by Harborne (1973). 5g of the powdered sample was soaked in 2ml of 10% ethanolic acetic acid. The mixture was stood for four (4) hours at room temperature. Thereafter, the mixture was filtered through whatman filter paper no. 42. The filterate was concentrated by evaporation over steam bath to a quarter of its original volume. The precipitate was recovered by filtration using previously weighed filter paper. After filtration, the precipitate was washed with 9% ammonia (NH_3) solution and dried in the oven at 60^0C for 30 minutes, cooled in a desiccator and reweighed. The process was repeated two more times and the average was taken. The weight of alkaloid was

determined by the differences and expressed as percentage of weight of sample analyzed as shown below:-

$$\%\text{Alkaloid} = \frac{W_2 - W_1}{\text{Weight of sample}} \times \frac{100}{1}$$

Where;

W_1= weight of filter paper

W_2 = weight of filter paper and alkaloid precipitate

3.8.2 Flavonoid (%)

The flavonoid content of the leaves of the plant was determined by the gravimetric method as was described by Harborne (1973). 5g of the powdered sample was placed into a conical flask and 50ml of water and 2ml **Hydrochloric acid** (HCl) solution was added. The solution was allowed to boil for 30minutes. The boiled mixture was allowed to cool before it was filtered through Whatman filter paper (no. 42). 10ml of ethyl acetate which contained flavonoid was recovered, while the aqueous layer was discarded. A pre-weighed Whatman filter paper was used to filter the second (ethyl acetic layer), The residue was then placed in an oven to dry at 60^0C. It was cooled in a dessicator and weighed. The quantity of flavonoid was determined using the formular:-

$$\%Flavoniod = \frac{W_2 - W_1}{\text{Weight of sample}} \times \frac{100}{1}$$

Where;

W_1= weight of filter paper

W_2 = weight of filter paper and flavonoid extract

3.8.3 Phenols (%)

The concentration of phenols in the sample was determined using the follin-cio Caltean colorimetric method described by Pearson (1976). 0.2g of the powdered sample was added to it and shaken thoroughly the mixture was left to stand for 15 minutes before filtering using Whatman no. 42 filter paper. 1ml of the extract was placed in a test tube and 1ml folin-cio Calten reagent in 5ml distilled water was added and color was allowed to develop for about 1 to 2 hours at room temperature. The absorbance of the developed color was measured at 760nm wave. The process was repeated two more times and an average taken. The phenol content was calculated thus: -

$$\%Phenol = \frac{100}{w} \times \frac{AU}{As} \times \frac{C}{100} \times \frac{VF}{VA} \times D$$

Where;

W = weight of sample analyzed

AU = absorbance of test sample

AS = absorbance of standard solution

C = concentration of standard in mg/ml

VF = total filtrate volume

VA = volume of filtrate analyzed

D = dilution factor were applicable

3.8.4 Saponin(%)

The Saponin content of the sample was determined by double extraction gravimetric method (Harborne, 1973). 5g of the powdered sample was mixed with 50ml of 20% aqueous ethanol solution in a flask. The mixture was heated with periodic agitation in water bath for 90 minutes at 55^0C; it was then filtered through a Whatman filter paper (no. 42). The residue was extracted with 50ml of 20% ethanol and both extract was poured together and the combined extract was reduced to about 40ml at 90^0C and transferred to separating funnel where 40ml of diethyl ether was added and shaken vigorously. Separation was by partition during which the ether layer was discarded and the aqueous layer reserved. Re-extraction by partitioning was done repeatedly until the aqueous layer become clear in color. The saponins were extracted, with 60ml of normal butanol. The combined extracts

were washed with 5% aqueous sodium chloride (NaCl) solution and evaporated to dryness in a pre-weighed after cooling in a desiccator. The process was repeated two more times to get an average. Saponin content was determined by difference and calculated as percentage of the original thus: -

$$\%\text{Saponin} = \frac{W_2 - W_1}{\text{Weight of sample}} \times \frac{100}{1}$$

Where;

W_1= weight of evaporating dish

W_2 = weight of dish + sample

3.8.5 Tannin (%)

The tannin content of the sample was determined using the Follin Dennis spectrophotometric method by Pearson (1976). 2g of the powdered sample was mixed with 50ml of distilled water and shaken for 30 minutes in a shaker. The mixture was measured into a 50ml volume flask and diluted with 3ml distilled water. Similarly 5ml of standard tanuric acid solution and 5ml of distilled water was added separately. 1ml of Folin Dennis reagent was added to each of the flask followed by 2.5ml of saturated sodium carbonate solution. The content of each flask was made up to a mark and incubated for 90minutes at room temperature.

The absorbance of the developed color was measured at 760.nm wavelength with the reagent blank at zero. The process was repeated two more times to get an average. The tannin content was calculated as shown below:-

$$\text{Tannin in mg/100} = \frac{100}{w} \times \frac{AY}{As} \times \frac{C}{100} \times \frac{VF}{VA} \times D$$

Where;

W = weight of sample analyzed

AY = absorbance of test sample

AS = absorbance of standard solution

C = concentration of standard in mg/ml

VF = total filtrate volume

VA = volume of filtrate analyzed

D = dilution factor were applicable

3.9 Proximate analysis

Proximate analyses for moisture, protein, fat, ash and crude fibre of samples were determined using the standard methods of analysis of Association of Official Analytical Chemists (AOAC , 1990) procedures. Carbohydrate content was

estimated based on the net difference between the other nutrients and the total percentage composition.

3.9.1 Protein

The protein content was determined by Kjeidahl method described by James, 1995). The total nitrogen was determined and multiplied with the factor 6.25 to obtain the protein. One half gram (0.5g) of each sample was mixed with 10mls of concentrated sulphuric acid in a Kjeidahl digestion flask. A tablet of Selenium catalyst was added to it and the mixture was digested (heated) under a fume cupboard until a clear solution was obtained in a separate flask. The acid and other reagent were digested but without sample to form the blank control.

All the digests were carefully transferred to 100ml volumetric flask and made up to a mark using distilled water. A 100ml portion of each digest was mixed with equal volume of 45% NaOH solution in Kjeidahl distilling unit. The mixture was distilled and the distillate collected into 10ml of 4% Boric acid solution containing three (3) drops of mixed indicators (bromocresol green methyl red). A total of 50ml distillate was obtained and titrated again 0.02m H_2SO_4 solution. Titration was done from the initial green color to deep red end point.

The Nitrogen content was calculated as shown below and the result expressed as a percentage of the original sample.

$$N_2 \text{ in mg/100} = \left(\frac{100}{W} \times \frac{N \times 14}{1000} \times \frac{VF}{Va}\right) T$$

Where;

W = wt of sample analysed

N = conc. of H_2SO_4 titrant

Vf = total Volume of digest

Va = Volume of digest distilled

T = Titre value – Blank

3.9.2 Fat content

Fat content of the samples were determined by the continuous solvent extraction method using a soxhlet apparatus. The method was described by James (1995). Five grammes (5g) of each sample were wrapped in a porous paper (Whatman no. 1 filter paper). The wrapped sample was put in a soxhlet efflux flask containing 200ml of petroleum ether. The upper end of the reflux flask was connected to a condenser. By heating the solvent in the flask through electro-thermal heater, it vapourizes and condenses into the reflux flask. Soon the wrapped sample was completely immersed in the solvent and remained in contact with it until the flask was filled up and siphoned over thus carrying oil extract from the sample down to

the boiling flask. This process was allowed on repeatedly for about 4hrs before the defatted sample was removed and reserved for crude analysis. The solvent was recovered and the extracting flask with its oil content was dried in the oven at 60^0C for 3mins (i.e. to remove any residue solvent). After cooling in a dessicator, the flask was reweighed.

The difference, the weight of fat (oil) extracted was determined and expressed as a percentage of the sample weight. It was calculated as:

$$\%Fat = \frac{W_2 - W_1}{\text{Wt of Sample}} \times \frac{100}{1}$$

Where;

W_1 = wt of empty extraction flask

W_2 = wt of flask and oil extract

3.9.3 Crude Fibre

This was determined by the Wende method (James, 1995). Five grammes (5g) of each sample were defatted (during fat analysis). The defatted sample was boiled in boiled 200ml of 1.25% tetraoxosulphate VI acid (H_2SO_4) solution under reflux for 30mins. After that, the samples were washed with several portion of hot boiling water using a two-fold muslin cloth to trap the particle. The washed samples were

carefully transferred quantitatively back to the flask and 20ml of 1.25% NaOH solution was added to it. Again, the samples were boiled for 30mins and washed as before with hot water. Then they were carefully transferred to a weighed porcelain crucible and dried in the oven at 105^0C for 3hrs, after cooling in a dessicator, it was reweighed (W_2) and then put in a muffle furnace and burnt at 550^0C for 2 hours (until they become ash). Again they were cooled in a dessicator and weighed.

The crude fibre content was calculated gravimetrically as:-

$$\% \text{ Crude Fibre} = \frac{W2 - W3}{\text{Wt of Sample}} \times \frac{100}{1}$$

Where;

W_2 = weight of crucible + sample after washing and drying in oven

W_3 = weight of crucible + sample as ash

3.9.4 Total Ash

This was done using the furnace incineration gravimetric method (AOAC 1990). A measured weight (5g) of each fruit sample was put in a previous by weighed porcelain crucible. The sample was put in muffle furnace set at 550^0C. The sample in crucible was carefully removed from the furnace (taking care not to allow air blow ash away) and cooled in a dessicator. It was reweighed by

difference; the weight of ash was obtained as percentage of sample weight. It was given by the formular: -

$$\% \text{ Ash} = \frac{W2 - W3}{\text{Wt of Sample}} \times \frac{100}{1}$$

Where;

W_2 = weight of crucible

W_3 = weight of crucible + sample of ash

3.9.5 Carbohydrate

The carbohydrate content was calculated by difference method as the nitrogen free extractive (NFE), a method separately described b y James ,1995). The NFE was by;

%NFE = (a + b + c + d + e)

Where;

a = Protein%

b = Fat %

c = Fibre%

d = Ash%

e = Moisture%   100-(a+b+c+d+e) =NFE%

3.9.6 Moisture content

Moisture content was determined by gravimetric method (James, 1995). A measured weight of each sample (5g) was weighed into a moisture can. The can and its sample content were dried in the oven at 105^0C for 3hrs in the first instance. It was cooled in a desiccator. And reweighed. The weight was recorded while the sample was returned to the oven for further drying. The drying, cooling and weighing was continued repeatedly until a constant weight was obtained. By the difference, the weight of moisture lost was determined and expressed as a percentage.

It was calculated as shown below: -

Wt. of Water (g) = (Wt. of Moist Sample + Wt. of can) - (Wt. of Dry Sample + Wt. of can)

Wt. of Dry Sample (g) = (Wt. of Dry Sample + Wt. of can) - (Wt. of can)

$$(\%)\ \text{Moisture Content}\ (\%) = \frac{\text{Wt. of Water}}{\text{Wt. of Dry Sample}} \times 100\%$$

3.10 Mineral Analysis

One gram (1g) of powdered sample was weighed into a pyrex glass conical flask. Ten milliliters (10ml) of concentrated nitric acid was introduced into the flask with a straight pipette. Five milliliters (5 ml) of Perchloric acid ($HClO_4$) was also added. The mixture was heated on an elctro-thermal heater for about twenty (20) minutes until a clear digest was obtained. The digest was cooled to room temperature and diluted to 50 ml with distilled water. The diluent was filtered into a plastic vial for the determination of sodium, potassium, calcium, magnesium, phosphorus and iron, content. Phosphorous was determined by spectrophotometer while sodium and potassium were determined by flame photometer (Khalil and Mannan, 1990). Iron, calcium and magnesium were determined by atomic absorption spectrophotometer and their absorption compared with absorption of standards of these minerals (A.O.A.C., 1990).

3.11 Development of taxonomic key for *Musa sapientum* studied

The morphological, anatomical, genetical, phytochemical, proximate, and mineral features of six varieties of *Musa* species that are of discontinuous type (characters that are not affected by environment) were used in construction of more dichotomous taxonomic key for identification of banana varieties studied.

3.12 Statistical Analysis:

SPSS software 13.00 was used to analyze the data .The experimental results were expressed as mean ± standard error of the mean (SEM) of three replicates. The sample means were compared using Analysis of Variance (ANOVA) followed by Duncan multiple range test to determine the level of significance. Differences in mean values were considered significant where $P < 0.05$.

CHAPTER FOUR

RESULTS

Objective 1: Morphological features of the plant Varieties

4.1 Morphological Result: The results were presented on the tables1 - 9 and plates 1-36 below.

4.1.1Habit: From the observations the habit of all the six varieties are perennial herbs

4.1.2 Root: From table 1, the gross morphology of the roots indicates that six varieties have adeventious roots. The roots colors are all white for the young roots of the six varieties and when mature the roots assume milk color except that of Akpukpoike and Obuo odaa which became brown.

4. 1.3 Rhizome: The features of the rhizomes are indicated in plates 1-6. The six varieties have underground true stems which are rhizomes. The leaves of the herb arise from the ground stem and their petioles get clustered together to form the pseudostems. The rhizomes are white in color except that of Unele Mmemme and Obuo odaa which are pinkish in color. For all the varieties the rhizomes are smooth. For the attachment of the suckers Egbeala and Unele Mmemme suckers arose from the bases of the rhizomes, the suckers of Obuo Odaa and Unele Ocha arose very close to the mother plants on the upper surface of the rhizomes. The suckers of Unele Ojii arose as horizontal outgrowth of the rhizome, while the suckerof Akpukpoike arose from the lower surface of the rhizome and then curves upwards.

Table 1: Root and rhizome morphological characters of six banana varieties.

Character	Cultivar					
	Egbeala	Unele mmemme	Obuo odaa	Unele Ocha	Unele Ojii	Akpukpoike
Root **Morphology**						
➢ **Root type**	Fibrous	Fibrous	Fibrous	Fibrous	Fibrous	Fibrous
➢ **Root color**						
Young:	White Young	White Young	White Young	White Young	White Young	White Young
Mature:	Light milky	Milky	Deep brown	Light milky	Milky	Dark brown
Rhizome: ***Morphology:***						
➢ **Color**	White	Pale pinkish	Light pink	White	White	white
➢ **Surface**	Smooth	Smooth	smooth	Smooth	Smooth	smooth
➢ **Sucker's Attachments**	arising from the base of the undergruond stem	arising from the base of the underground stem	Attached close to the stem of the mother plant on the upper surface of the rhizme	Attached close to the mother plant on the upper surface of the underground stem	arising as a horizontal outgrowth of the stem	Arising from lower surface of the underground stem and then curve

Plate 1.Egbeala root and rhizome

Plate 2.Unele Mmemme root and rhizome

Plate 3. Unele Obuo odaa root and rhizome

Plate 4.Unele Ocha root and rhizome

Plate 5.Unele Ojii root and rhizome

Plate 6. Akpukpoike root and rhizome

Plate 7. The Egbeala showing sucker's attachment

Plate 8.The Mmemme showing sucker’s attachment

Plate 9. The Obuo Odaa showing sucker's attachment

Plate 10.The Unele Ocha showing sucker's attachment

Plate 11.The Unele Ojii showing sucker's attachment

Plate12.The Akpukpoike showing sucker's attachment

4. 1.4 Leaves: The leaves of the six varieties of banana namely: Egbeala, Unele Mmemme, Obuo odaa, Unele Ocha , Unele Ojii and Akpukpoike are similar. The six varieties of *Musa sapientum* were found to be similar in general structure of the leaves consisting of a psendostem made of distichous arrangement of petioles of the leaves, large oblong simple leaves, color and bases of the leaves (plates 13-18).

Plate 13. Distichous leaf arrangement of Egbeala

Plate 14. Distichous leaf arrangement of Unele mmemme

Plate 15. Distichous leaf arrangement of unele Obuo odaa

Plate 16. Distichous leaf arrangement of Unele Ocha

Plate 17. Distichous leaf arrangement of Unele Ojii.

Plate 18a. Distichous leaf arrangement of Akpukpoike

Plate 18b. Distichous leaf arrangement of Akpukpoike

4. 1.5 Morphological Features of the petiole of six varieties of banana

Table 2 and plates 19-24, indicated the features of petioles of 6 *Musa sapientum* varieties under study. The petiole canals of Unele Ocha and Unele Ojii had overlapping margins, Unele Egbeala had open canal with margins spreading out, Unele Mmemme petiole canal had margins curved inside while the petiole canals of Akpukpoike and Obuo odaa varieties of *Musa sapientum* have wide range canals with erect margins. Petiole color was light green for Unele Ocha and Unele Ojii, almost lemon color for Unele Egbeala and Unele Akpukpoike, purplish green for Mmemme variety and green with brown blotches for Unele Obuo odaa. Dripping of sap upon cutting of petiole was few for Unele Ocha , few and sticky drips for Unele Ojii and Unele Mmemme, While Unele Egbeala and Unele Akpukpoike had no drips but sticky surface. Unele Obuo odaa had only 2-3 drips.

Table 2. Morphological Features of the petiole of six varieties of banana

Varieties	**Petiole canal of the third leaf**	**Color of petiole**	**Sap dripping upon cutting**
Unele Egbeala	Open with Margins spreading	Almost lemon	Little or no drips but sticky
Unele Mmemme	Margins curved inward	Purplish green	Few drips
Obuo odaa	Wide range With erect Margins	Green with brown blotch	2 or 3 drips
Unele Ocha	Margins overlapping	Light Green	Few drips
Unele Ojii	Margin overlapping	Light Green	Few drips and stickly
Akpukpo ike	Wide range With erect Margins	Almost lemon	No drips but sticky

Plate 19 indicated the features of petiole of *Musa sapientum* var ‘Unele Egbeala ’ variety under study. The petiole color was almost lemon color and the canal was open with margins spreading out .

Plate 19. Open with margins spreading of Egbeala petiole canal

Plate 20 indicated the features of petiole of *Musa sapientum* var 'Unele Mmemme' variety under study. The petiole color was Purplish green color and the canal groove-like with Margins curved inward.

Plate 20. groove-like petiole canal with Margins curved inward in Unele Mmemme

Plate 21 indicated the features of petiole of *Musa sapientum* var ‘Obuo odaa’ variety under study. The petiole color was Green with brown blotch color and the petiole canal Wide with erect Margins.

Plate 21. Wide range with erect Margins of Unele Obuo odaa petiole canal

Plate 22 indicated the features of petiole of *Musa sapientum* var ‘Unele Ocha ’ variety under study. The petiole color was Light Green color and the canal was Margins overlapping .

Plate 22. Closed petiole canal with overlapping margins in Unele Ocha

Plate 23 indicated The features of petiole of *Musa sapientum* var 'Unele Ojii' variety under study. The petiole color was Light green color and the canal closed with the Margins overlapping.

Plate 23. Margins overlapping of Unele Ojii petiole canal

Plate 24 indicated the features of petiole of *Musa sapientum* var 'Unele Akpukpoike' variety under study. The petiole color was almost lemon color and the canal was wide range with erect Margins.

Plate 24. Wide open canal with erect margins of Akpukpoike petiole

4. 1.6 Morphological features of the pseudostem of the six banana varieties

Observations of the morphological features of pseudostems of the six varieties of *Musa sapientum* under study are depicted in table 3 and plates 25-30. The colors of the pseudostems varied from green for Unele Ojii, light medium green for Unele Ocha and Egbeala , dark green for Obuo odaa, greenish brown for Akpukpoike to purple red for Unele Mmemme. The shape of the base of the pseudostem is round for five of the six *Musa x Sepientum* varieities and curved shape for Unele Ojii. Color blotches on the pseudostem was black for three varieties of Unele Ocha , Unele Ojii and Obuo odaa; no blotches were found on pseudostem of Akukpoike and Egbeala varieties, brown to rusty brown for Unele Mmemme. The appearance of the pseudostem was shiny for 3 varieties- Unele Ocha, Unele Mmemme and Egbeala and dull waxy for Unele Ojii, Akpukpoike and Obuo odaa. Sap color is watery clear for 3 varieties- Unele Ocha , Unele Ojii and Obuo odaa, and milk color for 3 Varieties of Akpukpoike, Unele Mmemme and Egbeala .

Table 3: Morphological features of the pseudostem of the six banana varieties

Varieties of banana	Color of pseudostem	Shape of the base of Pseudostem	Blotches color of pseudostem	Pseudostem appearance	Color of the sap
Egbeala	Medium green	Round none	None	Shiny (not waxy)	Milky
Unele Mmemme	purple –Red	Round	Brown / rusty brown	Shiny (not waxy)	Milky
Obuo odaa	Dark green	Round	Black	Dull (waxy)	Watery
Unele Ocha	Medium green	Round shape	Black	Shiny (not waxy	Watery
Unele Ojii	green	Curved shape	Black	Dull (waxy)	Watery.
Akpukpo ike	Greenish brown	Round	None	Dull (waxy)	Milky

Plate 25 indicated the appearance of the transverse section of Unele Egbeala pseudostem. The transverse section of the pseudostem of Unele Egbeala had a sticky surface and with no drop of sap on cutting the surface.

Plate 25. Transverse section of the Pseudostem of Egbeala cultivar

Plate 26 indicated the appearance of the transverse section of Unele Mmemme pseudostem. The transverse section of the pseudostem of Unele Mmemme had few drops of sap on cutting the surface.

Plate 26: Transverse section of the Pseudostem Unele Mmemme

Plate 27 indicated the appearance of the transverse section of Unele Obuo odaa pseudostem. The transverse section of the pseudostem of Unele Obuo odaa had 2 to 3 drops of sap on cutting the surface.

Plate 27: Transverse section of the Pseudostem of Obuo odaa cultivar

Plate 28 indicated the appearance of the transverse section of Unele Ocha pseudostem. The transverse section of the pseudostem of Unele Ocha had a sticky surface and few drops of sap on cutting the surface.

Plate 28: Transverse section of the Pseudostem of Unele Ocha

Plate 29 indicated the appearance of the transverse section of Unele Ojii pseudostem. The transverse section of the pseudostem of Unele Ojii had a sticky surface and few drops of sap on cutting the surface.

Plate 29: Transverse section of the Pseudostem Unele Ojii

Plate 30 indicated the appearance of the transverse section of Unele Akpukpoike pseudostem. The transverse section of the pseudostem of Unele Akpukpoike had a sticky surface and with no drop of sap on cutting the surface.

Plate 30: Transverse section of the Pseudostem Akpukpoike

4. 1.7 Result of the fruits morphology of the six banana varieties

Considerable variation was observed in the fruits of evaluated banana varieties. The fruit measured differently in the length of fingers, the width and the distance from one hand to another. There were similarities in the fingers and Endosperms of six *M. Sapientum* varieties studied (table 4).

Findings from the study of the fruits morphology of six varieties of banana indicated considerable variation as depicted in table 4, 5, 6 and 7. Number of hands in the bunches ranged from 5.4 ± 0.8 for Unele Ojii to 12.8 ± 1.6 for Obuo odaa. Number of fingers in the hand ranged from the lowest 13.8 ± 2.86 for Egbeala variety to the highest of 16 .6 ± 1.75 for Unele Mmemme. The numbers of faces of the fingers are four for Egbeala , Akpukpoike and Obuo odaa, 3 – 4 for Unele Ojii and Unele Ocha and 3 for Unele Mmemme.

From table 4, The length of fingers of the six banana varieties varied and that their lengths ranged from the lowest of 8.2 ± 0.8cm for Unele Ojii to the highest of 15.4 ± 0.9cm for Unele Ocha . The circumferences of the fingers of the six varieties of banana varied between the range of lowest value of 9.6 ± 0.78cm for Unele Akpukpoike variety to the highest value of 13.0 ± 0.6 for Obuo odaa variety. Distance from one hand to another also varied among the 6 varieties in the range of lowest value of 6.8 ± 0.44cm for Unele Ojii to the highest value of 10.4±0.36cm for Unele Akpukpoike variety.

Tables 4: The number of banana hands, banana fingers , banana faces, Length of finger, Circumference of finger and Distance from one hand to another of the fruit of six banana fruit.

Banana	No of hand	No of fingers	No of faces	Circumference of finger	Distance from one hand to another	Length of finger
Egbeala	10±2.76	13.8±2.86	4	11.4±0.9	10±0.69	11±0.51
Unele Mmemme	6.8±1.6	16.6±1.75	3	12.2±0.5	7.2±0.53	9.2±0.5
Obua odaa	12.8±1.6	14.8±1.6	4	13±0.6	7.2±1.86	11.2±0.5
Unele Ocha	7.2±1.17	14.6±1.96	3-4	10.6±0.78	8.4±0.9	15.4±0.9
Unele Ojii	5.4±0.8	14±1.55	3-4	11.2±0.5	6.8±0.44	8.2±0.5
Akpukpo Ike	12.4±2.06	14.4±2.06	4	9.6±0.78	10.4±0.36	10.8±1.28

mean ± S.E of the parameters

On the number of symmetrical lines on the surface of the fingers, the variation was not wide. The number was 4 for 3 varieties; Unele Mmemme, Unele Akpukpoike and Unele Obuo odaa. It was 3 to 5 for Unele Ocha and Unele Ojii and 3 to 4 for Unele Egbeala varieties. The shapes of the fingers of the six varieties of banana were all oblong. The colors of the fingers were yellow when ripe for all except the finger of Unele mmemme which was reddish brown when ripe. The surfaces of the fingers of all the six varieties were smooth.

The fruit bunches of the banana used for study and leaf

Plate 31. Unele Egbeala showing the fruit bunch

Plate 32. Unele mmemme banana plant showing the fruit bunch

Plate 33.Unele Obuo odaa plant showing the fruit bunch

Plate 34.Unele Ocha banana plant showing the fruit bunch

Plate 35.Unele Ojii plant showing the fruit bunch

Plate 36. Unele Akpukpoike plant showing the fruit bunch

Table 5: other features of the fingers of 6 banana varieties

Character	Cultivar					
	Egbeala	Unele mmemme	Obuo odaa	Unele Ocha	Unele Ojii	Akpukpoike
fruit						
Morphology						
➢ shape	Oblong	Oblong	Oblong	Oblong	Oblong	Oblong
➢ color	Yellow when ripe	Brown whenRipe	Yellow when ripe	Yellow when ripe	Yellow when ripe	Yellow when ripe
➢ surface	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth
➢ symmetrical lines of banana	3-4	4	4	3-5	3-5	4

4. 1.7 Physical features of the endosperm of the unripe banana fruit of six varieties of banana

The table 6 indicated the findings on the physical features of the endosperm of the unripe banana fruit of six varieties of banana understudy . From the Table 46 the findings were that the color of all the fruit endosperm was whitish except that of Unele Mmemme that was golden. All the endosperm of the unripe banana fruit tasted sour and had no phloem bundles. All the endosperms of the unripe six varieties of banana fruit were firm in consistency. Unele Ojii, Unele Mmemme and Akpukpoike were not gummy to touch while those of Unele Ocha, Unele Obuo odaa and Unele Egbeala were gummy to touch. All the endosperm of the six unripe varieties of banana fruit was coarse textured.

Table 6: Result of the physical features and texture of the endosperms of different unripe banana fruit samples (varieties).

VARIETIES	ENDOSPERM COLOR			TASTE		PHLOEM BUNDLES		STIFFINESS		STICKINESS		SMOOTHNESS	
	Whitish	Cream	Golden	Sweet	Sour	Present	Absent	Soft	firm	Not-Gummy	Gummy	Smooth	Coarse
Unele Ojii	+	-	-	-	+	-	+	-	+	+	-	-	+
Unele – Ocha	+	-	-	-	+	-	+	-	+	-	+	-	+
Unele obuo odaa	+	-	-	-	+	-	+	-	+	-	+	-	+
Unele - Mmemme	-	-	+	-	+	-	+	-	+	+	-	-	+
Egbeala	+	-	-	-	+	-	+	-	+	-	+	-	+
Akpukpo ike	+	-	-	-	+	-	+	-	+	+	-	-	+

KEY:- + represents Present
- represents Absent

4. 1.8 The texture and features of ripe banana varieties

Table 7 indicated the findings on the texture and features of ripe banana varieties.The color of ripe fruit endosperm of Unele Ocha and Unele Egbeala was whitish and for Unele Ojii and Unele Akpukpoike the color was cream. The endosperm of ripe fruit Unele Obuo odaa was whitish brown and that of Unele Mmemme was golden. All the endosperms of ripe banana fruit tasted sweet.

Phloem bundles were present in all the ripe endosperm specimens of the five varities of banana fruit except in that of Unele Mmemme. The endosperms of all the six banana varieties were soft in consistency. The surfaces of the ripe endosperm of the six varieties of banana fruit were all smooth.

Table 7:Result of the texture of different ripe banana fruit samples (varieties)
-

VARIETIES	ENDOSPERM COLOR				TASTE		PHLOEM BUNDLES		FIRMNESS		SMOOTHNESS	
	Whitish	**Cream**	**Golden**	**Whitish Brown**	**Sweet**	**Sour**	**Present**	**Absent**	**Soft**	**firm**	**Smooth**	**Coarse**
Egbeala	+	-	-	-	+	-	+	-	+	-	+	-
Unele Mmemme	-	-	+	-	+	-	-	+	+	-	+	-
Unele obuo odaa	-	-	-	+	+	-	+	-	+	-	+	-
Unele Ocha	+	-	-	-	+	-	+	-	+	-	+	-
Unele Ojii	-	+	-	-	+	-	+	-	+	-	+	-
akpukpo ike	-	+	-	-	+	-	+	-	+	-	+	-

KEY:- + represents Present
- represents Absent

4. 1.9 Floral and inflorescence characters of six banana varieties

Table 8 depicts the floral and inflorescence characteristics of the six banana varieties understudy. From the table it is evident that all the varieties possess white or cream colored male flower. The arrangements of the flowers were whorl – like clusters along the spike for all the six varieties. It is evident that the bracts of the flowers of the six banana varieties behaves in one or two ways as described .The bracts of Unele Mmemme, Unele Ojii, Obuo odaa and Egbeala bend backwards before facing off while those Unele Akpupoike and Unele Ocha raises without bending backwards before facing off.

Table 8: Floral and inflorescence characters of six banana varieties

Varieties	Pedicel	Neutral flowers	Ovule	Position of the bract	Shape of bract	Peak of the bract	color of the bract	Color of the male flower	Arrangement of the flower	Bend of the bract
Egbeala	Short	Not prominent and upto 6 layers	Two regular rows in the locule	Inferior	Egg-shape	Acute	Purple on the outside, deep-red inside	White or cream	Whorl-like cluster along the spike	The bract bends backwards and wraps round.
Unele Mmemme	Short	Prominent and upto 30layer	Two regular rows in the locule	Inferior	Egg – shape	Acute	Purple outside, red on the inside	White or cream	Whorl – like clusters, along the spike	The bract bends backwards and wraps round.
Obuo odaa	Short	Prominent and upto 30layer	Two regular rows in the locule	Inferior	Egg-shape	Acute	Purple on the outside, deep-red inside	Pink	Whorl-like cluster, along the spike	The bract bends backwards and wraps round.
Unele Ocha	Long	Not prominent and upto 6 layers	Four irregular rows in the locule	Inferior	Egg – shape	Obtuse	Purple on the outside, deep-red inside.	White or cream	Whorl-like clusters, along the spike	The bract raises without bending
Unele Ojii	Short	Not prominent and upto 6 layers	Two regular rows in the locule	Inferior	Egg – shape	Acute	Opaque purple on the outside, deep red inside	White or cream	Whorl-like clusters, along the spike	The bract bend backwards and wraps round
Unele Akpupoike	Long	Not prominent and upto 6 layers	Four irregular rows in the locule	Inferior	Egg – shape	Obtuse	Purple on the outside, deep – red in the inside	Pink	Whorl-like cluster, along the spike	The bract raises without bending

4. 1.10 The results and observations of the deformed fruits in six banana varieties.

Differences are evident from observations made on the morphology of the vestigial fruits arising from the neutral flower of the inflorescence of the six varieties of banana studied. The vestigial fruits in the two varieties Unele Mmemme and Obuo odaa were relatively prominent in size while they are not prominent in the remaining four varieties. The number of layers of the vestigial fruits on the rachis varied much among the six varieties of banana. The number of layers was least in Unele Ojii ranging from 1-2layers and was highest in Obuo odaa ranging from 5-16.

Table 9: The results and observations of the deformed fruits in seven banana varieties.

Varieties of banana	Color of the deformed fruits	Size of the deformed fruits	Deformed fruits
Unele Egbeala	Green	Not prominent	2-5 Five layers
Unele mmemme	Red color	Prominent	5-15 layers
Abuo odaa	Green	Prominent	5-16 layers
Unele Ocha	Light green	Not Prominent	3-5 layers
Unele Ojii	Green	Not prominent	1-3layers
Akpukpoike	Green	Not prominent	1-6 layers

Objective 2: Anatomical Features of Roots, rhizome and leaves

4.2 Anatomical Features of Roots of six Varieties of Banana

The root anatomy of the six varieties of *Musa sapientum* studied is presented in plates 37,38, 39, 40, 41 and 42. Roots of all six varieties have similar structure, which consisted of three tissue systems, epidermis, ground parenchyma and vascular cylinder.

4.2.1 Transverse section of the root of the *Musa sapientum* var 'Unele Egbeala '

Plate 37 indicated the findings in the transverse section of the root of the *Musa sapientum* var 'Unele Egbeala '. The root of the cultivar consisted of three tissue systems namely, epidermis, ground parenchyma, and vascular cylinder. The cortex comprised of five sided irregularly shaped cells with big air spaces (lacunae), a single layer of thick walled endodermis. A single layer of pericycle was also present. There were many big vascular cylinders and also many small vessels scattered at the center of the root. Phloem cells were found alternating with vessel cells in the peripheral side of the cylinder. Root parenchyma was composed of thick walled cells. Laticifer cells were scattered in the cortex and vascular cylinder zones.

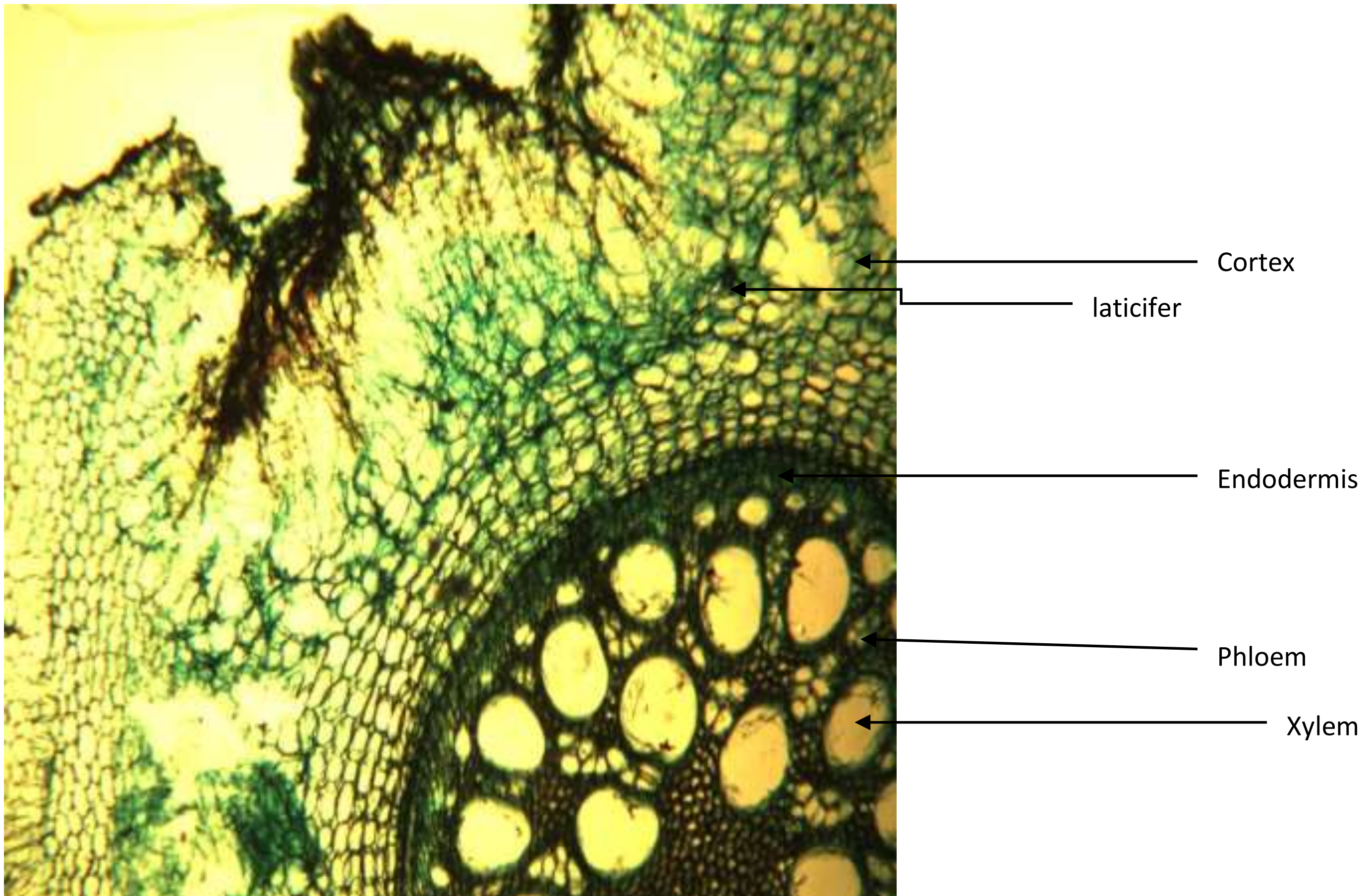

Plate 37.Transverse section of Unele Egbeala Root (x40)

4.2 .2 Transverse section of the root of the *Musa sapientum* var 'Unele Mmemme'

Plate 38 indicated the findings in the transverse section of the root of the *Musa sapientum* var 'Unele Mmemme'. The root of the cultivar consisted of three tissue systems namely, epidermis, ground parenchyma and vascular cylinder. The cortex comprised of five sided irregularly shaped cells with big air spaces (lacunae). A single layer of thick walled endodermis and pericycle were present. There were many big vascular cylinders and also many small vessels scattered at the centre of the root. Phloem cells were found alternating with vessel cells in the peripheral side of the cylinder. Root parenchyma was composed of thick walled cells. Laticifer cells were scattered in the cortex and vascular cylinder zones.

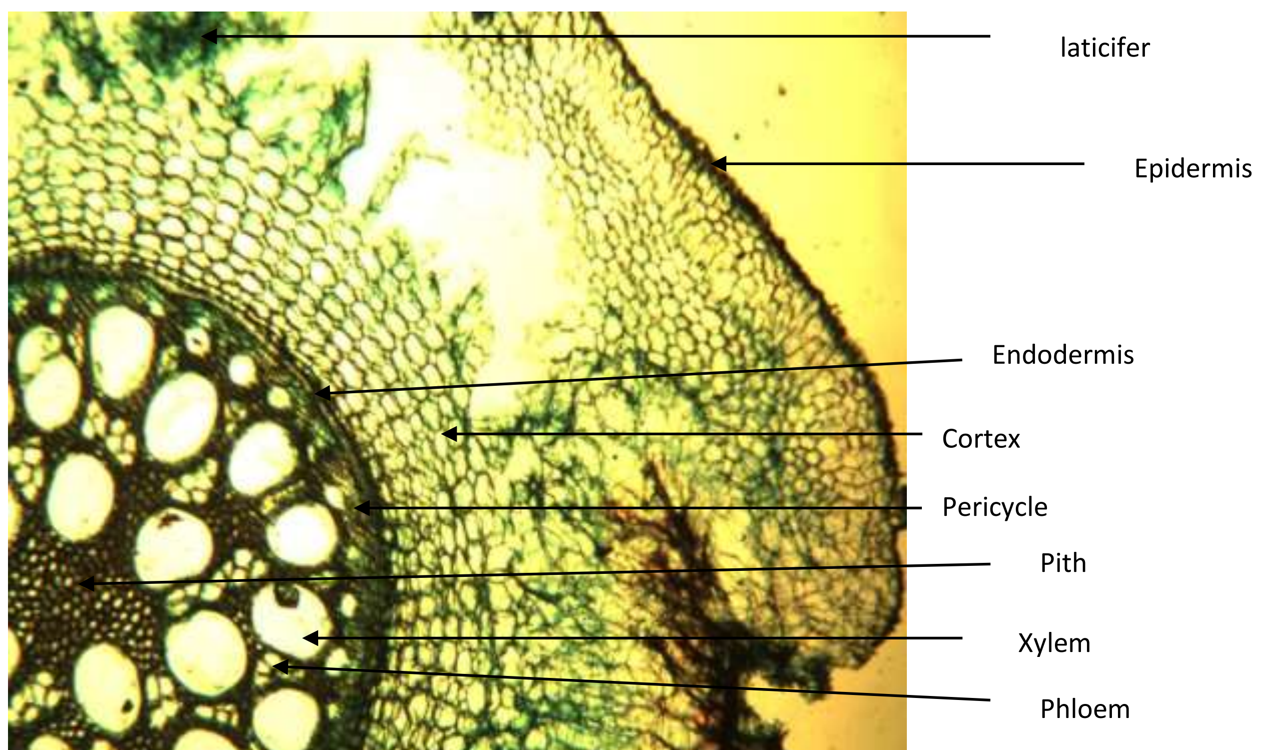

Plate38.Transverse section of Unele Mmemme root (x40)

4.2.3 Transverse section of the root of the *Musa sapientum* var 'Unele Obuo odaa'.

Plate 39 indicated the findings in the transverse section of the root of the *Musa sapientum* var 'Unele Obuo odaa'. The root of the cultivar consisted of three tissue systems namely, epidermis, ground parenchyma and vascular cylinder. The cortex comprised of five sided irregularly shaped cells with big air spaces (lacunae). A single layer of thick walled endodermis and pericycle were present. There were many big vascular cylinders and also many small vessels scattered at the centre of the root. Phloem cells were found alternating with vessel cells in the peripheral side of the cylinder. Root parenchyma was composed of thick walled cells. Laticifer cells were scattered in the cortex and vascular cylinder zones.

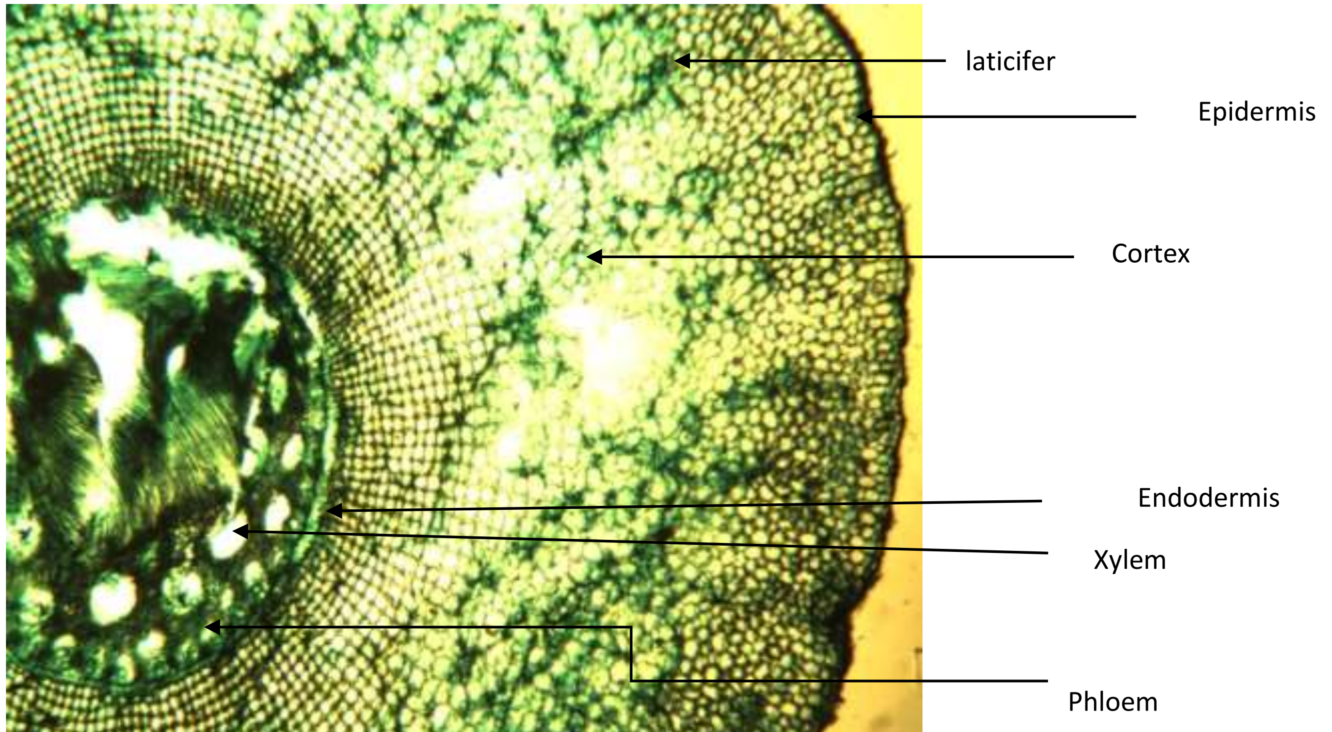

Plate 39.Transverse section of Unele Obuo odaa root (x40)

4.2 .4 Transverse section of the root of the *Musa sapientum* var 'Unele Ocha'

Plate 40 indicated the findings in the transverse section of the root of the *Musa sapientum* var 'Unele Ocha '. The root of the cultivar consisted of three tissue systems namely, epidermis, ground parenchyma and vascular cylinder. The cortex comprised of five sided irregularly shaped cells with big air spaces (lacunae). A single layer of thick walled endodermis and pericycle were present. There were many big vascular cylinder and also many small vessels scattered at the center of the root. Phloem cells were found alternating with vessel cells in the peripheral side of the cylinder . Root parenchyma was composed of thick walled cells. Laticifer cells were scattered in the cortex and vascular cylinder zones.

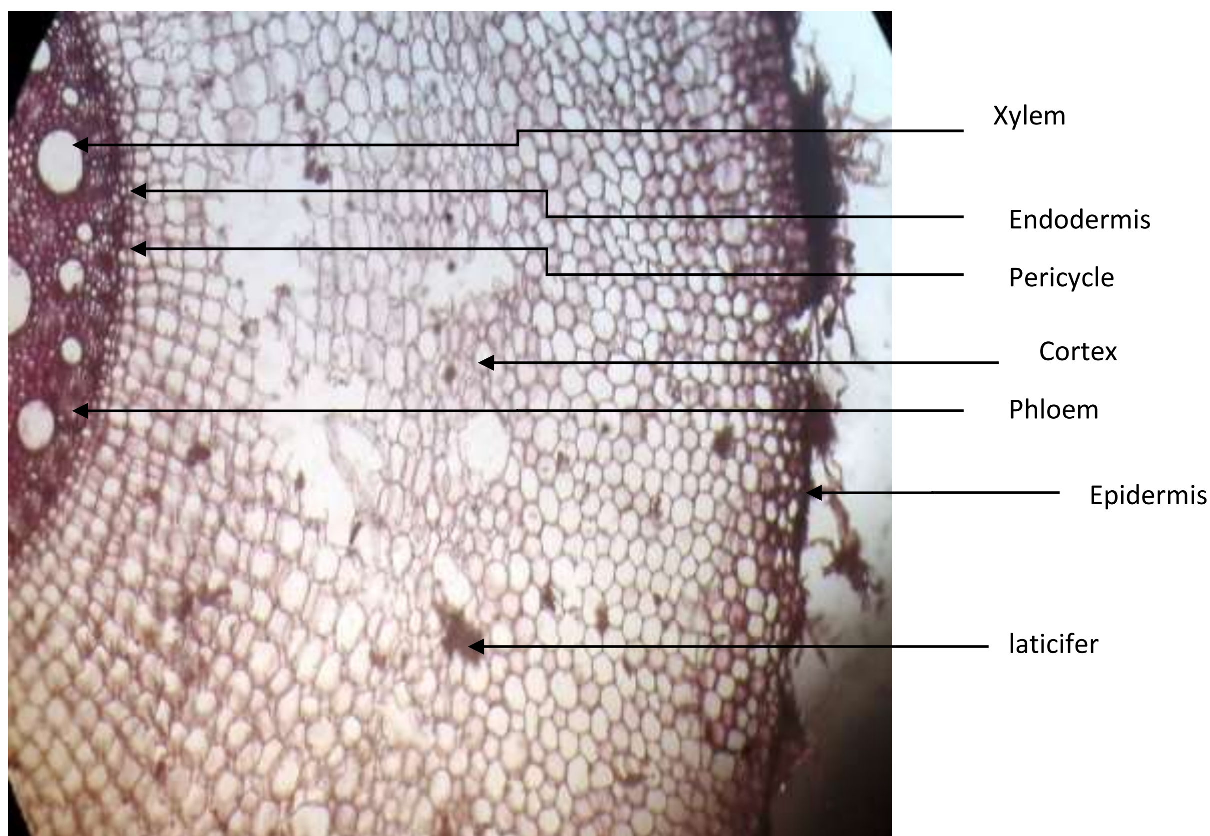

Plate 40.Transverse section of Unele Ocha root (x40)

4.2 .5 Transverse section of the root of the *Musa sapientum* var 'Unele Ojii'.

Plate 41 indicated the findings in the transverse section of the root of the *Musa sapientum* var 'Unele Ojii'. The root of the cultivar consisted of three tissue systems namely, epidermis, ground parenchyma and vascular cylinder. The cortex comprised of five sided irregularly shaped cells with big air spaces (lacunae). A single layer of thick walled endodermis and pericycle were present. There were many big vascular cylinder and also many small vessels scattered at the centre of the root. Phloem cells were found alternating with vessel cells in the peripheral side of the cylinder . Root parenchyma was composed of thick walled cells. Laticifer cells were scattered in the cortex and vascular cylinder zones.

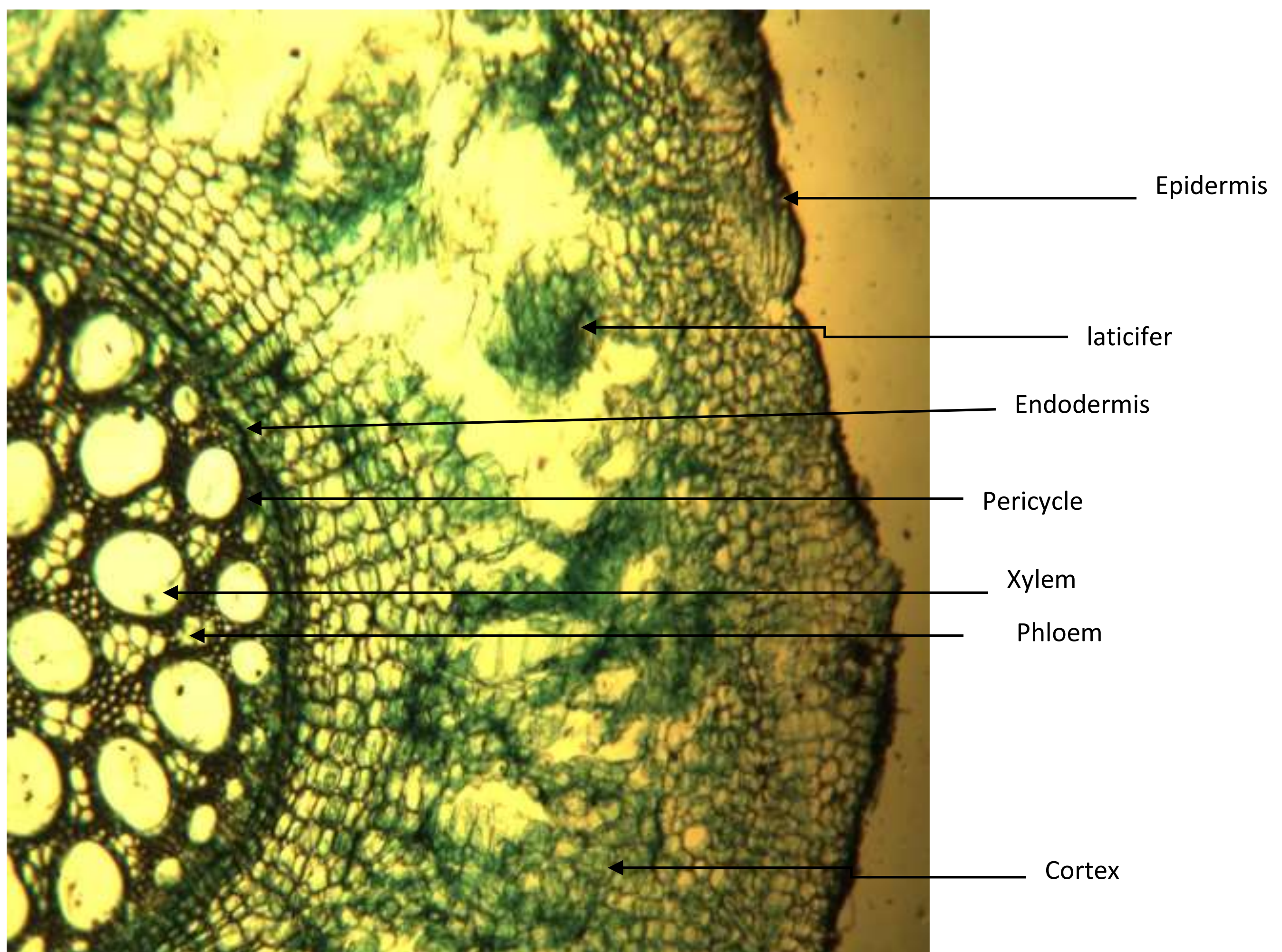

Plate 41.Transverse section of Unele Ojii root (x40)

4.2.6 Transverse section of the root of the *Musa sapientum* var 'Unele Akpukpoike'

Plate 42 indicated the findings in the transverse section of the root of the *Musa sapientum* var 'Unele Akpukpoike'. The root of the cultivar consisted of three tissue systems namely, epidermis, ground parenchyma , and vascular cylinder. The cortex comprised of five sided irregularly shaped cells with big air spaces (lacunae). A single layer of thick walled endodermis. A single layer of pericycle was also present. There was a primordial of adventitious root which originated from the cortex and transversing the cortex and stopping at the epidermis. There were many big vascular cylinders and also many small vessels scattered at the centre of the root. Phloem cells were found alternating with vessel cells in the peripheral side of the cylinder. Root parenchyma was composed of thick walled cells. Laticifer cells were scattered in the cortex and vascular cylinder zones.

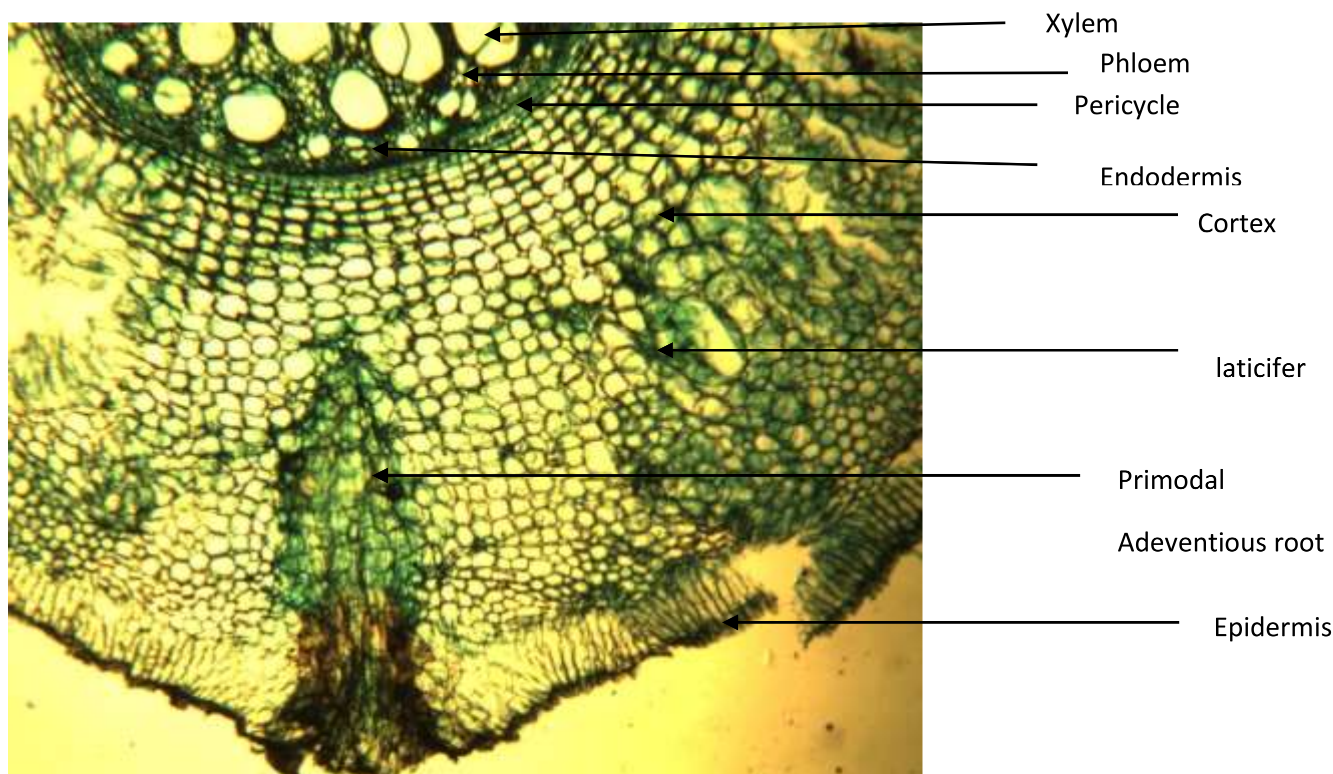

Plate 42.Transverse section of Unele Akpukpoike Root (x40).

Table 10: Comparative root anatomy characters of six varieties of Banana

	Varieties					
Character	Egbeala Root	Mmemme root	Odaa root	Ocha root	Ojii root	Akpukpoike Root.
Epidermis Number	Not well differentiated	Not well differentiated	Not well differentiated	Not well differentiated	Not well differentiated	Not well differentiated
• **Cartex Shape of parenchyma**	Five sides	Five sides	Five sides	Five sides	Five sides	Five sides
• **Airspace**	Present	Present	Present	Present	Present	Present
• **Pericycle**	I layer	I layer	I layer	I layer	I layer	I layer
Cylinder circular						
• **Xylem**	Thick wall,	Thick wall,	Thick wall,	Thick wall,	Thick wall,	Thick wall,
• **Phloem**	scattered	scattered	scattered	scattered	scattered	scattered
• **Stele**	Anomalous	Anomalous	Anomalous	Anomalous	Anomalous	Anomalous
Laticifer						
• **Distribution** • **Type**	Cortex and stele non anastormosis	Cortex and stele non anastormosis	Cortex and stele non anastormosis	Cortex and stele non anastormosis	Cortex and stele non anastormosis	Cortex and stele non anastormosis
Nature of the endodermis	Well thickened Cells deposited radially and tangentially	Moderately thickened Cells deposited radially and tangentially	Lightly thickened Cells deposited radially and tangentially	Lightly thickened Cells deposited radially and tangentially	Moderately thickened Cells deposited radially and tangentially	Lightly thickened Cells deposited radially and tangentially
Presence of primordial of adventitious root.	More circular and without primordial of adventitious root	More circular and without primordial of adventitious root	More circular and without primordial of adventitious root	More circular and without primordial of adventitious root	More circular and without primordial of adventitious root	Primordial of adventitious root which originated from the cortex and transversing the cortex and stopping at the epidermis
Size and number of vascular bundles	Big and many	Big and many	Big and many	Big and many	Big and many	Big and many
Size and number of vessels	Small and many	Small and many	Small and many	Small and many	Small and many	Small and many

4.3 Anatomical features of the rhizome of the six varieties of banana

4.3.1 Transverse Section of the Unele EgbealaRhizome

Plate 43 indicated the findings in the transverse section of the Unele Egbeala Rhizome. The rhizome consisted of epidermis, peripheral and central zones.The epidermis had a single layer of cells without intercellular spaces. The peripheral zone consisted of small irregularly shaped paenchymatous cells and scattered small vascular bundles. There was no partition between the peripheral and central zones. The peripheral zone was narrower than the central zone. The central zone consisted of big irregularly shaped parenchymatous cells and big scattered close-collateral vascular bundles (vascular bundle without cambium layer). The laticifers were present in the rhizome.

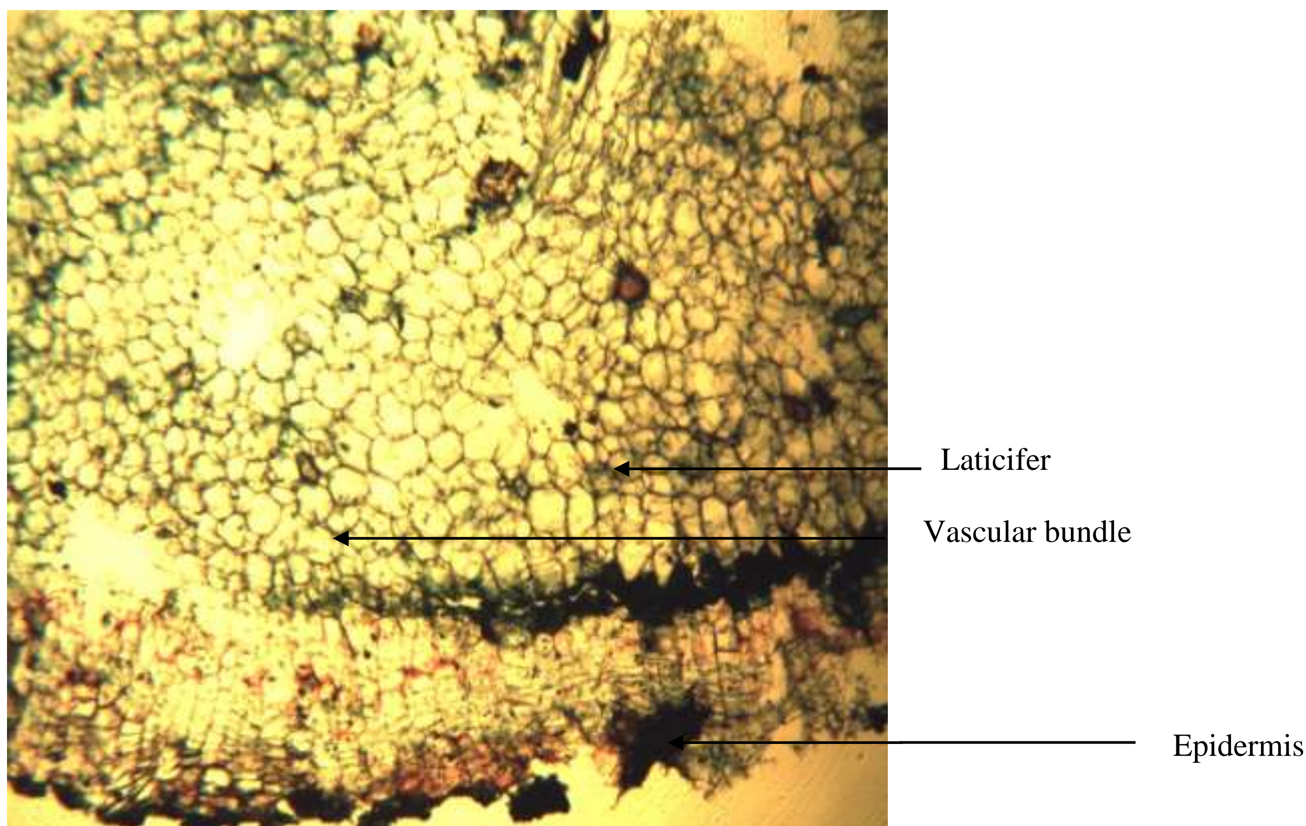

Plate 43.Transverse section of Stem Unele Egbeala (X40)

4.3.2 Transverse section of the Unele Mmemme Rhizome

Plate 44 indicated the findings in the transverse section of the Unele Mmemme Rhizome. The rhizome consisted of epidermis, peripheral and central zones.The epidermis had a single layer of cells without intercellular spaces. The peripheral zone consisted of small irregularly shaped paenchymatous cells and scattered small vascular bundles. There was no partition between the peripheral and central zones. The peripheral zone was narrower than the central zone. The central zone consisted of big irregularly shaped parenchymatous cells and big scattered close-collateral vascular bundles (vascular bundle without cambium layer). The laticifers were present in the rhizome.

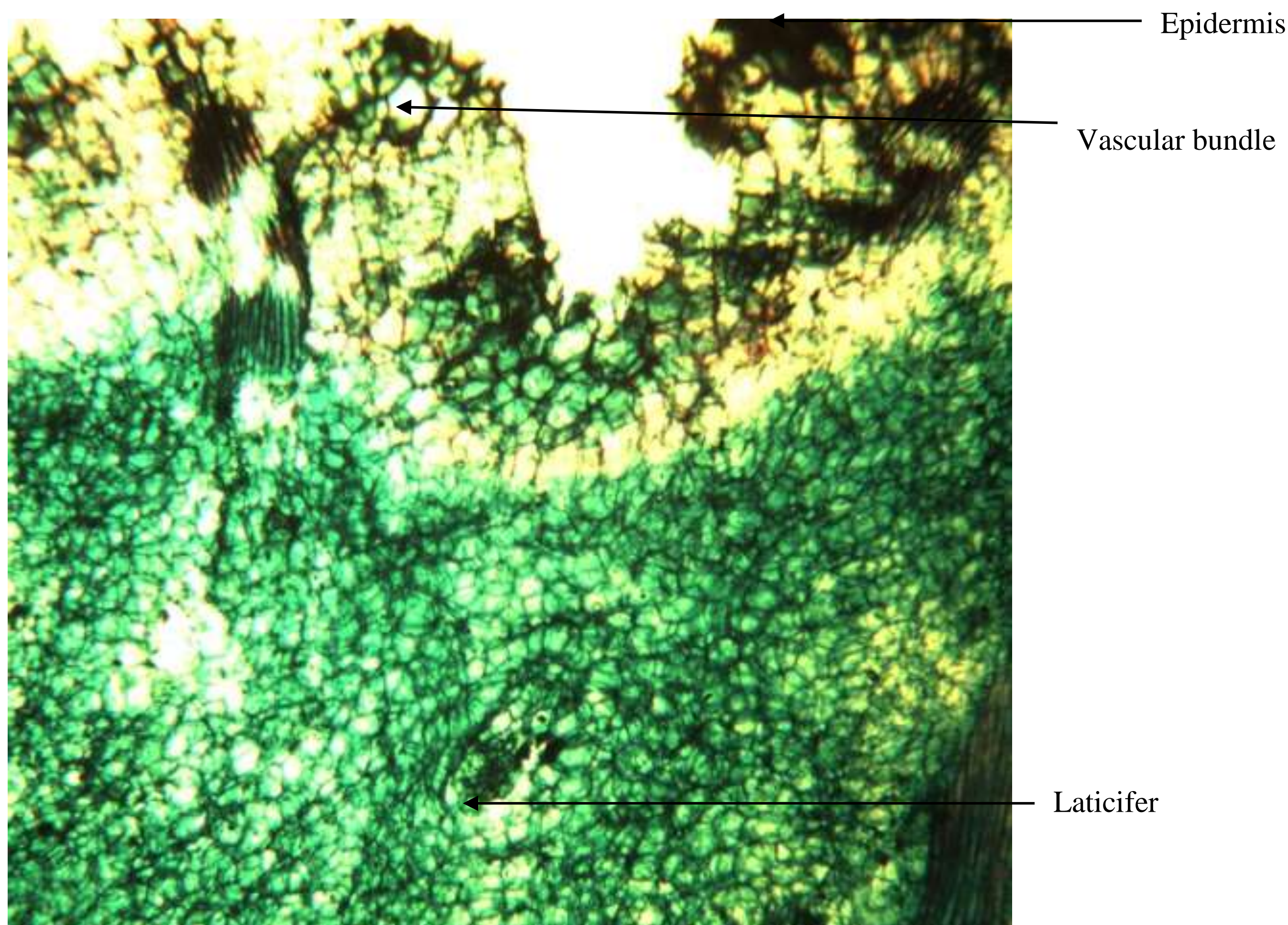

Plate 44.Transverse section of Unele Mmemme rhizome (X40)

4.3.3 Transverse section of the Unele Obuo odaa Rhizome

Plate 45 indicated the findings in the transverse section of the Unele Obuo odaa Rhizome. The rhizome consisted of epidermis, peripheral and central zones.The epidermis had a single layer of cells without intercellular spaces. The peripheral zone consisted of small irregularly shaped paenchymatous cells and scattered small vascular bundles. There was no partition between the peripheral and central zones. The peripheral zone was narrower than the central zone. The central zone consisted of big irregularly shaped parenchymatous cells and big scattered close-collateral vascular bundles (vascular bundle without cambium layer). The laticifers were present in the rhizome.

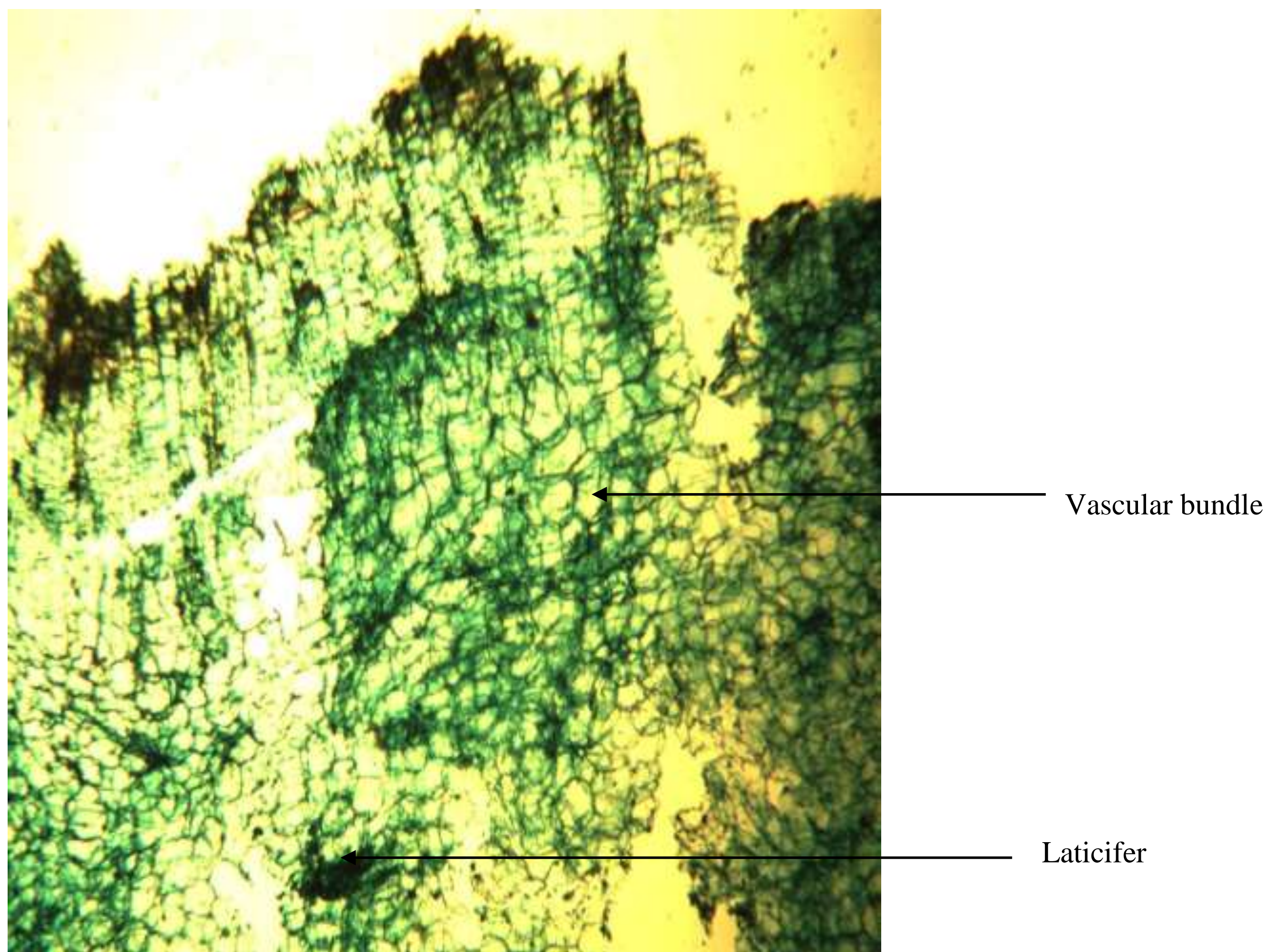

Plate 45.Transverse section of Unele Obuo odaa rhizome (X40)

4.3.4 Transverse section of the Unele Ocha rhizome

Plate 46 indicated the findings in the transverse section of the Unele Ocha rhizome. The rhizome consisted of epidermis, peripheral and central zones.The epidermis had a single layer of cells without intercellular spaces. The peripheral zone consisted of small irregularly shaped paenchymatous cells and scattered small vascular bundles. There was no partition between the peripheral and central zones. The peripheral zone was narrower than the central zone. The central zone consisted of big irregularly shaped parenchymatous cells and big scattered close-collateral vascular bundles (vascular bundle without cambium layer). The laticifers were present in the rhizome.

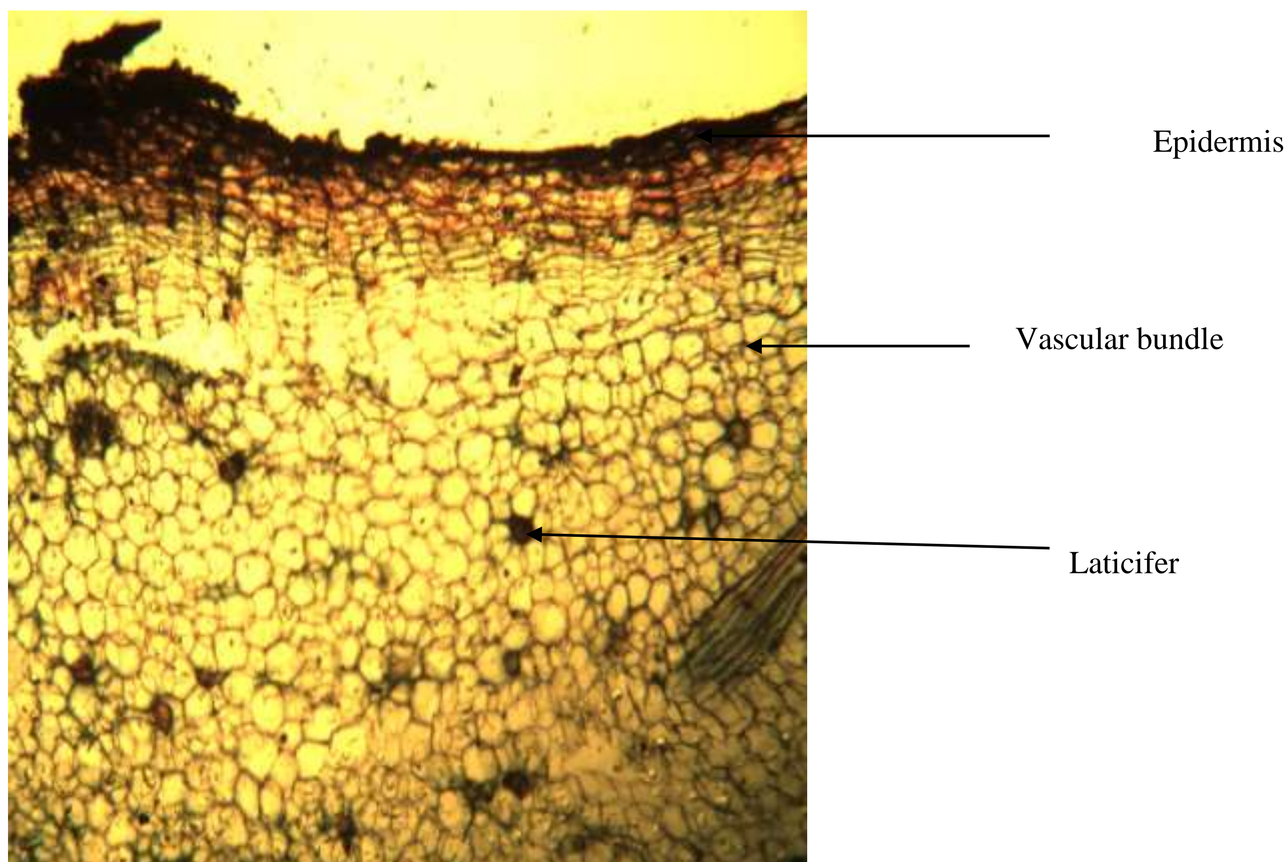

Plate 46.Transverse section of Unele Ocha Rhizome (X40)

4.3.5 Transverse section of the Unele Ojii Rhizome

Plate 47 indicated the findings in the transverse section of the Unele Ojii cultivar Rhizome. The rhizome consisted of epidermis, peripheral and central zones.The epidermis had a single layer of cells without intercellular spaces. The peripheral zone consisted of small irregularly shaped paenchymatous cells and scattered small vascular bundles. There was no partition between the peripheral and central zones. The peripheral zone was narrower than the central zone. The central zone consisted of big irregularly shaped parenchymatous cells and big scattered close-collateral vascular bundles (vascular bundle without cambium layer). The laticifers were present in the rhizome.

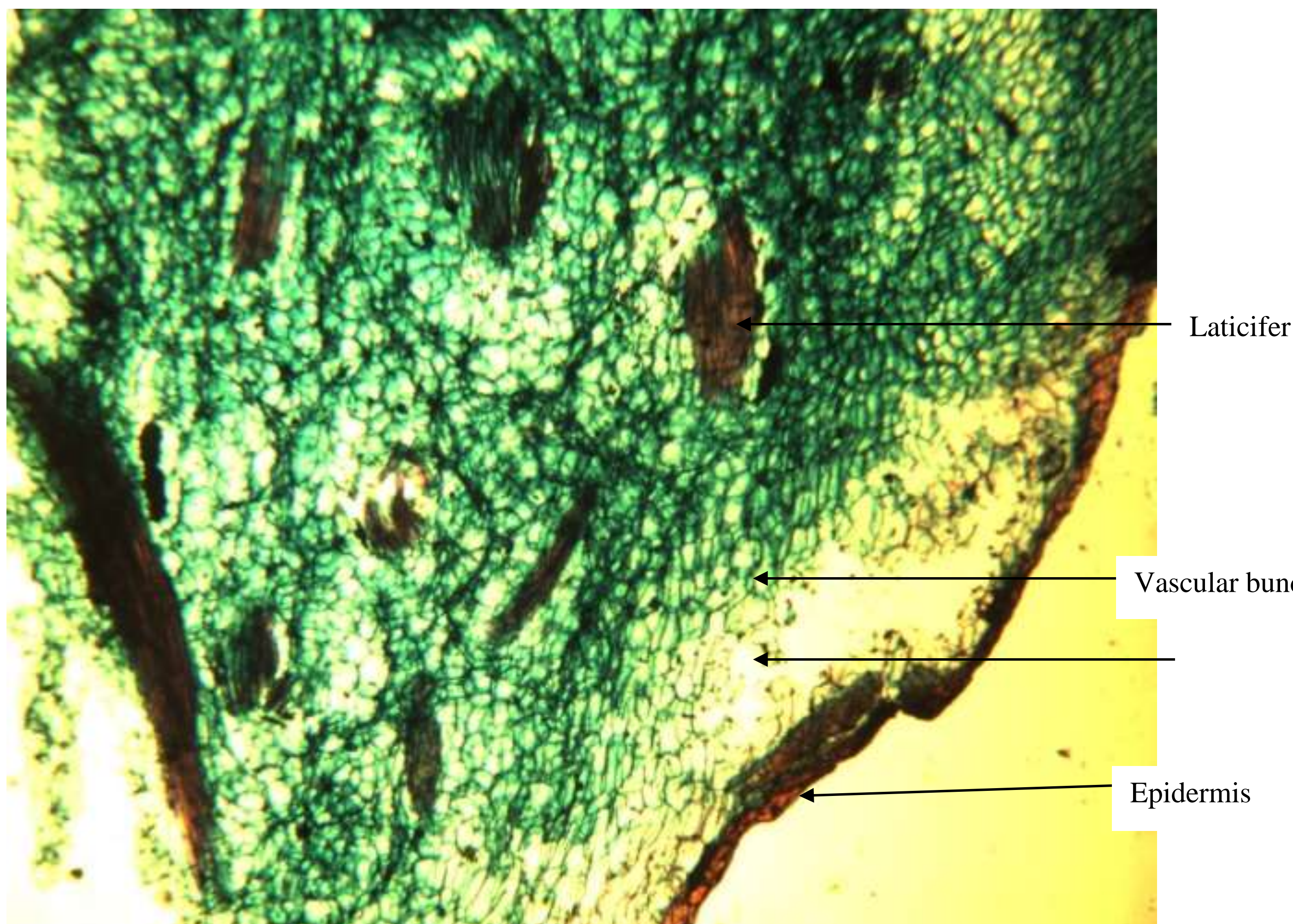

Plate 47.Transverse section of Unele Ojii rhizome (X40)

4.3.6 Transverse section of the Unele Akpukpoike Rhizome

Plate 48 indicated the findings in the transverse section of the Unele Akpukpoike Rhizome. The rhizome consisted of epidermis, peripheral and central zones.The epidermis had a single layer of cells without intercellular spaces. The peripheral zone consisted of small irregularly shaped paenchymatous cells and scattered small vascular bundles. There was no partition between the peripheral and central zones. The peripheral zone was narrower than the central zone. The central zone consisted of big irregularly shaped parenchymatous cells and big scattered close-collateral vascular bundles (vascular bundle without cambium layer). The laticifers were present in the rhizome.

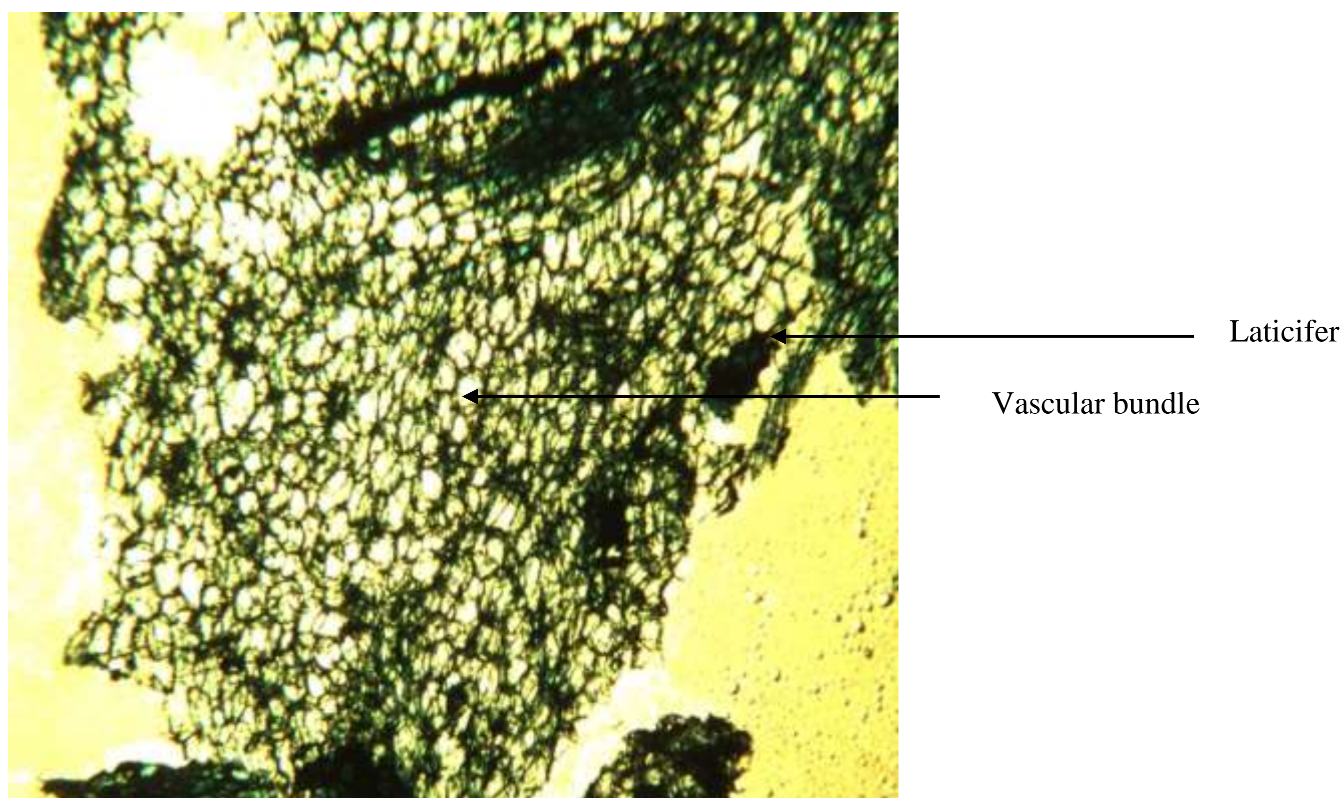

Plate 48.Transverse section of Unele Akpukpoike (X40)

Table 11: Anatomical characters of rhizome of six varieties of banana

	Varieties					
Character	Egbeala	Mmemme	Odaa	Ocha	Ojii	Akpukpoike
Epidermis						
• Number	I layer	I layer	I layer	I layer	I layer	I layer
• Shape	Four sides	Four sides	Four sides	Four sides	Four sides	Four sides
Periphery zone parenchyma shape	Irregular	Irregular	Irregular	Irregular	Irregular	Irregular
Central zone						
• Xylem	I, trachea	I, trachea	I, trachea	I, trachea	I, trachea	I, trachea
• Phloem	One side of xylem	One side of xylem	One side of xylem	One side of xylem	One side of xylem	One side of xylem
• vascular bundle type	Close collateral	Close collateral	Close collateral	Close collateral	Close collateral	Close collateral
• stele	Atactostele	Atactostele	Atactostele	Atactostele	Atactostele	Atactostele
• pith	No pith	No pith	No pith	No pith	No pith	No pith
• vascular tissues	Small and big vascular	Small and big vascular	Small and big vascular	Small and big vascular	Small and big vascular	Small and big vascular
Presence of hypodermis	Hypodermis present	Hypodermis present	Hypodermis present	Hypodermis present	Hypodermis present	Hypodermis present
Shape of epidermis cells	Pentagonal	Pentagonal	Pentagonal	Pentagonal	Pentagonal	Pentagonal
Size of airspace	Big sir space	Big sir space	Big sir space	Big sir space	Big sir space	Big sir space

4.4 Petiole Anatomy of the six banana varieties

4.4 .1 Transverse section of the petiole of Unele Egbeala cultivar

Plate 49 indicated the findings in the transverse section of the petiole of Unele Egbeala cultivar. It showed three tissue systems that included epidermis layer, ground tissue system (parenchyma tissue) and vascular system. The epidermis layer was composed of a single layer of compact rectangular cells and big air spaces in the middle part of the petiole. The vascular bundles consisted of two groups. The first group was consisted of small vascular bundles located beneath the epidermis and the second group consisted of

big vascular bundles were distributed in the inner side of the petiole. The type of vascular bundle were close-collateral and it consisted of xylem and phloem elements and both were surrounded by thick wall. The position of xylem in petiole was in the upper side while the phloem was in the lower side.

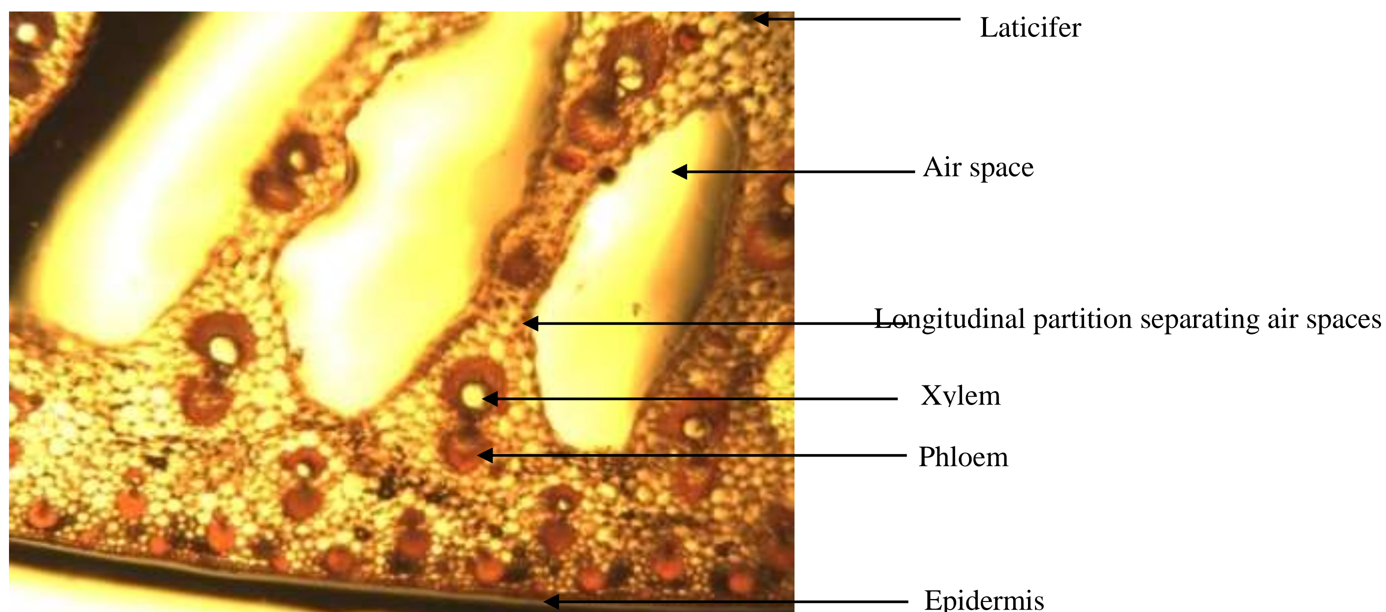

Plate 49.Transverse section of Leaf petiole of Unele Egbeala (X40)

4.4 .2 Transverse section of the petiole anatomy of Unele Egbeala cultivar

Plate 50 indicated that the findings in the transverse section of the petiole anatomy of Egbeala cultivar was composed of three tissue systems that included epidermis layer, ground tissue system (parenchyma tissue) and vascular system. The epidermis layer was composed of a single layer of compact rectangular cells and big air spaces in middle part of the petiole. The vascular bundles consisted of two groups. The first group consisted of small vascular bundles located beneath the epidermis and the big ones were distributed in the inner side of the petiole. The type of vascular bundle were close-collateral and it consisted of xylem and phloem elements and both were surrounded by thick wall. The position of xylem in petiole was in the upper side while the phloem was in the lower side.

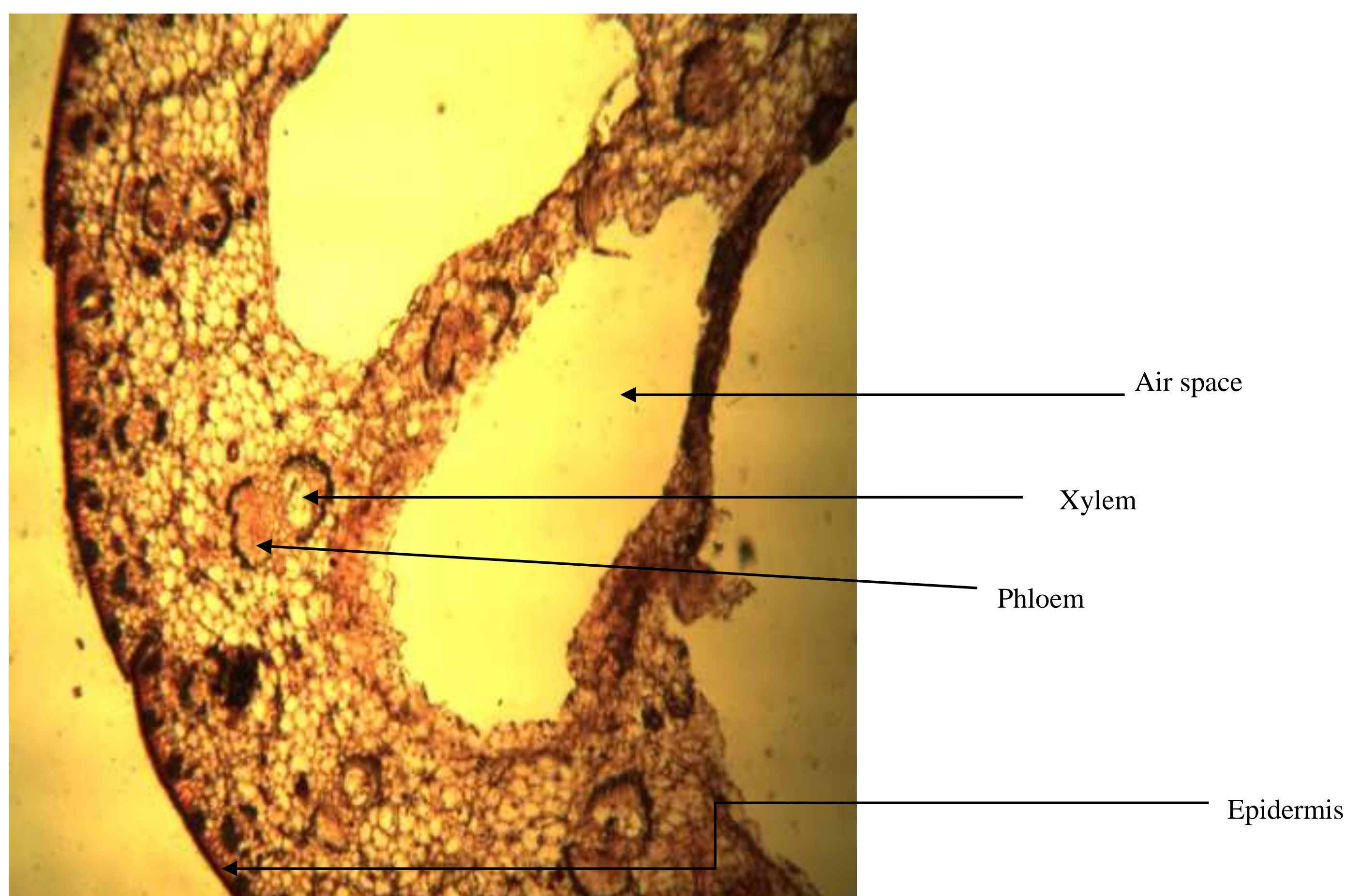

Plate 50.Transverse section of Egbeala petiole (X40)

4.4 .3 Transverse section of the petiole anatomy of Unele Mmemme cultivar

Plate 51 indicated that the findings in the transverse section of the petiole anatomy of Unele Mmemme cultivar was composed of three tissue systems that included epidermis layer, ground tissue system (parenchyma tissue) and vascular system. The epidermis layer was composed of a single layer of compact rectangular cells and big air spaces in middle part of the petiole. The vascular bundles consisted of two groups. The first group consisted of small vascular bundles located beneath the epidermis and the big ones were distributed in the inner side of the petiole. The type of vascular bundle were close-collateral and it consisted of xylem and phloem elements and both were surrounded by thick wall. The position of xylem in petiole was in the upper side while the phloem was in the lower side.

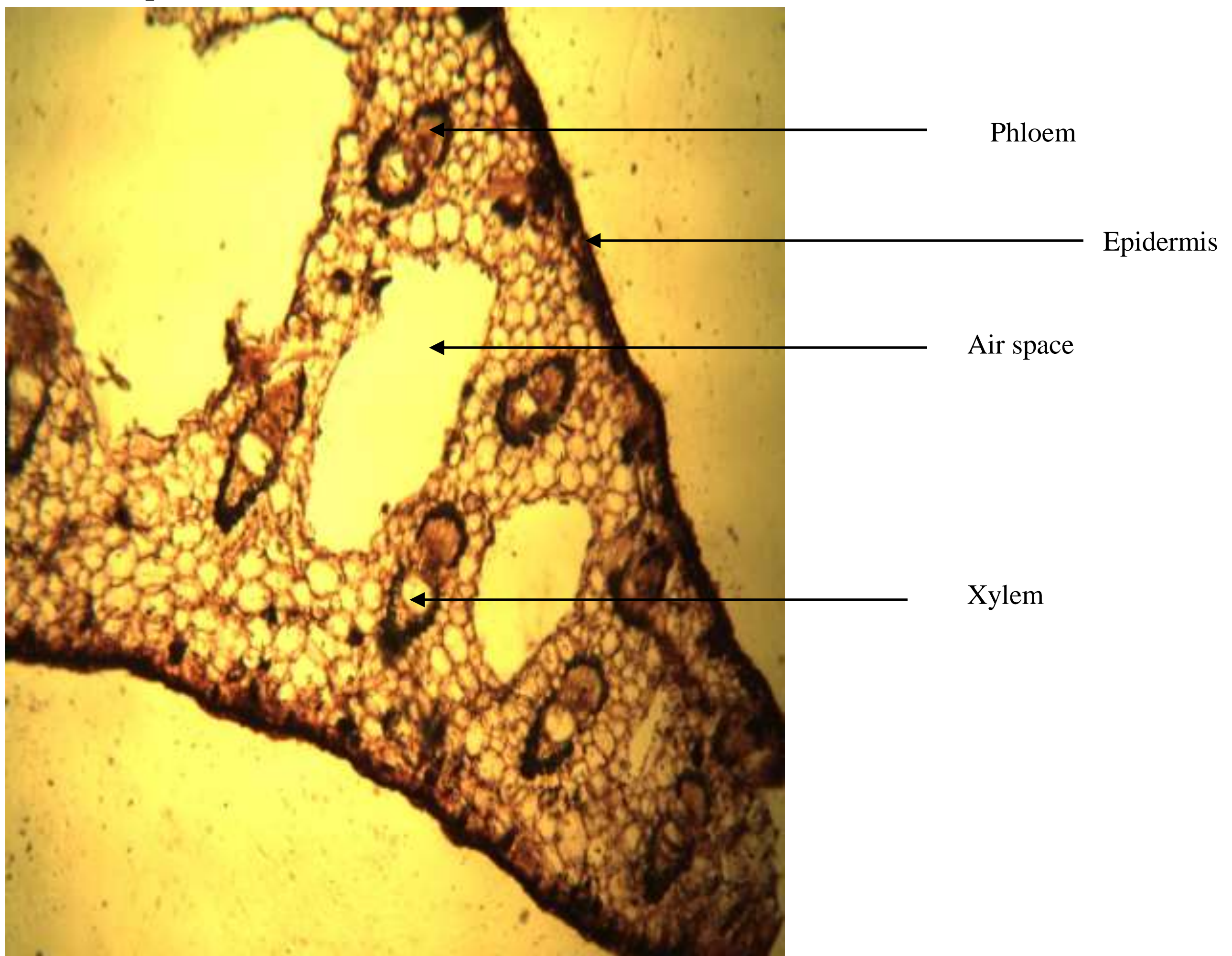

Plate 51.Transverse section of Mmemme petiole (X40)

4.4.4Transverse section of the petiole anatomy of Unele Obuo odaa cultivar

Plate 52 indicated that the findings in the transverse section of the petiole anatomy of Unele Obuo odaa cultivar was composed of three tissue systems that included epidermis layer, ground tissue system (parenchyma tissue) and vascular system. The epidermis layer was composed of a single layer of compact rectangular cells and big air spaces in middle part of the petiole. The vascular bundles consisted of two groups. The first group consisted of small vascular bundles located beneath the epidermis and the big ones were distributed in the inner side of the petiole. The type of vascular bundle were close-collateral and it consisted of xylem and phloem elements and both were surrounded by thick wall. The position of xylem in petiole was in the upper side while the phloem was in the lower side.

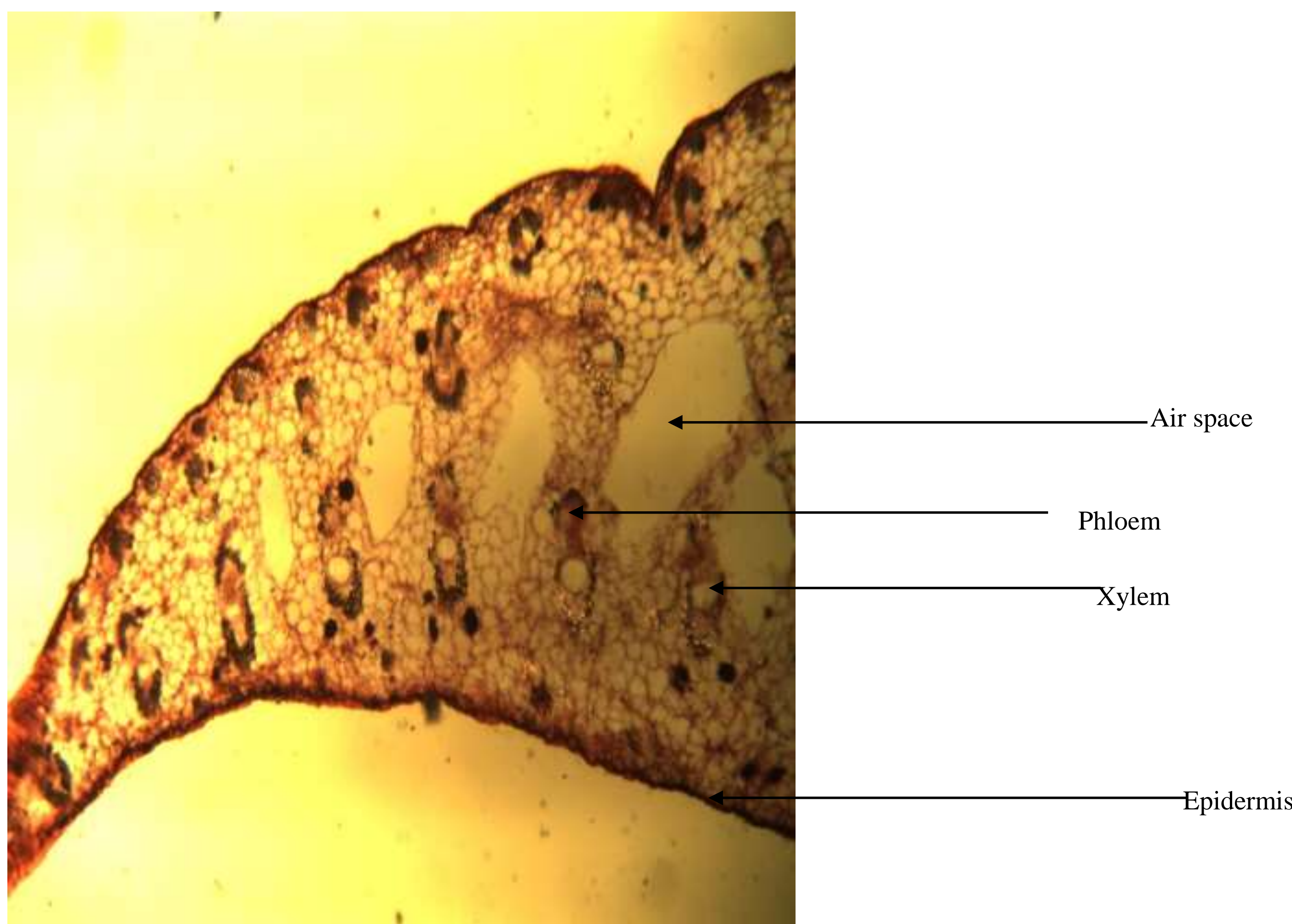

Plate 52.Transverse section of Unele Obuo odaa petiole (X40)

4.4 .5 Transverse section of the petiole anatomy of Unele Ocha cultivar

Plate 53 indicated that the findings in the transverse section of the petiole anatomy of Unele Ocha cultivar was composed of three tissue systems that included epidermis layer, ground tissue system (parenchyma tissue) and vascular system. The epidermis layer was composed of a single layer of compact rectangular cells and big air spaces in middle part of the petiole. The vascular bundles consisted of two groups. The first group consisted of small vascular bundles located beneath the epidermis and the big ones were distributed in the inner side of the petiole. The type of vascular bundle were close-collateral and it consisted of xylem and phloem elements and both were surrounded by thick wall. The position of xylem in petiole was in the upper side while the phloem was in the lower side.

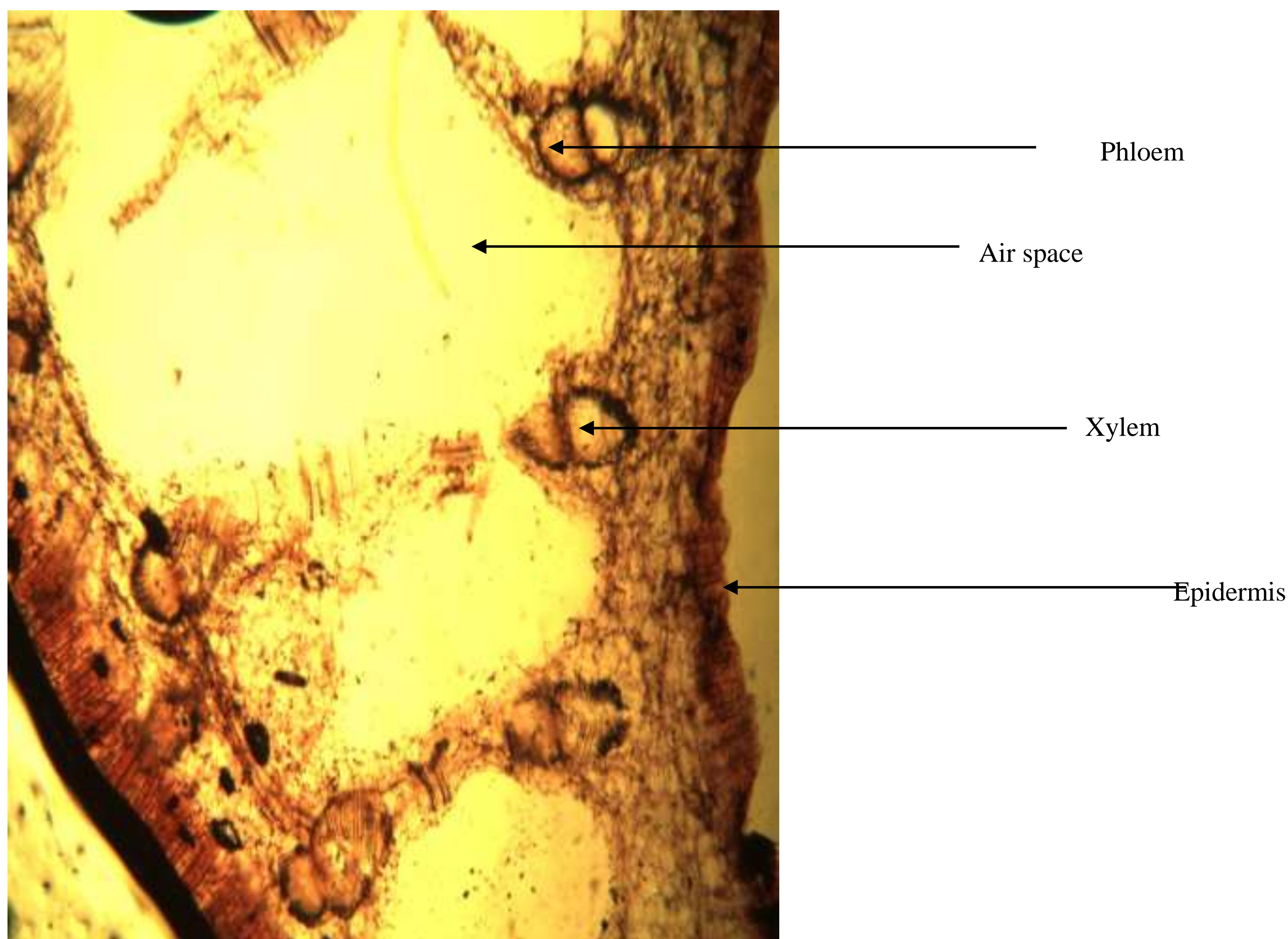

Plate53.Transverse section of Unele Ocha petiole (X40)

4.4 .6 Transverse section of the petiole anatomy of Unele Ojii cultivar

Plate 54 indicated that the findings in the transverse section of the petiole anatomy of Unele Ojii cultivar was composed of three tissue systems that included epidermis layer, ground tissue system (parenchyma tissue) and vascular system. The epidermis layer was composed of a single layer of compact rectangular cells and big air spaces in middle part of the petiole. The vascular bundles consisted of two groups. The first group consisted of small vascular bundles located beneath the epidermis and the big ones were distributed in the inner side of the petiole. The type of vascular bundle were close-collateral and it consisted of xylem and phloem elements and both were surrounded by thick wall. The position of xylem in petiole was in the upper side while the phloem was in the lower side.

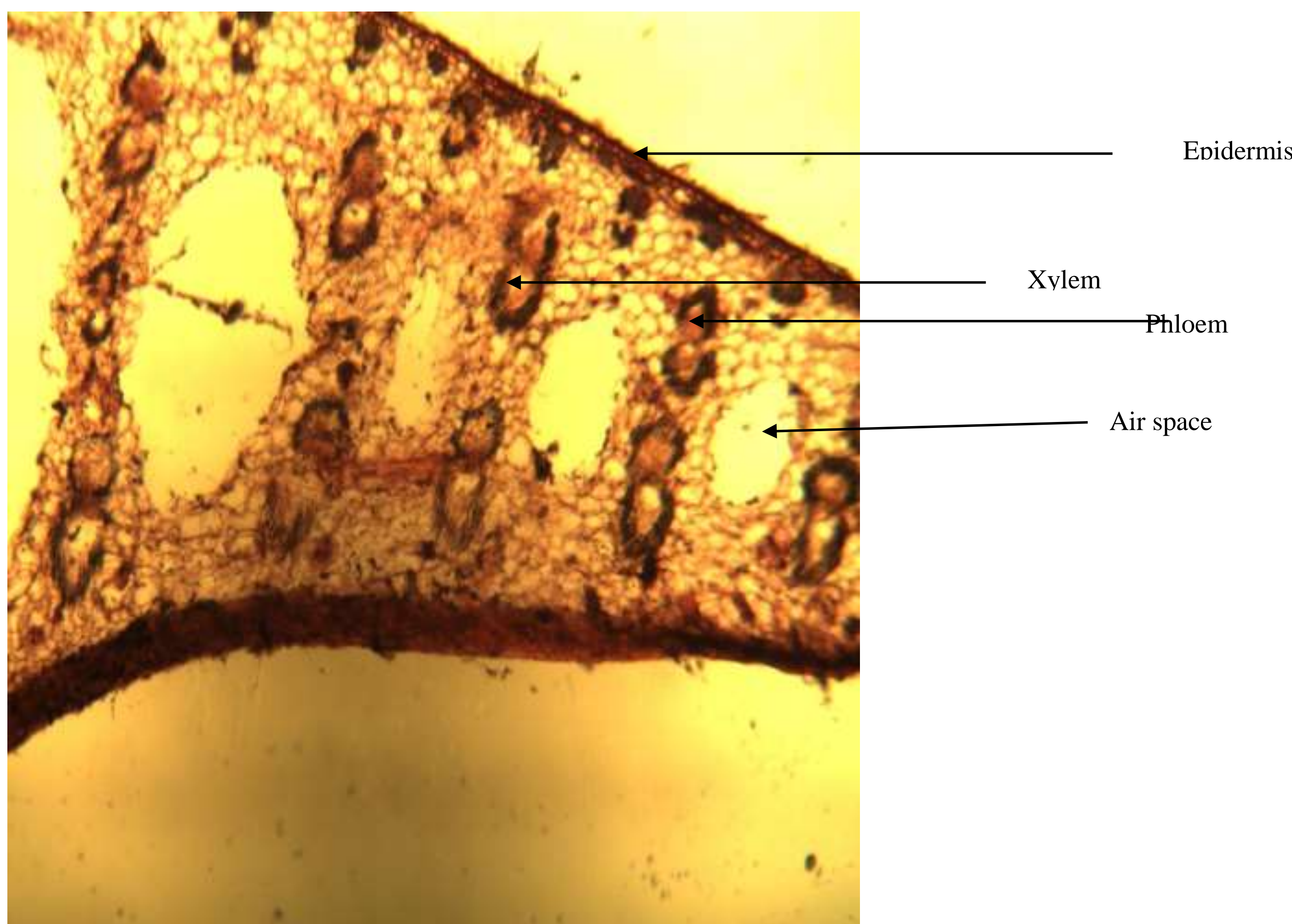

Plate54.Transverse section of Unele Ojii petiole (X40)

4.4.7 Transverse section of the petiole anatomy of Unele Akpukpoike cultivar

Plate 55 indicated that the findings in the transverse section of the petiole anatomy of Unele Akpukpoike cultivar was composed of three tissue systems that included epidermis layer, ground tissue system (parenchyma tissue) and vascular system. The epidermis layer was composed of a single layer of compact rectangular cells and big air spaces in middle part of the petiole. The vascular bundles consisted of two groups. The first group consisted of small vascular bundles located beneath the epidermis and the big ones were distributed in the inner side of the petiole. The type of vascular bundle were close-collateral and it consisted of xylem and phloem elements and both were surrounded by thick wall. The position of xylem in petiole was in the upper side while the phloem was in the lower side.

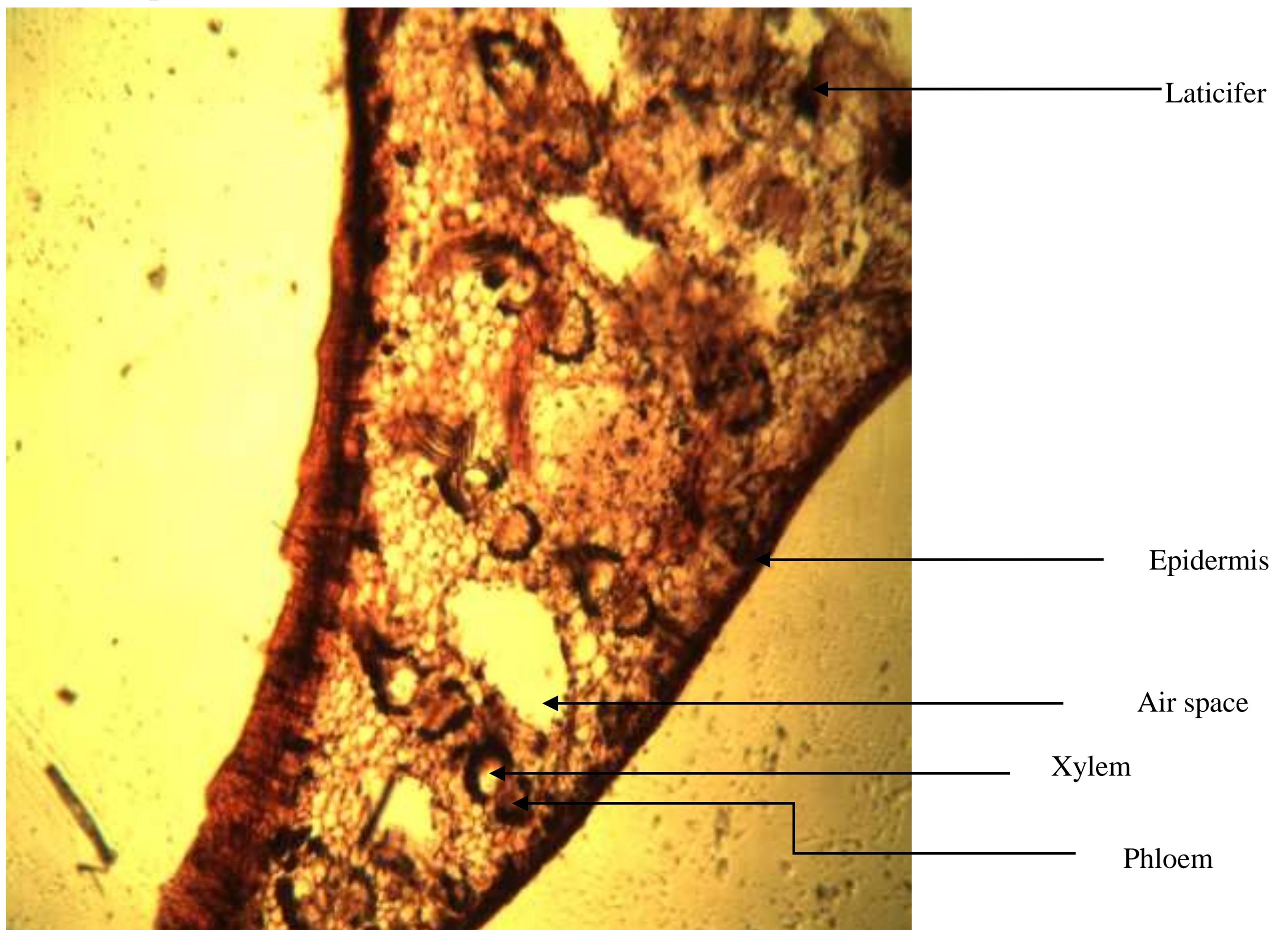

Plate 55.Transverse section of Unele Akpukpoike petiole (X40)

Table 12: Petiole Anatomy of the six Banana varieties

	Varieties					
Characters	**Egbeala petiole**	**Mmemme petiole**	**Obuo odaa petiole**	**Ocha petiole**	**Ojii petiole**	**Akpukpoike petiole**
Petiole shape	Circular	Circular	Circular	Circular	Circular	Circular
Cuticle structure	Thick and straight to undulating wall	Thick and straight to undulating wall	Thick and straight to undulating wall	Thick and straight to undulating wall	Thick and straight to undulating wall	Thick and straight to undulating wall
Epidermal cell	Uniseriate	Uniseriate	Uniseriate	Uniseriate	Uniseriate	Uniseriate
Epidermal cell shape	Rectangular to oval	Rectangular to oval	Rectangular to oval	Rectangular to oval	Rectangular to oval	Rectangular to oval
Number of vascular bundle	One	One	One (bi-lobed)	One (bi-lobed)	One	One
Vascular bundle shape	U- shaped	U- shaped	U- shaped	U- shaped	U- shaped	U- shaped
Number of vascular crescent	1	1	1	1	1	1
Nature of vascular bundle	close-Collateral	close-Collateral	close-Collateral	close-Collateral	close-Collateral	close-Collateral
Trichome	Present	Present	Present	Present	Present	Present

4.5 Anatomical features of the leaves of the six varieties of banana

4.5 .1 Transverse section of the Blade (lamina) of Unele Egbeala leaf

Plate 56 indicated the findings in the transverse section of the Blade (lamina) of Unele Egbeala leaf. The blade consisted of epidermis layer, vascular bundles and parenchyma cells. The shape of the epidermis cells was rectangular. Hypodermal layer was found beneath the upper epidermal layer, the adaxial epidermis of this specie was composed of two layers of cells, while the abaxial one was a single layer. The adaxial epidermis of the Unele Egbeala leaf was covered with cuticle. Mesophyll tissue was located between upper (adaxial) and lower (abaxial) epidermis and had big airspaces. The vascular bundles were composed of xylem and phloem and surrounded by the parenchymatic or sclerenchymatic cells, which were called bundle sheaths. Laticifers were scattered between mesophyll cells.

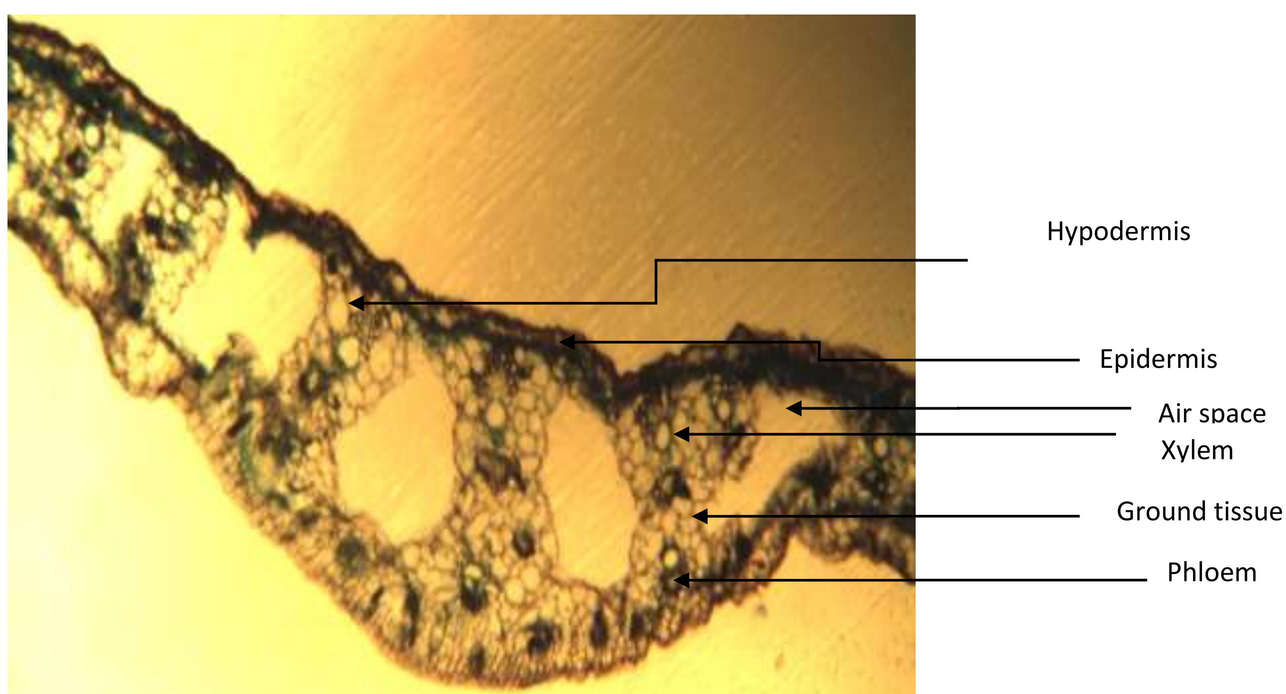

Plate 56.Transverse section of Unele Egbeala leaf (x40)

4.5 .2 Transverse section of the Blade (lamina) of Unele Mmemme leaf

Plate 57 indicated the findings in the transverse section of the Blade (lamina) of Mmemme leaf. The blade consisted of epidermis layer, vascular bundles and parenchyma cells. The shape of the epidermis cells was rectangular. Hypodermal layer was found beneath the upper epidermal layer, the adaxial epidermis of this specie was composed of two layers of cells, while the abaxial one was a single layer. The adaxial epidermis of the Mmemme leaf was covered with cuticle. Mesophyll tissue was located between upper (adaxial) and lower (abaxial) epidermis and had big airspaces. The vascular bundles were composed of xylem and phloem and surrounded by the parenchymatic or sclerenchymatic cells, which were called bundle sheaths. Laticifers were scattered between mesophyll cells.

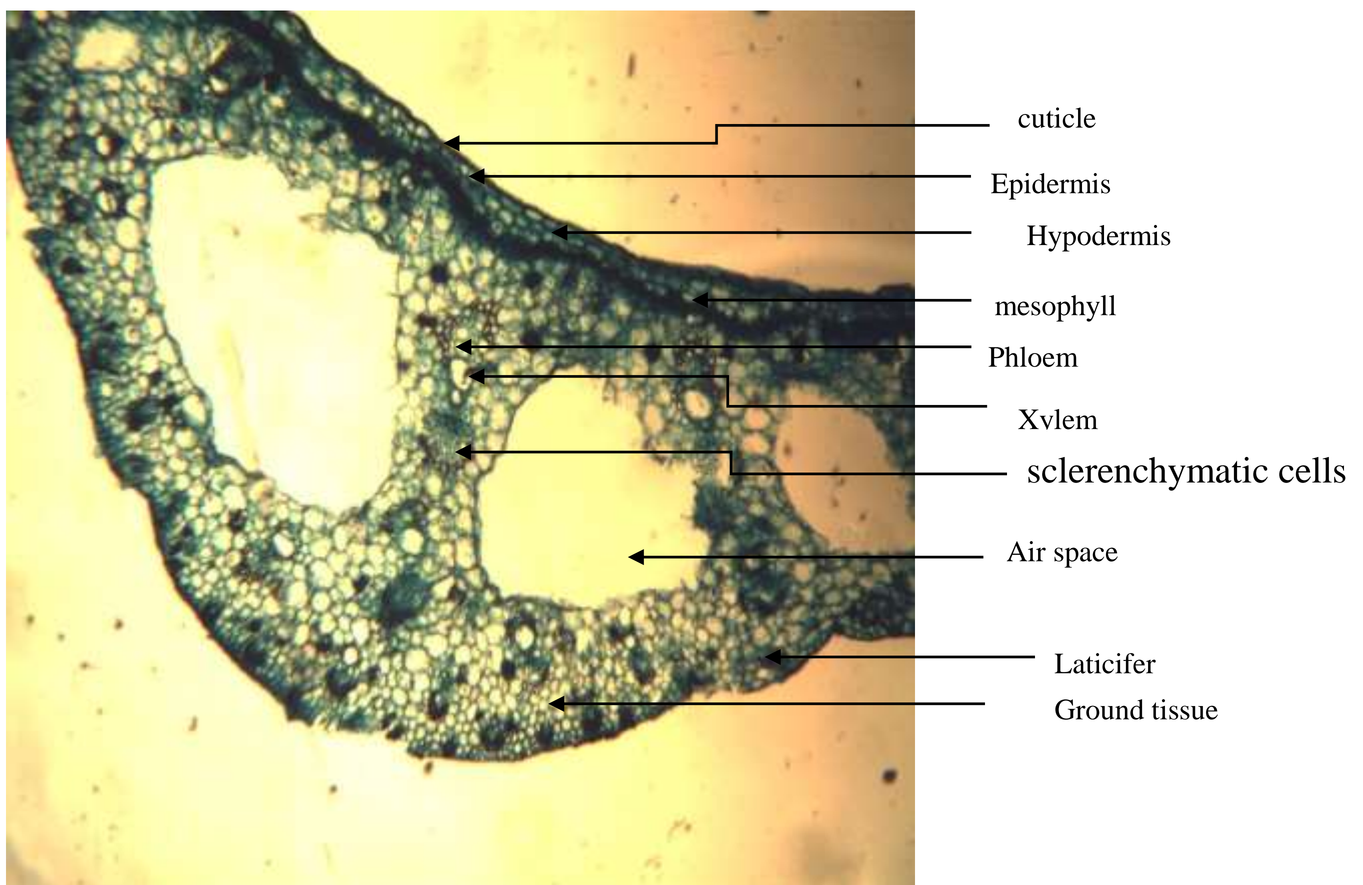

Plate 57.Transverse section of Unele Mmemme leaf (x40)

4.5.3 Transverse section of the Blade (lamina) of Unele Obuo odaa leaf

Plate 58 indicated the findings in the transverse section of the Blade (lamina) of Unele Obuo odaa leaf. The blade consisted of epidermis layer, vascular bundles and parenchyma cells. The shape of the epidermis cells was rectangular. Hypodermal layer was found beneath the upper epidermal layer, the adaxial epidermis of this specie was composed of two layers of cells, while the abaxial one was a single layer. The adaxial epidermis of the Obuo odaa leaf was covered with cuticle. Mesophyll tissue was located between upper (adaxial) and lower (abaxial) epidermis and had big airspaces. The vascular bundles were composed of xylem and phloem and surrounded by the parenchymatic or sclerenchymatic cells, which were called bundle sheaths. Laticifers were scattered between mesophyll cells.

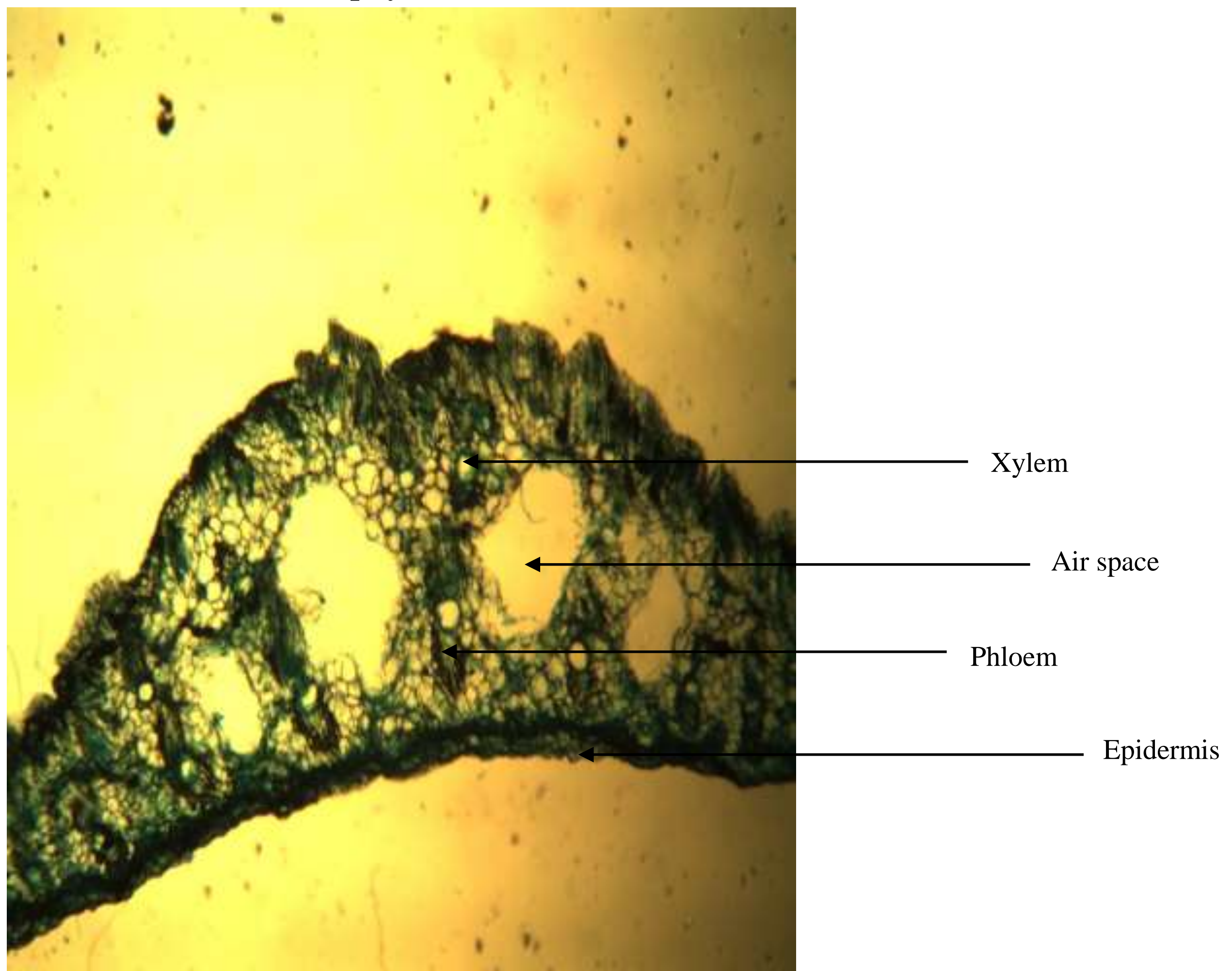

Plate 58.Transverse section of Unele Obuo odaa leaf (X40)

4.5 .4 Transverse section of the Blade (lamina) of Unele Ocha leaf

Plate 59 indicated the findings in the transverse section of the Blade (lamina) of Unele Ocha leaf. The blade consisted of epidermis layer, vascular bundles and parenchyma cells. The shape of the epidermis cells was rectangular. Hypodermal layer was found beneath the upper epidermal layer, the adaxial epidermis of this specie was composed of two layers of cells, while the abaxial one was a single layer. The adaxial epidermis of the Ocha leaf was covered with cuticle. Mesophyll tissue was located between upper (adaxial) and lower (abaxial) epidermis and had big airspaces. The vascular bundles were composed of xylem and phloem and surrounded by the parenchymatic or sclerenchymatic cells, which were called bundle sheaths. Laticifers were scattered between mesophyll cells.

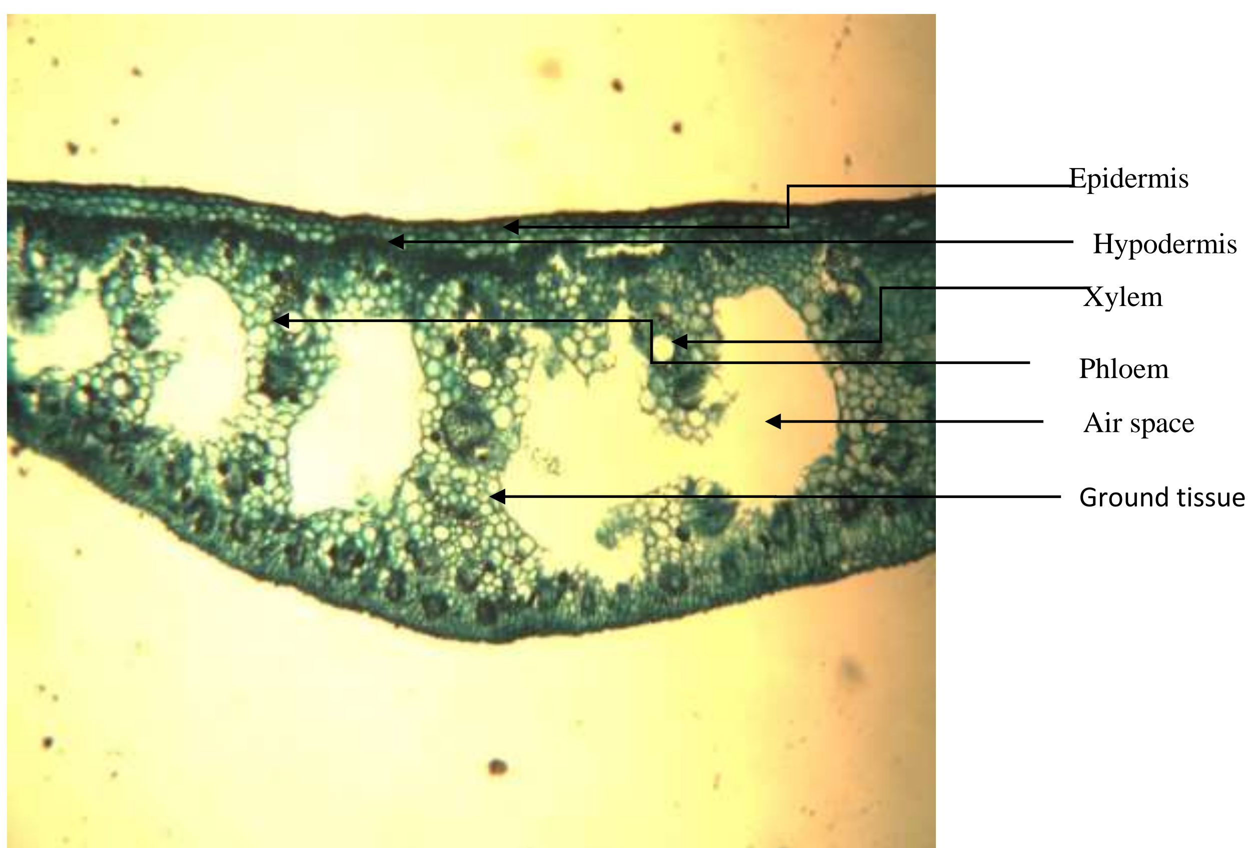

Plate 59.Transverse section of Unele Ocha leaf (x40)

4.5.5 Transverse section of the Blade (lamina) of Unele Ojii leaf

Plate 60 indicated the findings in the transverse section of the Blade (lamina) of Unele Ojii leaf. The blade consisted of epidermis layer, vascular bundles and parenchyma cells. The shape of the epidermis cells was rectangular. Hypodermal layer was found beneath the upper epidermal layer, the adaxial epidermis of this specie was composed of two layers of cells, while the abaxial one was a single layer. The adaxial epidermis of the Unele Ojii leaf was covered with cuticle. Mesophyll tissue was located between upper (adaxial) and lower (abaxial) epidermis and had big airspaces. The vascular bundles were composed of xylem and phloem and surrounded by the parenchymatic or sclerenchymatic cells, which were called bundle sheaths. Laticifers were scattered between mesophyll cells.

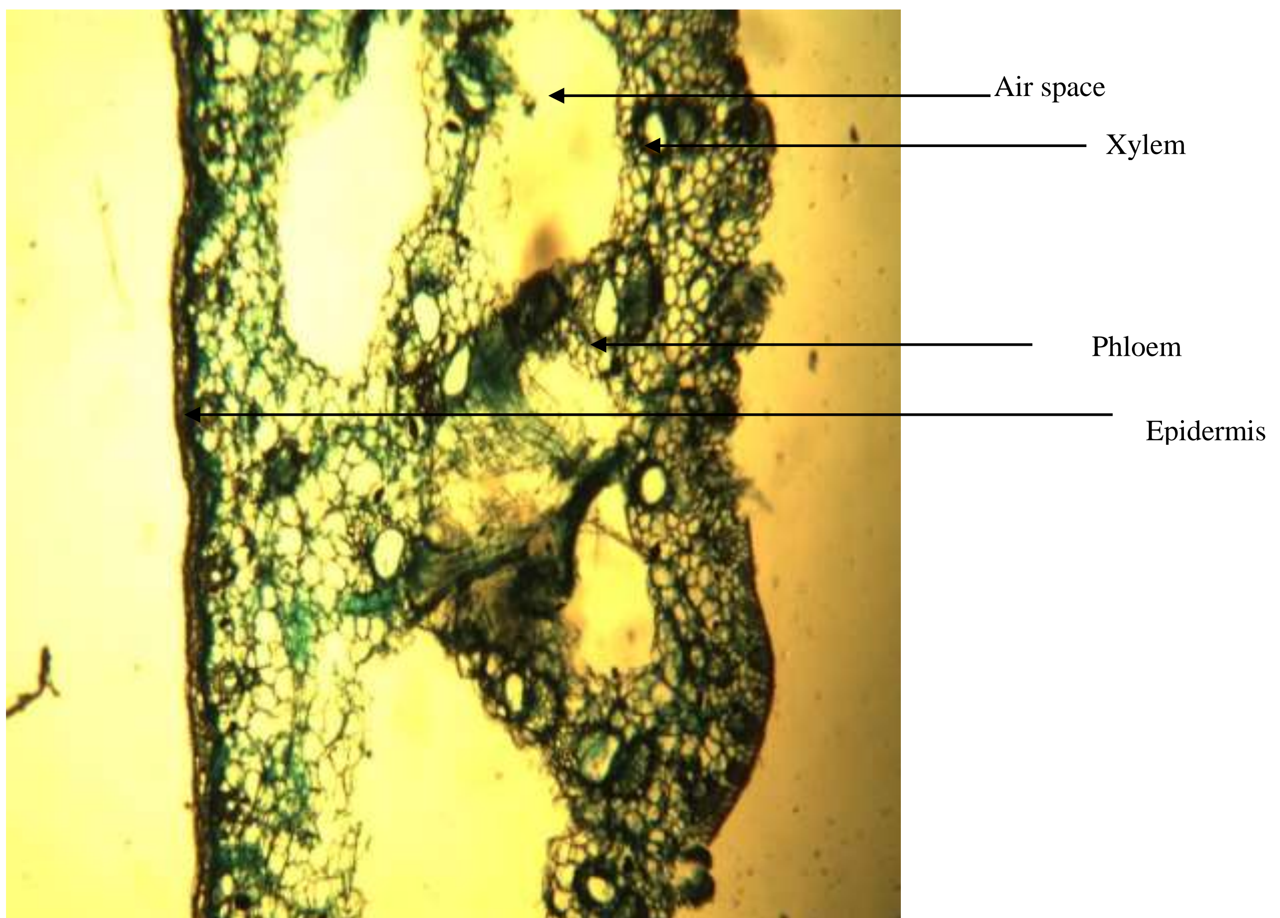

Plate 60.Transverse section of Unele Ojii leaf (X40)

4.5.6 Transverse section of the Blade (lamina) of Unele Akpukpoike leaf

Plate 61 indicated the findings in the transverse section of the Blade (lamina) of Unele Akpukpoike leaf. The blade consisted of epidermis layer, vascular bundles and parenchyma cells. The shape of the epidermis cells was rectangular. Hypodermal layer was found beneath the upper epidermal layer, the adaxial epidermis of this specie was composed of two layers of cells, while the abaxial one was a single layer. The adaxial epidermis of the Unele Akpukpoike leaf was covered with cuticle. Mesophyll tissue was located between upper (adaxial) and lower (abaxial) epidermis and had big airspaces. The vascular bundles were composed of xylem and phloem and surrounded by the parenchymatic or sclerenchymatic cells, which were called bundle sheaths. Laticifers were scatter ed between mesophyll cells.

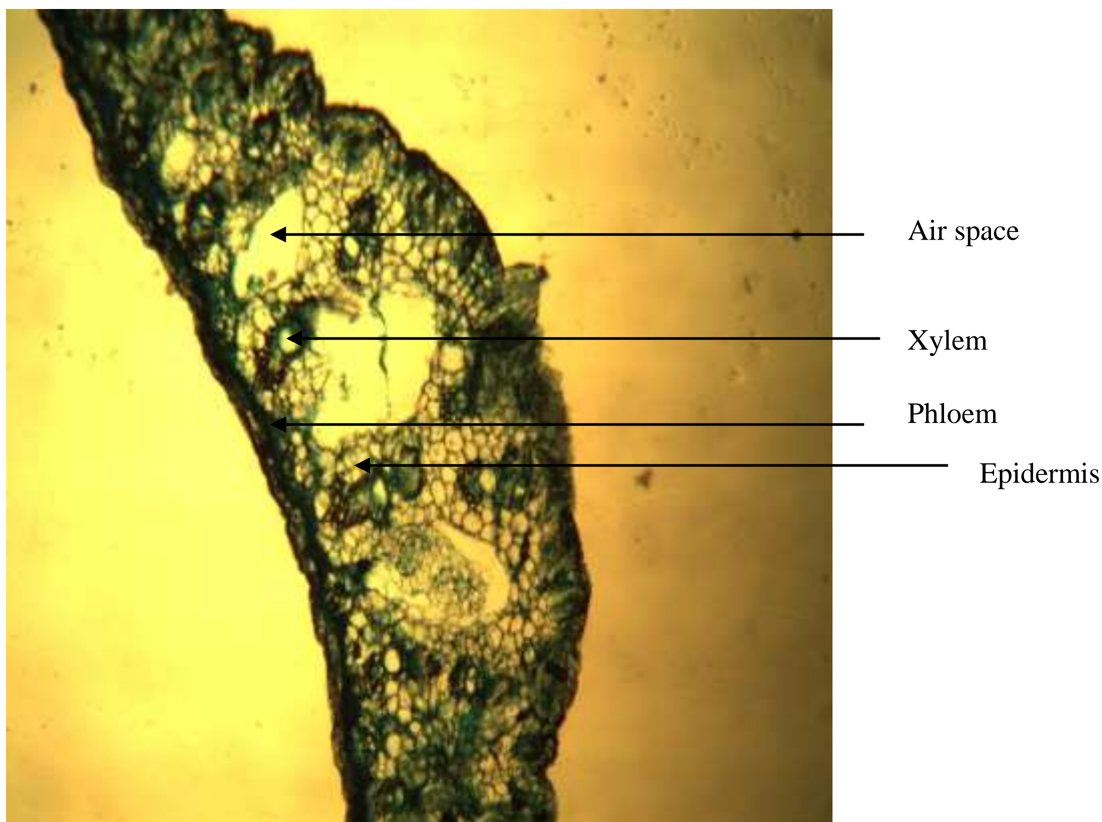

Plate 61.Transverse section of Unele Akpukpoike leaf (X40)

4.6 Leaf epidermal cells of six varieties of banana

4.6.1 Leaf lower epidermal cells of Unele Egbeala

Plate 62a indicated the findings in the Lower epidermis of Unele Egbeala .Stomata were found on both surfaces (amphistomatic) of epidermal layers(see plate 27a and b). The shape of guard cell was kidney-like. The number of subsidiary cells were two to three cells. The type of stomata was predominantly paracytic.

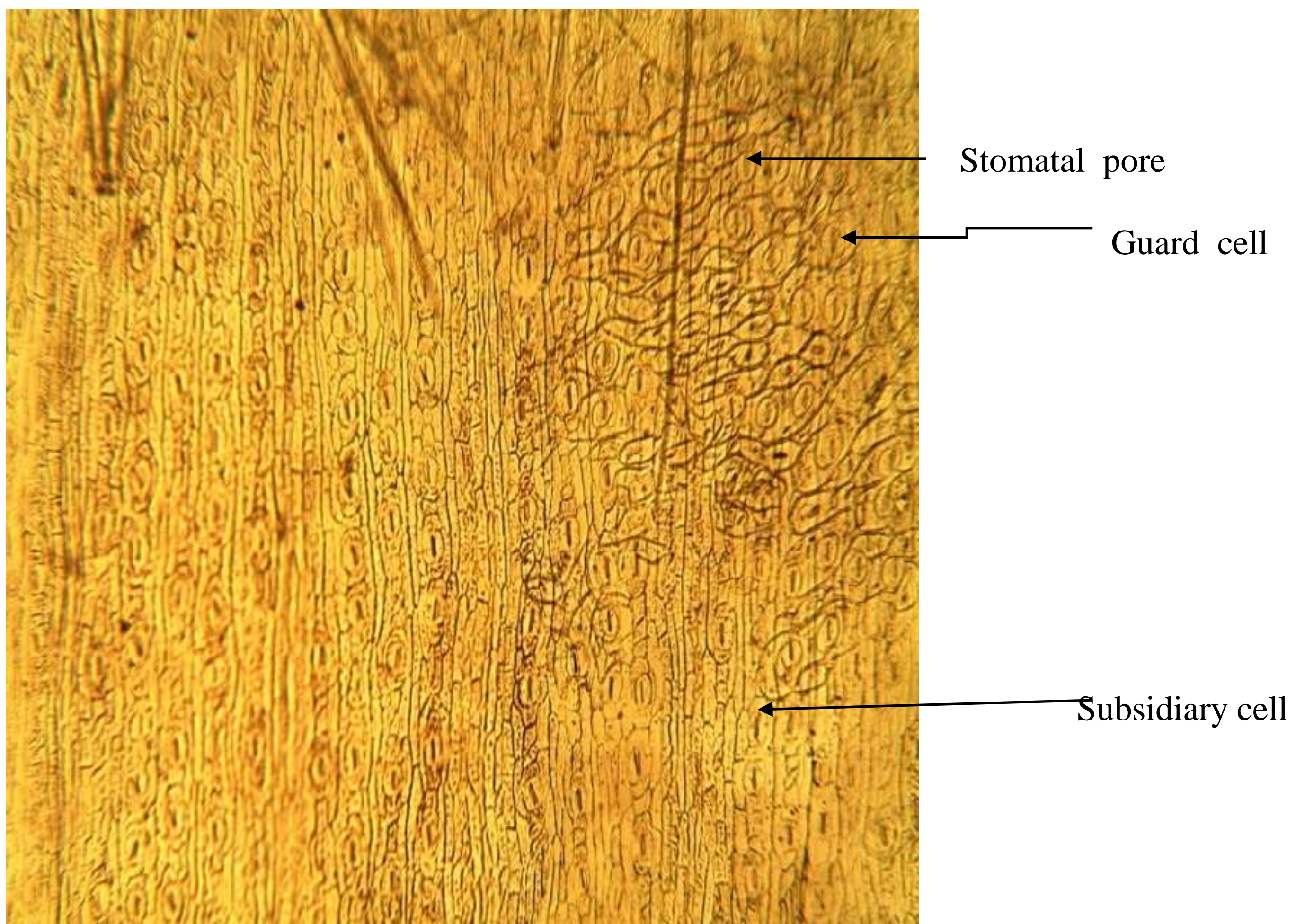

Plate 62a. Lower epidermis of Unele Egbeala (X40).

4.6.2 Leaf upper epidermal cells of Unele Egbeala .

Plate 62b indicated the findings in the upper epidermis of Unele Egbeala .Stomata were found on both surfaces (**amphistomatic**) of epidermal layers (see plate 62a and b). The shape of guard cell was kidney-like. The number of subsidiary cells were two to three cells. The type of stomata was predominantly anisocytic (three subsidiary cells, one being smaller or larger than the other ones).

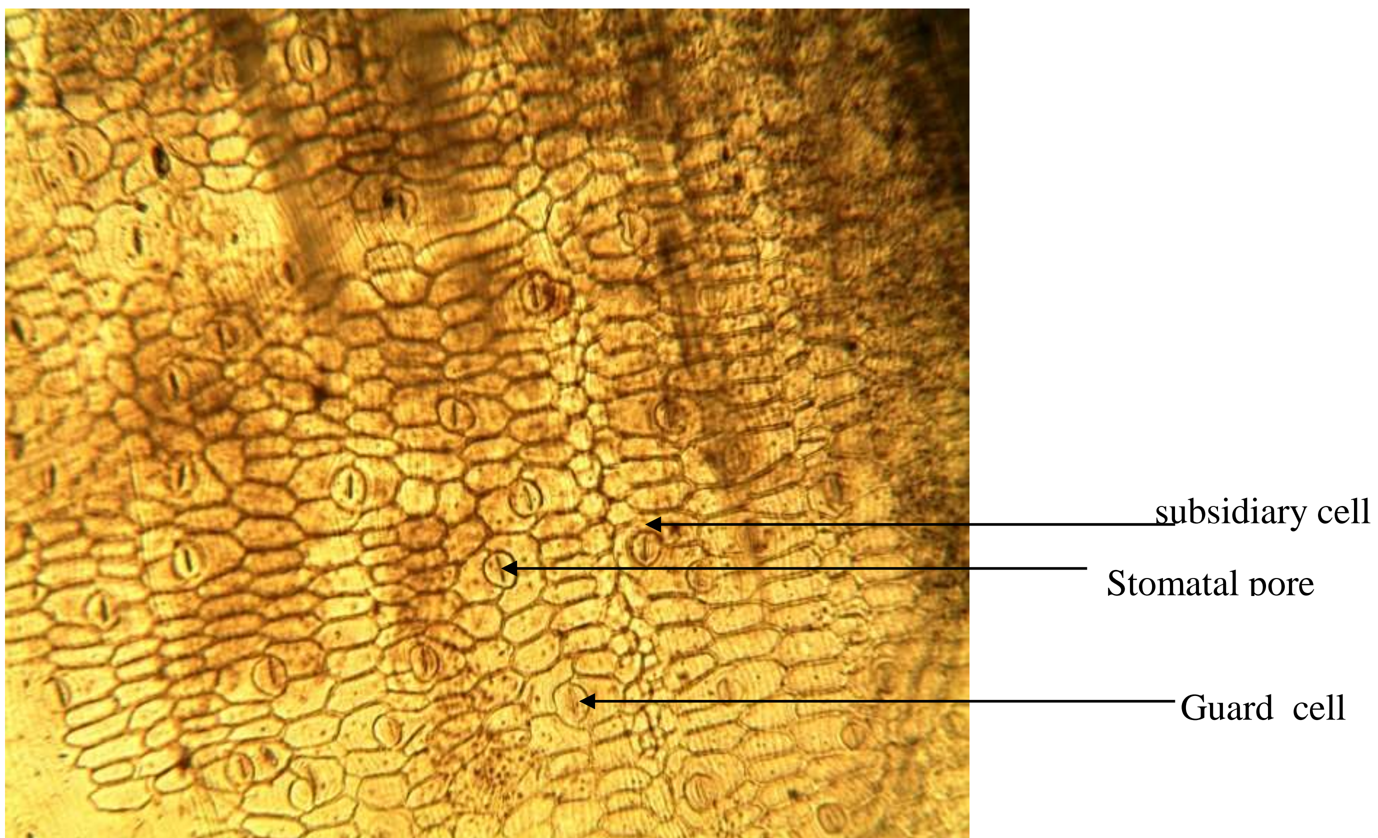

Plate 62b. upper epidermis of Unele Egbeala (X40)

4.6.3 Leaf lower epidermal cells of Unele Mmemme

Plate 63a indicated the findings in the Lower epidermis of Unele Mmemme. Stomata were found on both surfaces (amphistomatic) of epidermal layers (see plate 28a and b). The shape of guard cell was kidney-like. The numbers of subsidiary cells were two to three cells. The type of stomata was predominantly paracytic.

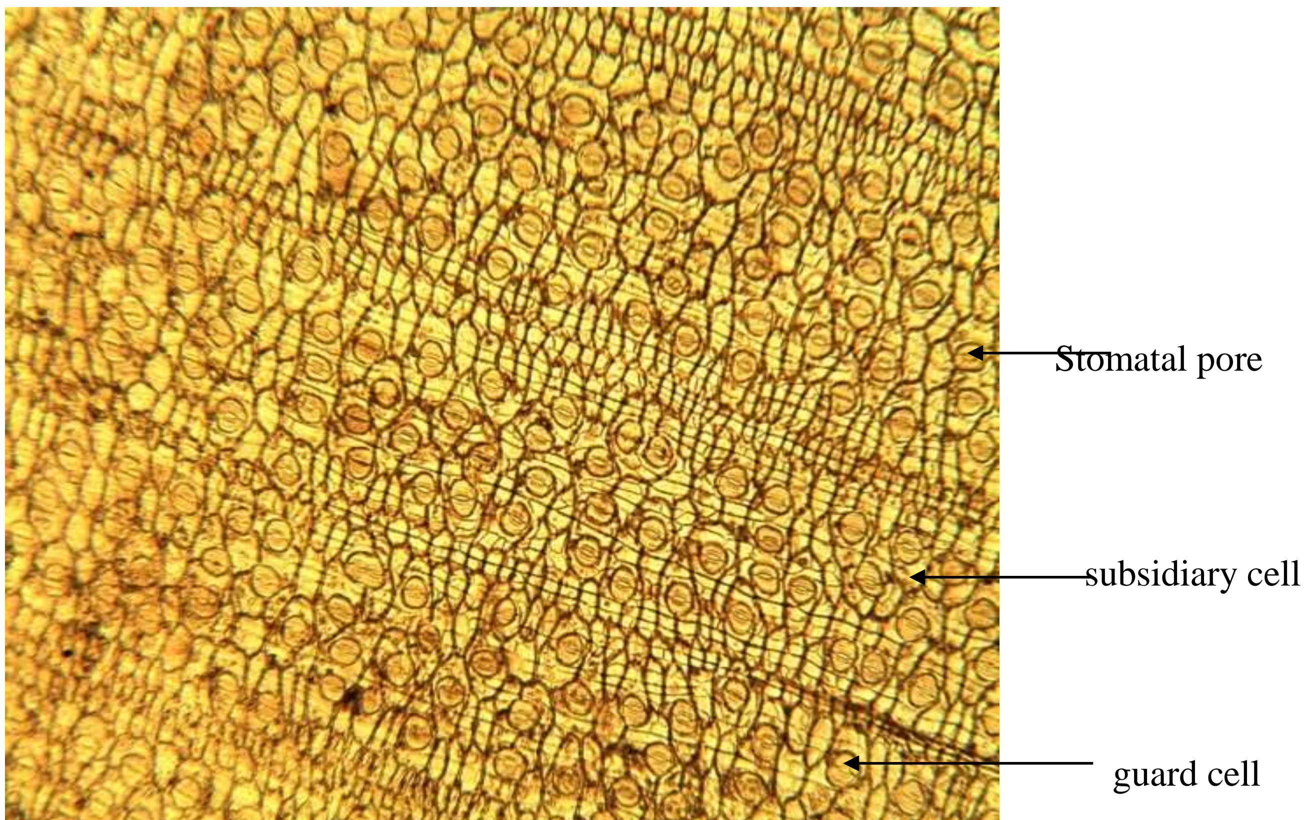

Plate 63a. Lower epidermis of Unele Mmemme (X40)

4.6.4 Leaf upper epidermal cells of Unele Mmemme

Plate 63b indicated the findings in the upper epidermis of Unele Mmemme Stomata were found on both surfaces (amphistomatic) of epidermal layers (see plate 63a and b). The shape of guard cell was kidney-like. The number of subsidiary cells were two to three cells. The type of stomata was predominantly anisocytic (three subsidiary cells, one being smaller or larger than the other ones).

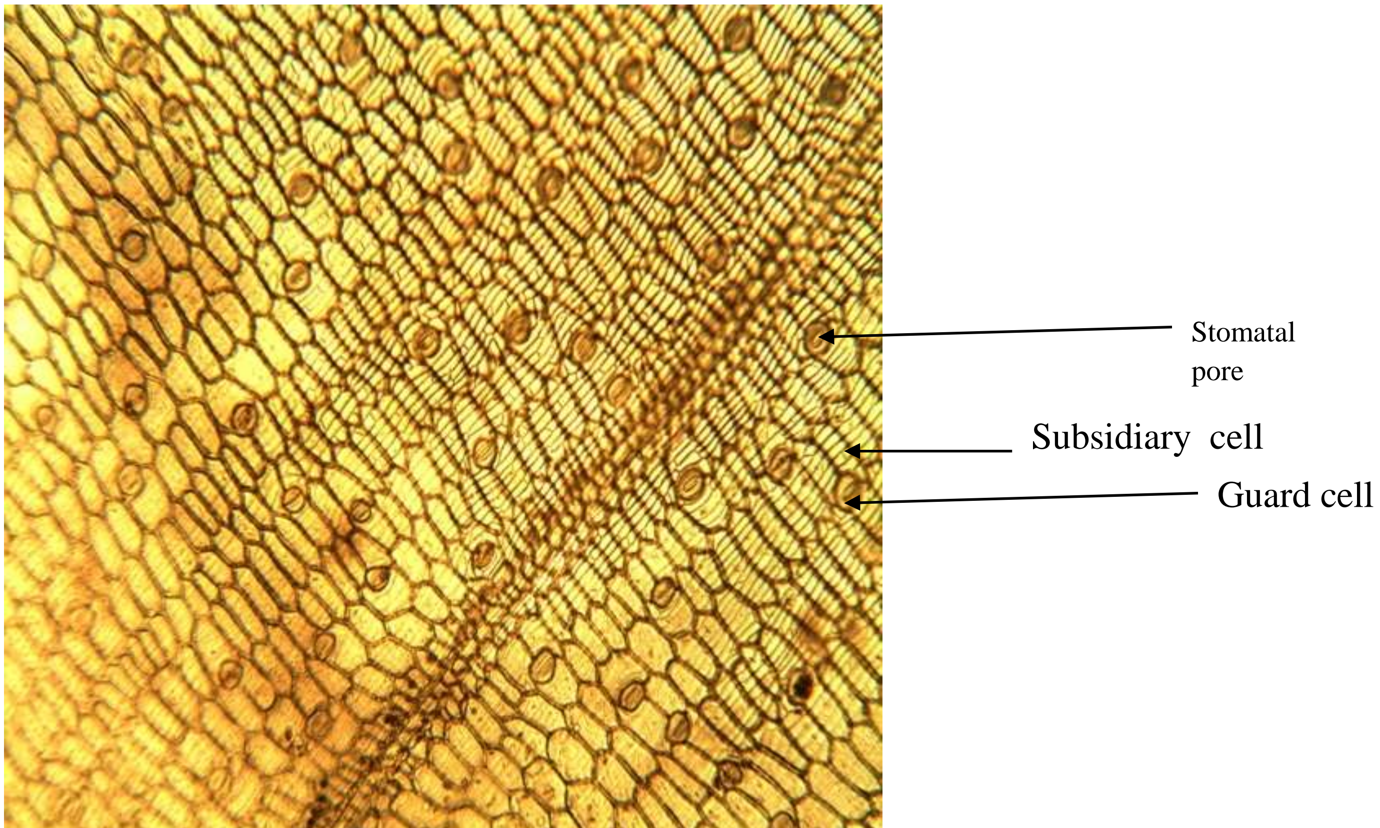

Plate 63b. upper epidermis of Unele Mmemme (X40)

4.6.5 Leaf lower epidermal cells of Unele Obuo odaa

Plate 64a indicated the findings in the Lower epidermis of Unele Obuo odaa. Stomata were found on both surfaces (**amphistomatic**) of epidermal layers. The shape of guard cell was kidney-like. The numbers of subsidiary cells were two to three cells. The type of stomata was predominantly cyclocytic.

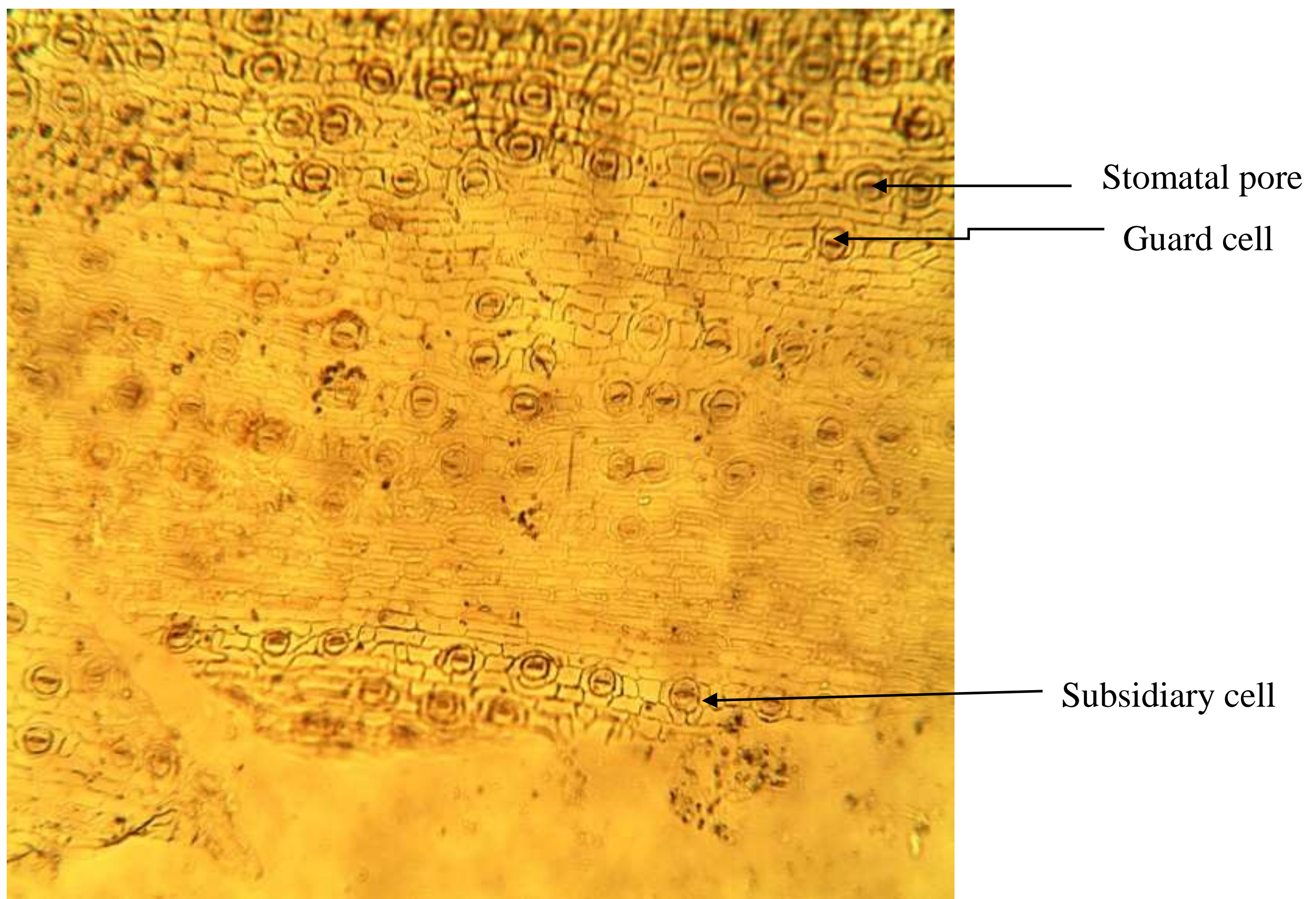

Plate 64a. Lower epidermis of Unele Obuo odaa (X40)

Subsidiary

4.6.6 Leaf upper epidermal cells of Unele Obuo odaa

Plate 65b indicated the findings in the upper epidermis of Unele Obuo odaa. Stomata were found on both surfaces (amphistomatic) of epidermal layers. The shape of guard cell was kidney-like. The numbers of subsidiary cells were two to three cells. The type of stomata was predominantly anisocytic.

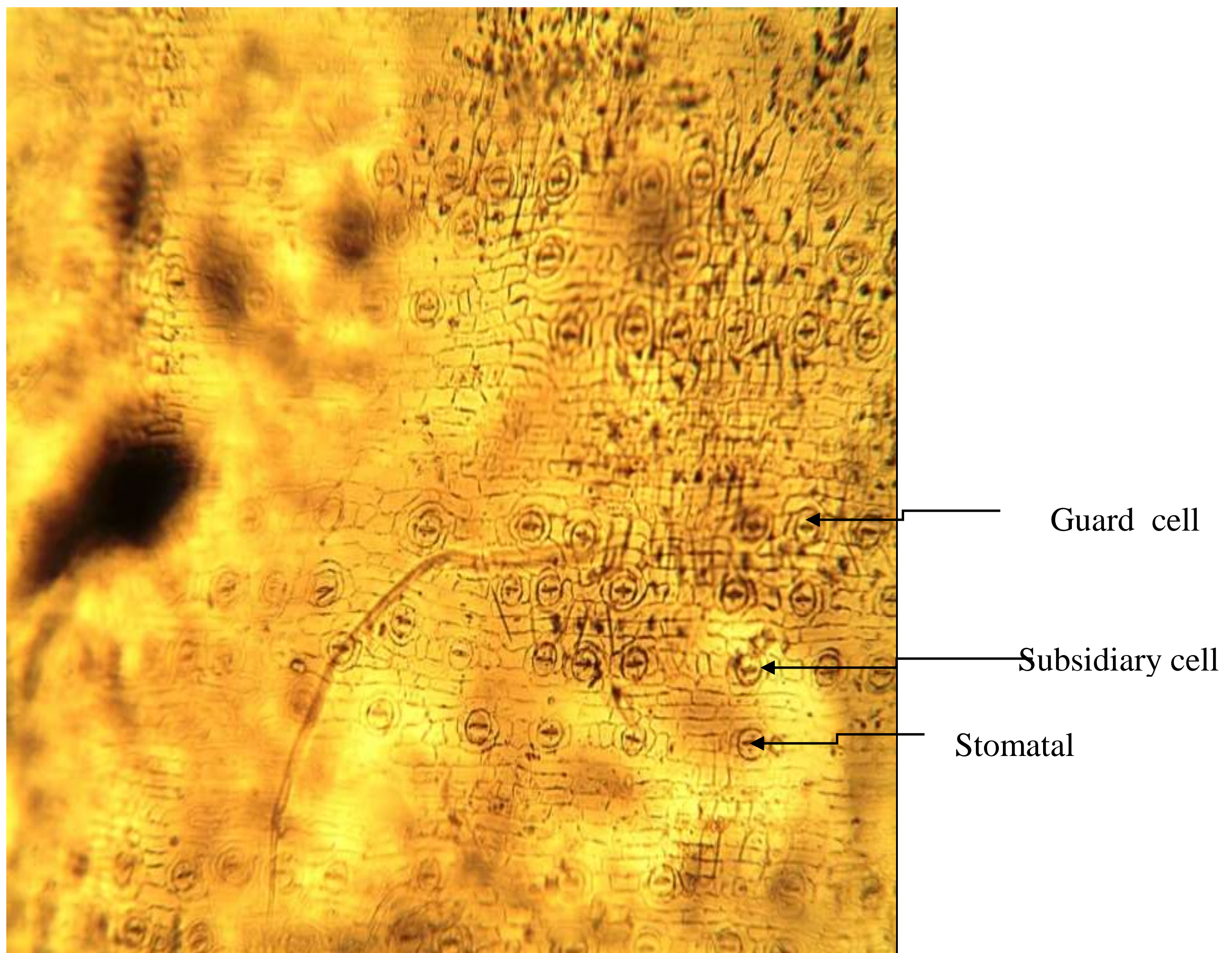

Plate 65b. upper epidermis of Unele Obuo odaa (X40)

4.6.7 Leaf lower epidermal cells of Unele Ocha

Plate 66a indicated the findings in the Lower epidermis of Unele Ocha . Stomata were found on both surfaces (**amphistomatic**) of epidermal layers. The shape of guard cell was kidney-like. The number of subsidiary cells were two to three cells. The type of stomata was predominantly paracytic.

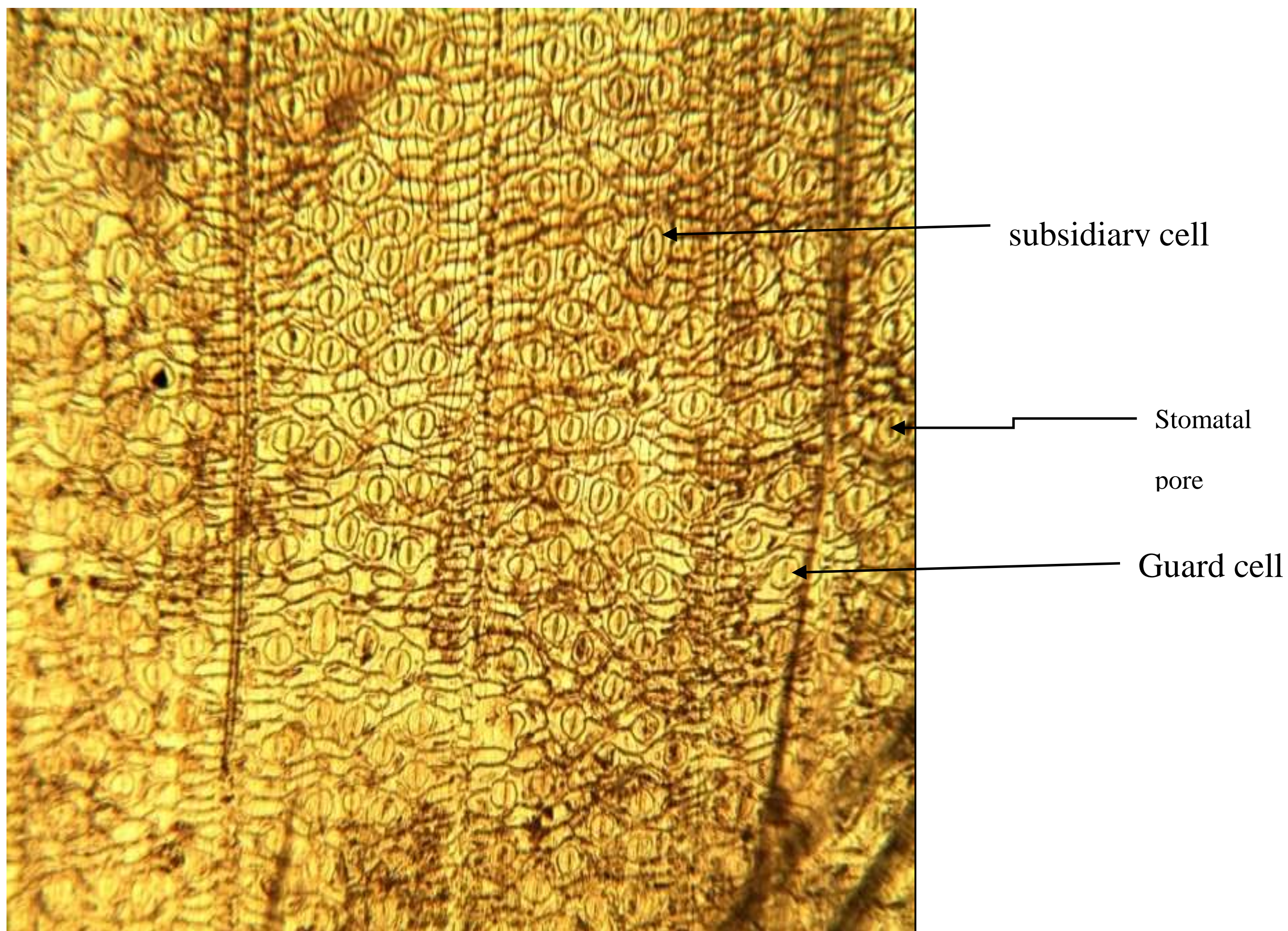

Plate 66a. Lower epidermis of Unele Ocha a (X40)

4.6.8 Leaf upper epidermal cells of Unele Ocha

Plate 66b indicated the findings in the upper epidermis of Unele Ocha . Stomata were found on both surfaces (amphistomatic) of epidermal layers. The shape of guard cell was kidney-like. The number of subsidiary cells were two to four cells. The type of stomata was predominantly anisocytic (three subsidiary cells, one being smaller or larger than the other ones).

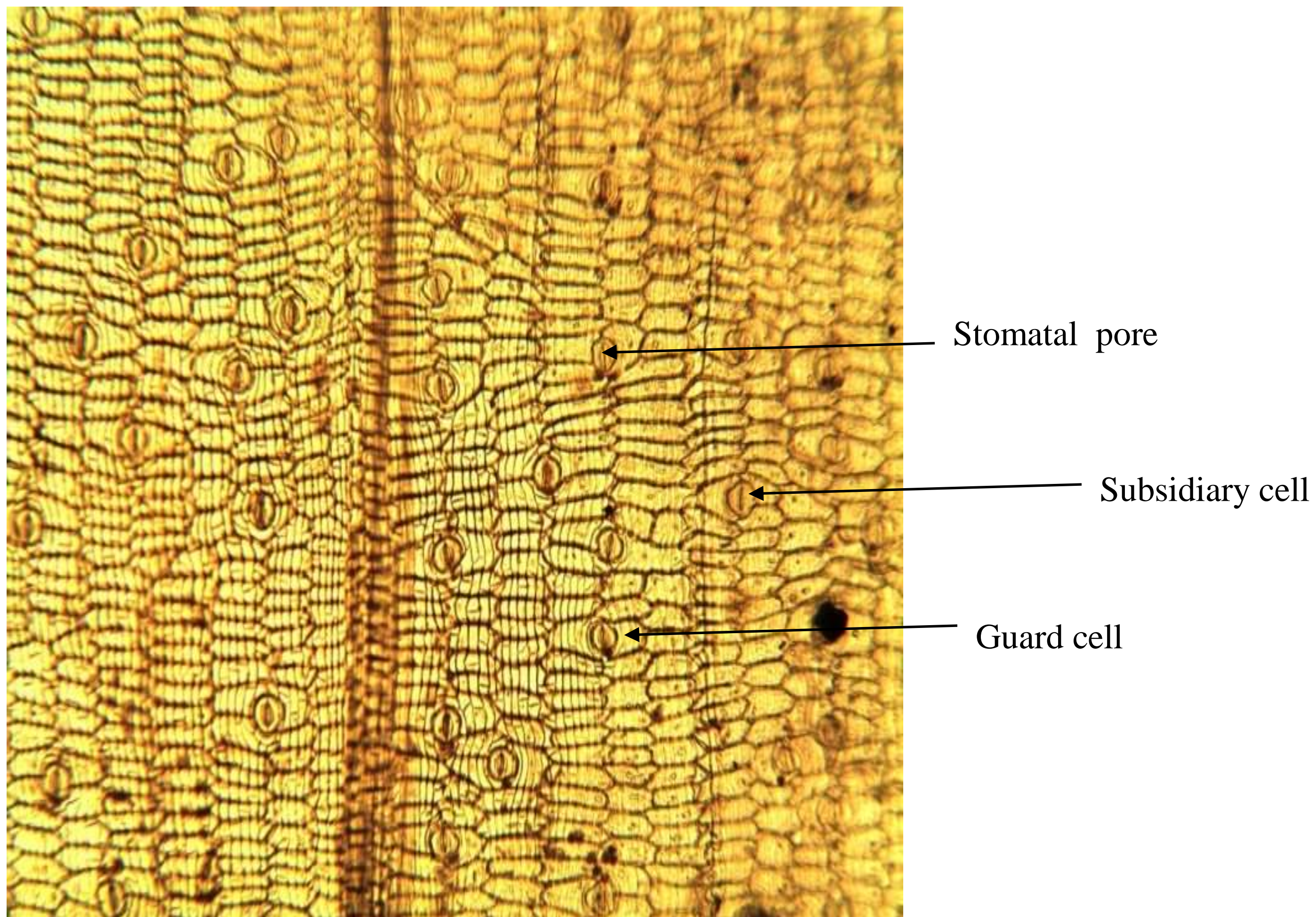

Plate 66b. upper epidermis of Unele Ocha (X40)

4.6.9 Leaf lower epidermal cells of Unele Ojii

Plate 67a indicated the findings in the Lower epidermis of Unele Ojii. Stomata were found on both surfaces (amphistomatic) of epidermal layers. The shape of guard cell was kidney-like. The number of subsidiary cells were two to three cells. The type of stomata was predominantly paracytic.

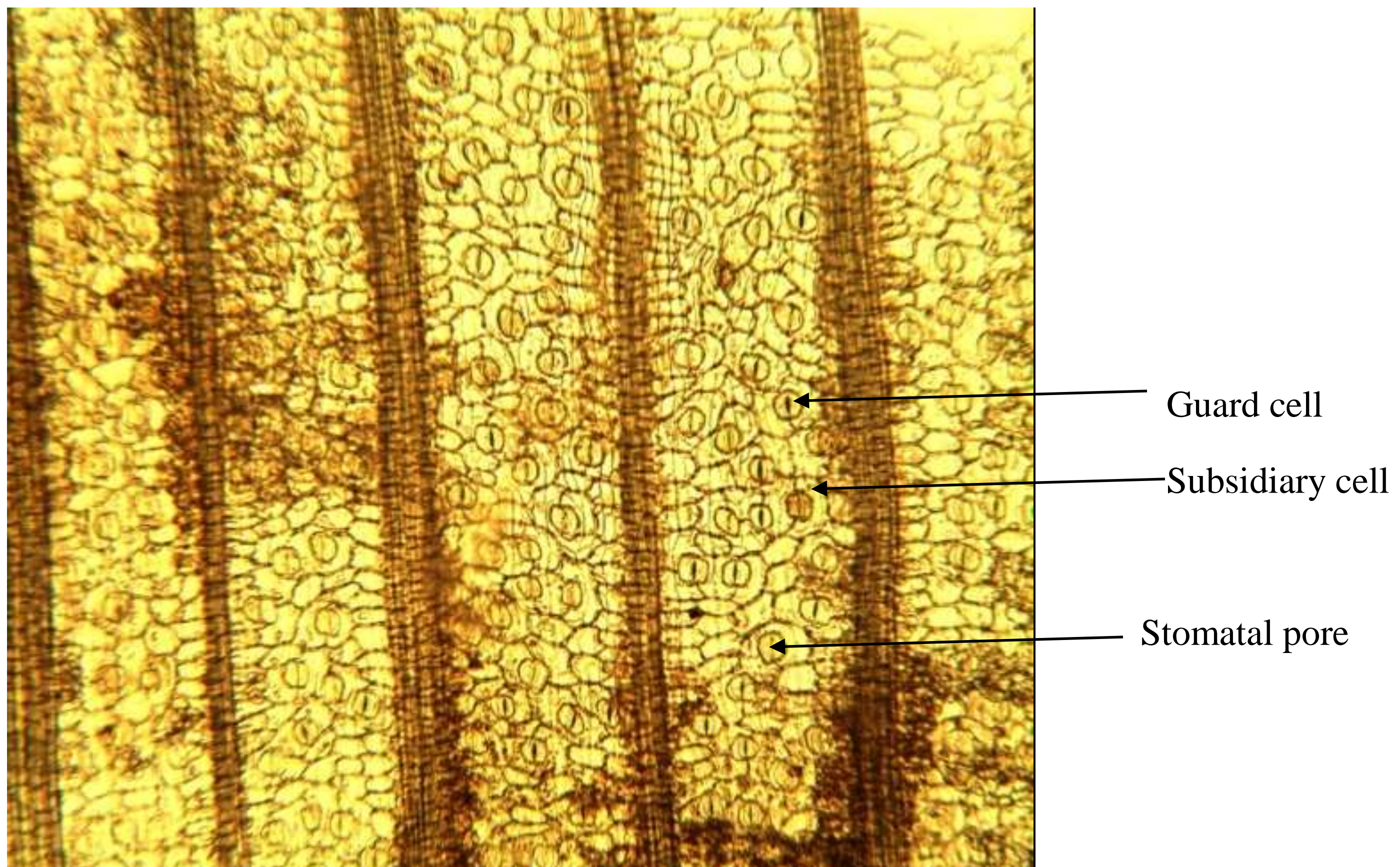

Plate 67a. Lower epidermis of Unele Ojii (X40)

4.6.10 Leaf upper epidermal cells of Unele Ojii

Plate 67b indicated the findings in the upper epidermis of Unele Ojii.

Stomata were found on both surfaces (amphistomatic) of epidermal layers. The shape of guard cell was kidney-like. The `number of subsidiary cells was two to three cells. The type of stomata was predominantly anisocytic (three subsidiary cells, one being smaller or larger than the other ones).

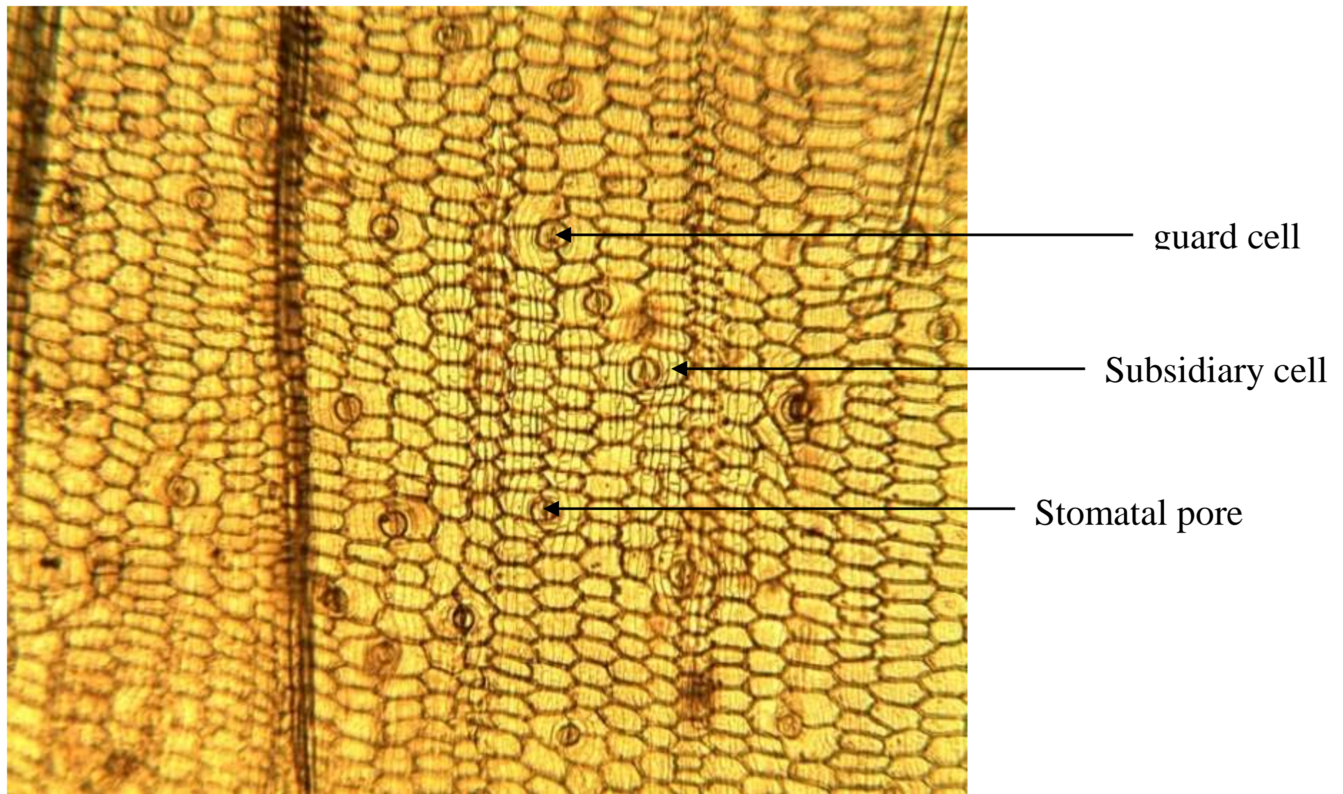

Plate 67b. upper epidermis of Unele Ojii (X40)

4.6.11 Leaf lower epidermal cells of Unele Akpukpoike

Plate 68a indicated the findings in the Unele Akpukpoike Lower epidermis. Stomata were found on both surfaces (amphistomatic) of epidermal layers (see plate 26a and b). The shape of guard cell was kidney-like. The numbers of subsidiary cells were two to three cells. The type of stomata was predominantly paracytic.

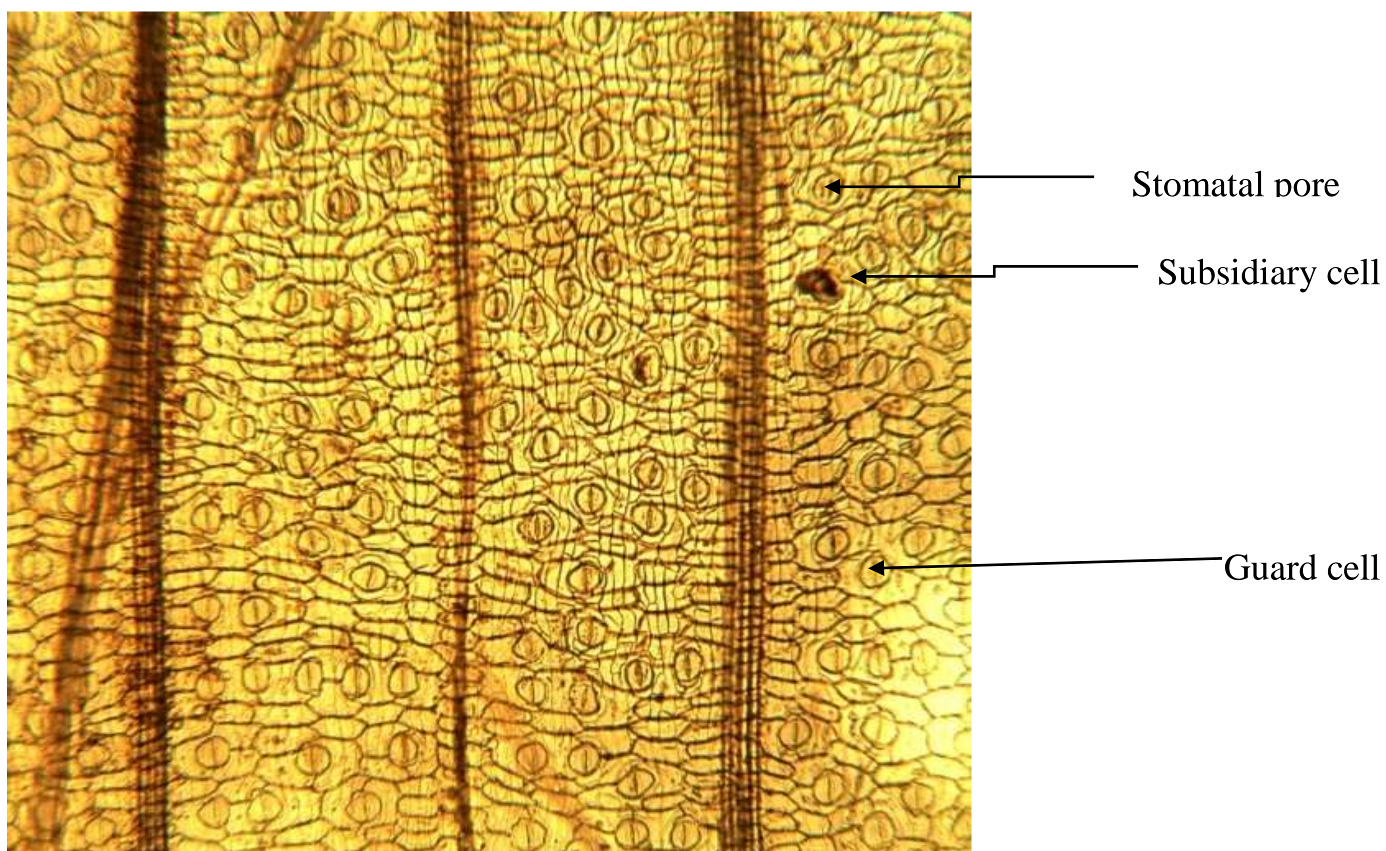

Plate 68a. Unele Akpukpoike Lower epidermis (X40)

4.6.12 Leaf upper epidermal cells of Unele Akpukpoike

Plate 68b indicated the findings in the Unele Akpukpoike upper epidermis. Stomata were found on both lower and upper surfaces (**amphistomatic**) of epidermal layers(see plate 26a and b). The shape of guard cell was kidney-like. The numbers of subsidiary cells were three to four cells. The type of stomata was predominantly anisocytic (three subsidiary cells, one being smaller or larger than the other ones).

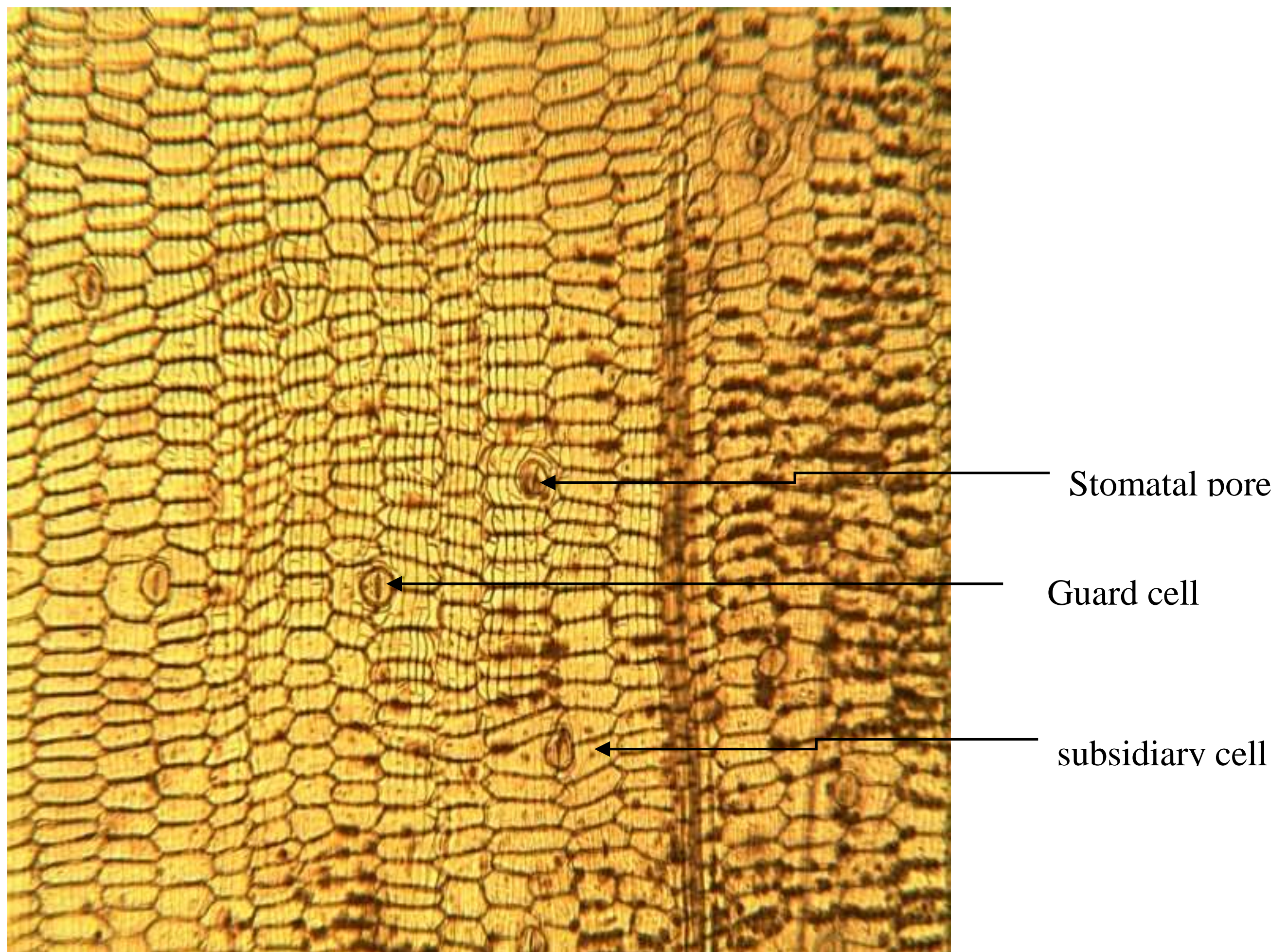

Plate 68b. upper epidermis Unele Akpukpoike (X40)

4.6.13 Number of subsidiary cell in adaxial and abaxial epidermis

The number of subsidiary cells was two to three cells in Unele Ojii, Unele Obuo odaa, Unele Egbeala and Unele Mmemme in both upper and lower epidermis. While it was 2-3 in lower epidermis of Unele Akpukpoike and Unele Ocha , 2-4 in upper epidermis of Unele Ocha and 3-4 in upper epidermis of Unele Akpukpoike

Table 13: Number of subsidiary cell in adaxial and abaxial epidermis

	Unele Ojii	**Unele Obuo odaa**	**Unele Ocha**	**Unele Mmemme**	**Unele Akpukpoike**	**Unele Egbeala**
Stomata of adaxial epidermis						
Number of subsidiary cell	2-3	2-3	2-4	2-3	3-4	2-3
Stomata of abaxial epidermis						
Number of subsidiary cell	2-3	2-3	2-3	2-3	2-3	2-3

4.6.14 Leaf Stomata Characters of the six varieties of banana understudy

Table 14.show the stomata characteristics of the upper and lower epidermis of the six varieties of banana. The study of the leaf stomata characters of the upper epidermis of the six varieties of banana understudy revealed that Unele Ojii has highest stomata width (13.000 ± 2.186 µm) and stomata length (13.800±1.135µm), Unele Egbeala has highest aperture length (10.350 ± 1.765µm), Unele Ocha has highest number of guard cells (756- 809) while Obuo odaa has highest stomata number (51- 64) and stomata index (9.381 ± 1.716) (Table 14). The upper epidermis of the leaves of six varieties of banana showed a significant difference in their stomata characters except in aperture width ($p<0.05$).

The study of the leaf stomata characters of the lower epidermis of the six varieties of banana revealed that Unele Ojii has highest stomata width (12.450±1.878 µm), Unele Ocha has highest aperture width (2.700±0.483), stomata number (140- 162) and stomata index (21.203±5.705), Mmemme has highest number of guard cells (613- 836), Akpupoike has highest stomata length (14.250±1.399 µm) while Unele Egbala has highest aperture length (8.800±1.295µm) (Table 14). The lower epidermis of the leaves of six varieties of banana showed a significant difference in their stomata characters except aperture width ($p<0.05$).

Table 14: Leaf Stomata Characters of the six varieties of banana understudy

Epidermal Surface	Plant	Stomata width (µm)	Stomata length (µm)	Aperture width (µm)	Aperture length (µm)	No of Guard Cells	Stomata No	Stomata Index
	Unele Egbeala	10.650±1.292[d]	11.900±1.542[d]	2.200±0.483[a]	10.350±1.765[a]	380- 487	24- 38	7.082±1.057[b]
	Mmemme	10.680±1.375[d]	13.000±1.054[b]	2.150±0.242[a]	7.920±1.015[c]	545- 857	46- 45	6.020±1.828[c]
	Obuo odaa	8.850±1.582[e]	11.400±1.647[d]	1.850±0.242[a]	7.050±0.725[d]	464- 781	51- 64	9.381±1.716[a]
	Unele Ocha	11.500±1.434[c]	12.600±1.713[c]	2.050±0.158[a]	6.900±0.699[e]	756- 809	27- 36	3.773±0.687[d]
Upper	**Unele Ojii**	13.000±2.186[a]	13.800±1.135[a]	2.200±0.350[a]	8.400±1.150[b]	735- 800	22- 32	3.245±0.582[e]
	Akpupoike	12.100±1.197[b]	12.400±1.075[c]	2.000±0.471[a]	7.300±0.949[d]	649- 694	6- 11	1.229±0.401[f]
	p-value	**	**	NS	**	-	-	**
	Unele Egbeala	10.100±1.560[e]	11.550±1.092[e]	2.250±0.589[c]	8.800±1.295[a]	400- 441	39- 90	12.047±4.304[d]
	Mmemme	11.550±1.787[c]	13.100±1.449[c]	2.300±0.587[b]	7.800±1.476[d]	613- 836	128- 150	15.343±1.870[b]
	Obuo odaa	9.600±0.843[f]	12.450±2.608[d]	2.100±0.316[c]	7.500±0.943[e]	625- 686	67- 85	10.436±1.537[e]
Lower	**Unele Ocha**	12.600±2.171[a]	14.000±1.826[a]	2.700±0.483[a]	8.200±1.135[c]	367- 585	140- 162	21.203±5.705[a]
	Unele Ojii	12.450±1.878[b]	13.650±1.055[b]	2.100±0.394[c]	8.600±0.658[b]	604- 674	87- 101	12.747±0.165[c]
	Akpupoike	11.100±1.792[d]	14.250±1.399[a]	2.350±0.412[b]	7.100±0.615[f]	600- 807	49- 62	7.817±0.848[f]
	p-value	**	**	**	**	-	-	**

Results are mean± Standard Deviation, ** Significantly different, Ns: Not significantly different

The same letters in a column is not significantly different

Objective 3: Genetic diversity of *M. Sapientum* varieties

4.7 DNA Electrophoresis

The quality of DNA detected by agarose gel electrophoresis and the size of fragment obtained was over 35kb for all the samples (figure: 1). The genomic DNA was later used for PCR amplification using RAPD makers.

M 1 2 3 4 5 6

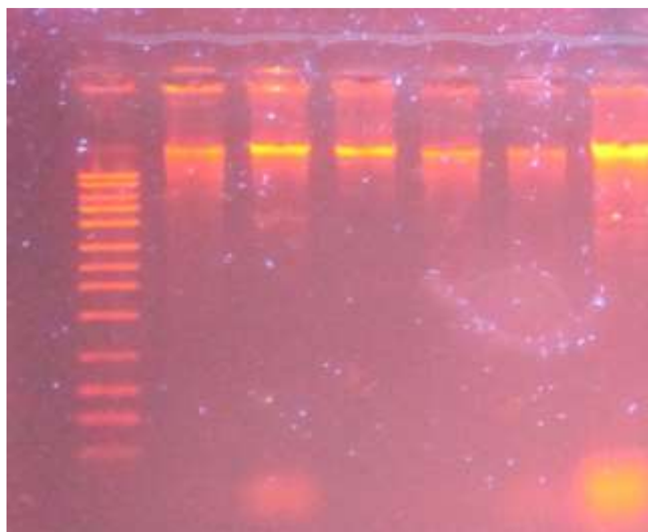

Figure 1. Electrophoresis gel for DNA

4.7.1 Genotyping using RAPD makers

Screening of 10 RAPD makers with two DNA samples. Primers which had informative and polymorphic products resolvable by electrophoresis were selected. Out of 10 RAPD primers that were used, there were 3 RAPD primers that were informative while 7 primers gave no amplification. In RAPD study, the primers OPAD 09, OPAE 04 and OPAE 05 were finally used for dendrogram building, because they gave highly polymorphic and reproducible banding patterns.

Out of the amplification products recorded, seven (7) primers gave no amplification while 3 RAPD primers revealed the relationship between these genotypes. From these three polymorphic RAPD makers that were used, 18 alleles were generated. Seven of the alleles generated were monomorphic while eleven were polymorphic.

Figure 2 indicated RAPD bands generated using primer OPAD 09 and DNA of six varieties of banana

M 1 2 3 4 5 6

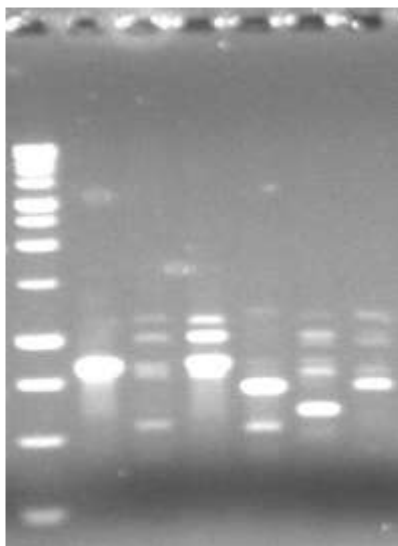

Figure 2. Electrophoresis gel for OPAD 09

Figure 3 indicated RAPD bands generated using primer OPAE 04and DNA of six varieties of banana

M 1 2 3 4 5 6

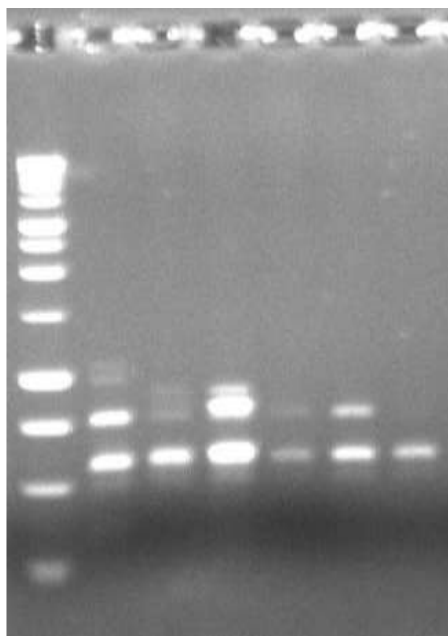

Figure: 3 Electrophoresis gel for OPAE 04

Figure 4 indicated RAPD bands generated using primer OPAE 05 and DNA of six varieties of banana

M 1 2 3 4 5 6

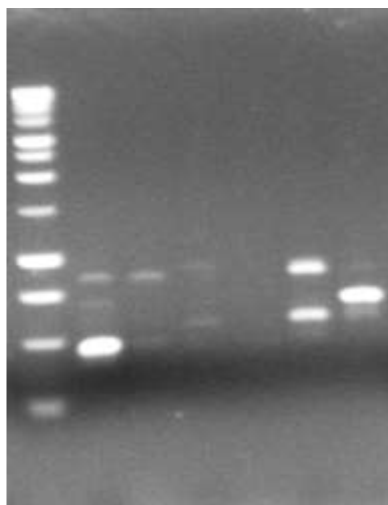

Figure: 4 Electrophoresis gel for OPAE 05

Table: 15 List of the primers used and their sequences

S/N	Primer Name	Sequence	Fragment size
1	OPAD 09	TCGCTTCTCC	200bp - 2500bp
2	OPAE 04	CCAGCACTTC	200bp - 2000bp
3	OPAE 05	CCTGTCAGTG	300bp - 1500bp

4.7.2 Samples with the polymorphic RAPD makers

Out of three polymorphic RAPD makers that were used, 18 alleles were generated from the makers. Seven of the alleles generated were monomorphic while eleven were polymorphic. RAPD bands were manually scored from the gel profile, `1’ for the presence and `0’ for the absence of band and the binary data generated from all the profile, were used for statistical analysis.

Table: 16 Data scoring from the electrophoresis gels

	cc1	cc2	cc3	cc4	cc5	cc6	cc7	cc8	cc9	cc10	cc11	cc12	cc13	cc14	cc15	cc16	cc17	cc18
1	0	0	0	1	1	0	0	0	0	1	1	0	1	1	1	0	1	1
2	0	1	1	0	1	0	0	1	0	0	0	1	1	1	1	0	1	0
3	0	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	0	0
4	1	0	0	0	0	1	0	1	0	0	0	0	1	1	0	0	0	0
5	0	1	1	0	1	0	1	0	1	0	0	0	1	1	0	0	1	0
6	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0	0	1	1

The dendogram generated showed two similarity clustering. The first similarity cluster consisted of varieties 1, 4 and 6 (which are Obuo odaa, Unele Mmemme, and Unele Ojii). While the second similarity cluster consists of varieties 2, 3 and 5 respectively (which are Unele Ocha, Unele Akpupoike and Unele Egbeala).

Thus, the dendogram grouping of the samples studied, showed that all the varieties in cluster one are similar and can also be cross breed while all the varieties in cluster two are similar and can also be cross breed.

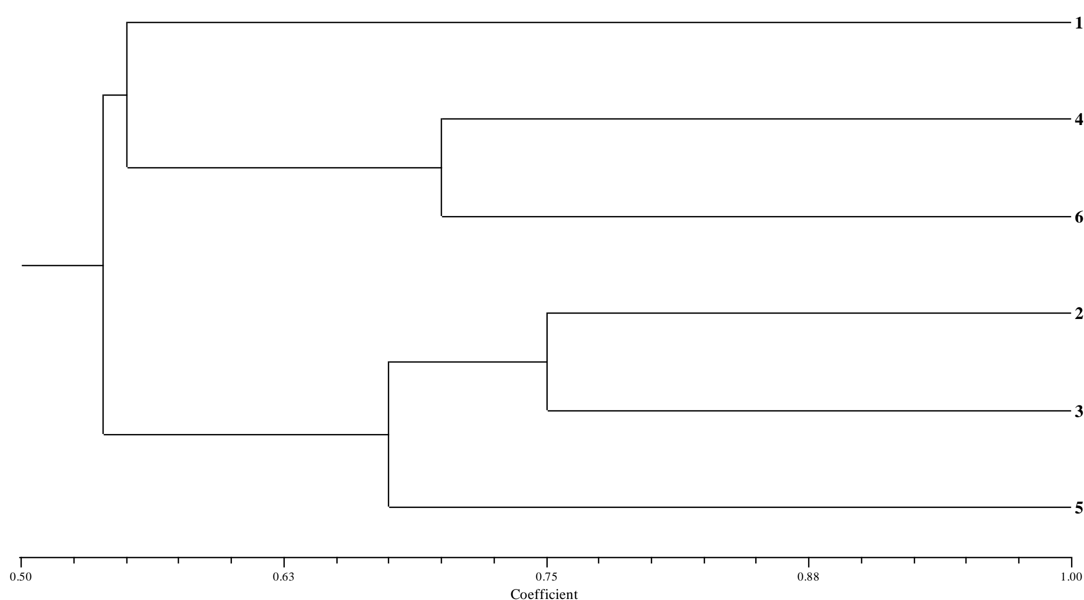

Figure: 5 Dendrogram showing the genetic relationships of 6 *Musa* individuals. The individuals are labeled with a species, plus an individual designator.

RAPD bands were manually scored from the gel profile, `1' for the presence and `0' for the absence of band and the binary data generated from all the profile, were used for statistical analysis. The similarity matrix was computed using squared Euclidean Distance (SED) that estimates all pair wise similarity in the amplification product. The dendogram (Figure: 5) was constructed by Ward's method of clustering. A pairwise comparison of the six (6) accessions shows the similarly coefficient ranges of the varieties.

Similarity Coefficient

```
" SIMQUAL: input=H:\RAPD WORK\Hajia\am1.NTS, coeff=SM
" by Rows
3 6L 6  0
1 2 3 4 5 6
1.0000000
0.6000000  1.0000000
0.5500000  0.7500000  1.0000000
0.5000000  0.6000000  0.4500000  1.0000000
0.5000000  0.7000000  0.6500000  0.5000000  1.0000000
0.6000000  0.6000000  0.4500000  0.7000000  0.6000000  1.0000000
```

Objective 4: Phytochemical , proximate and mineral constituents.

4.8 Phytochemical study

4.8.1 Qualitative Phytochemical constituents of local *Musa sapientum* varieties

Qualitative phyochemical analysis of various parts of banana plants showed the presence of Alkaloid, Tannin, Saponin, Flavonoid and Phenol. The presence or absence of these Phytochemicals in the root, stem, leaves and fruit of the varieties of banana are summarized in tables 17-20 .

Table 17 below indicated the results of phytochemical analysis of the leaves of the six *Musa sapientum* varieties. Alkaloid was present in the leaves of all the six varieties. Flavonoid was present in all the varieties except Unele Mmemme and Unele Ocha varieties. Saponin was present in all the varieties except Unele Akpukpoike cultivar. Phenol was present in all the varieties except Unele Mmemme cultivar. Tannin was found in all except Obuo odaa and Akpukpoike varieties.

Table I7 : Result of qualitative phytochemical analysis of leaves

	Preliminary Phytochemical constituents of the leaves				
	Alkaloid	flavonoid	Saponin	Phenol	Tannin
VARIETIES					
Unele Ebgeala	+	+	+	+	+
Unele Mmemme	+	-	+	-	+
Unele Obuo odaa	+	+	+	+	-
Unele Ocha	+	-	+	+	+
Unele Ojii	+	+	+	+	+
Unele Akpukpo ike	+	+	-	+	-

\+ = presence of the Phytochemical , - = Absence of the phytochemical

Table 18 indicated the result of phytochemical analysis of the fruit of the six *Musa sapientum* varieties as reported below. Alkaloid was present in the fruits of all the varieties except Unele Egbeala . Flavonoid and Phenol were present in the fruit of all the varieties . Saponin was present in the fruit of Unele Egbeala and Unele Akpokpoike varieties and absent in all other varieties . Tannin was found in all except Unele Egbeala and Unele Obuo odaa varieties .

Table 18 : Result of qualitative phytochemical analysis of fruit

CULTIVAR	**Preliminary Phytochemical constituents of the fruits**				
	Alkaloid	flavonoid	Saponin	Phenol	Tannin
Unele Ebgeala	-	+	+	+	-
Unele Mmemme	+	+	-	+	+
Unele Obuo odaa	+	+	-	+	-
Unele Ocha	+	+	-	+	+
Unele Ojii	+	+	-	+	+
Unele Akpukpo ike	+	+	+	+	+

+ = presence of the Phytochemical , - = Absence of the phytochemical

Table 19 indicated the result of phytochemical analysis of the constituents of the roots of the six *Musa sapientum* varieties. Alkaloid was present in all the roots except in Unele Mmemme and Unele Akpukpoike varieties . Flavonoid and phenol were present in all the varieties except Unele Egbeala cultivar. Saponin was present in all the varieties except Unele Mmemme and Unele Obuo odaa varieties . Tannin was present in Unele Mmemme, Unele Obuo odaa and Unele Ojii and absent in Unele Akpukpoike, Unele Egbeala , Unele Ocha .

Table 19 : Result of qualitative phytochemical analysis of the roots

CULTIVAR	Alkaloid	flavonoid	Saponin	Phenol	Tannin
Unele Ebgeala	+	-	+	-	-
Unele Mmemme	-	+	-	+	+
Unele Obuo odaa	+	+	-	+	+
Unele Ocha	+	+	+	+	-
Unele Ojii	+	+	+	+	+
Unele Akpukpo ike	-	+	+	+	-

+ = Presence of the phytochemical, - = Absence of the phytochemical

Table 20 indicated the result of phytochemical analysis of the stem of the six *Musa sapientum* varieties as reported below. Alkaloids, Saponin and Tannin were present in all the stems of the six varieties. Flavonoid and Phenol were present in all the varieties and absent in Unele Mmemme and Unele Egbeala varieties .

Table 20 : Result of qualitative phytochemical analysis of Stem of the six varieties

CULTIVAR	**Preliminary Phytochemical constituents of the Stem**				
	Alkaloid	flavonoid	Saponin	Phenol	Tannin
Unele Egbeala	+	-	+	-	+
Unele Mmemme	+	-	+	-	+
Unele Obuo odaa	+	+	+	+	+
Unele Ocha	+	+	+	+	+
Unele Ojii	+	+	+	+	+
Unele Akpukpo ike	+	+	+	+	+

+ = Presence of the Phytochemical , - = Absence of the phjytochemical

4.8.2 Quatitative Phytochemical constituents of *Musa sapientum* varieties

Table 21 indicated the result of alkaloid concentrations in the parts of the six *Musa sapientum* varieties. Alkaloids were found in the leaves and stems of the six varieties of *M. sapientum* varieties studied in range 0.210 ± 0.100 – 2.420 ± 0.010mg/100g in leaves and 0.900 ± 0.010 – 2.900 ± 0.010mg/100g in the stems. Alkaloids were present in fruits, leaves, stems and roots of Unele Ocha, Unele Obuo Odaa and Unele Ojii. It occurred in the range of 0.330 ± 0.40 – 1.027 ± 0.105mg/100g in all parts of obuo odaa variety, 0.420 ± 0.030 – 2.900 ± 0.030mg/100g in all parts of Unele ocha variety, and 0.450 ± 0.030 – 1.930 ± 0.010 in all parts of UneleOjii variety. It is absent in the fruits of Unele Egbeala , and roots of Unele Mmemme and Unele Akpukpoike.

TABLE:21. ALKALOID CONCENTRATIONS (mg/100g) IN PARTS OF THE SIX *M. sapientum* VARIETIES STUDIED

Plant Variety	Fruit	leaf	stem	root	P-value
Unele Ebgeala	-	$0.620{\pm}0.230^{d}$	$1.400{\pm}0.300^{c}$	$1.530{\pm}0.010^{a}$	
Unele Mmemme	$1.200{\pm}0.030^{a}$	$2.420{\pm}0.010^{a}$	$1.300{\pm}0.020^{c}$	-	
Unele Obuo odaa	$0.330{\pm}0.040^{b}$	$1.027{\pm}0.105^{c}$	$0.900{\pm}0.010^{d}$	$0.8200{\pm}0.030^{b}$	$p<0.05$,
Unele Ocha	$0.420{\pm}0.030^{b}$	$1.467{\pm}0.586^{b}$	$2.900{\pm}0.030^{a}$	$0.800{\pm}0.020^{b}$	
Unele Ojii	$0.620{\pm}0.010^{b}$	$1.700{\pm}0.030^{b}$	$1.930{\pm}0.010^{b}$	$0.450{\pm}0.030^{c}$	
Unele Akpukpoike	$0.060{\pm}0.010^{c}$	$0.210{\pm}0.100^{e}$	$1.200{\pm}0.070^{c}$	-	

Results are in Mean ± standard deviation

* The varieties having same letters in a column indicates that they are not significantly different in their constituents.

Table 22 indicated the result of tannins concentrations in the parts of the six *Musa sapientum* varieties. Tannins were present in all *Musa sapientum* varieties studied. (Table) but differed in its concentrations in different parts of the plants. Highest concentrations were observed in the stems (2.33 $\pm$ 0.065 – 7.400 $\pm$ 0.100 mg/100g) and leaves (1.120 $\pm$ 0.060 – 6.500 $\pm$ 0.020 mg/100g). It was observed in all parts (fruits, leaves, stem and roots) of Unele Mmemme cultivar (0.930 $\pm$ 0.100 – 4.500 $\pm$ 0.030 mg/100g); Unele Ojii cultivar (1.900 $\pm$ 0.010 – 6.500 $\pm$ 0.020mg/100g). It is absent in the fruits and roots of Unele Egbeala , leaves and stems of UneleObuo Odaa, leaves of Unele Akpukpoike and roots of Unele Ocha.

TABLE:22 TANNIN CONCENTRATION (mg/100g) IN PARTS OF THE SIX *M.sapientum* VARIETIES STUDIED

	Fruit	leaf	stem	root	P-value
Unele Ebgeala	-	1.120 ± 0.060^{c}	7.400 ± 0.100^{a}	-	
Unele Mmemme	0.930 ± 0.100^{b}	4.500 ± 0.030^{b}	2.867 ± 0.252^{d}	3.200 ± 0.000^{b}	
Unele Obuo odaa	0.769 ± 0.280^{b}	-	-	6.300 ± 0.010^{a}	$p<0.05$
Unele Ocha	1.930 ± 0.030^{b}	4.327 ± 0.074^{b}	2.333 ± 0.065^{e}	-	
Unele Ojii	3.010 ± 0.070^{a}	6.500 ± 0.020^{a}	4.820 ± 0.060^{c}	1.900 ± 0.010^{c}	
Unele Akpukpoike	0.040 ± 0.020^{c}	-	6.300 ± 0.200^{b}	4.420 ± 0.300^{b}	

Results are in Mean ± standard deviation

* The varieties having same letters in a column indicates that they are not significantly different in their constituents.

Table 23 indicated the result of saponins concentrations in the parts of the six *Musa sapientum* varieties. Saponins were found present in all the *Musa sapientum* varieties studied, but lacking in some parts of the varieties. It is present in the stems of all the varieties (1.400 ± 0.400 – 2.400 ± 0.030mg/100g) and all parts of Unele Egbeala (0.420 ±0.100 – 1.900 ± 0.010mg/100g). It is totally lacking in the fruits of Unele Mmemme, Unele Ocha, and Unele Ojii varieties. It is lacking in the leaves of Unele Obuo odaa, and Unele Akpukpoike and the roots of Unele Mmemme.

TABLE : 23 SAPONINS CONCENTRATION (mg/100g) IN PARTS OF SIX *Musa sapientum* VARIETIES.

Saponin

	Fruit	leaf	stem	root	P-value
Unele Ebgeala	0.420±0.000[b]	1.900±0.010[b]	1.400±0.040[c]	1.100±0.300[c]	
Unele Mmemme	-	1.200±0.020[b]	2.020±0.200[b]	-	
Unele Obuo odaa	4.950±1.527[a]		3.400±0.030[a]	2.200±0.040[a]	p<0.05
Unele Ocha	-	2.200±0.030[a]	2.400±0.020[b]	1.900±0.010[b]	
Unele Ojii	-	2.523±0.031[a]	1.900±0.400[c]	0.090±0.010[c]	
Unele Akpukpoike	0.050±0.044[c]	-	2.400±0.030[b]	1.800±0.220[b]	

Results are in Mean ± standard deviation
* The varieties having same letters in a column indicates that they are not significantly different in their constituents.

Flavonoids were present in all the *Musa sapientum*varieties studied (table24) in the range of 0.120 $\pm$ 0.044 – 2.800 $\pm$ 0.658mg/100g. It was present in the fruits of all the varieties (0.160 $\pm$ 000 – 2.800 $\pm$ 0.658 mg/100g); all parts of Unele Obuo odaa (0.110 $\pm$ 0.020 – 2.800 $\pm$ 0.658 mg/100g) and Unele Akpukpoike (0.120 $\pm$ 0.044 – 0.800 $\pm$ 0.090 mg/100g). It is absent in the leaves of UneleMmemme, UneleOcha, and UneleOjii, stems of Unele Egbeala and Unele Mmemme and the roots of Unele Egbeala .

TABLE: 24 . FLAVONOID CONCENTRATION (mg/100g) IN DIFFERENT PARTS OF THE SIX *M. sapientum*VARIETIES STUDIED

	Fruit	leaf	stem	root	P-value
Unele Ebgeala	0.160 ± 0.030^{d}	0.300 ± 0.100^{b}	-	-	
Unele Mmemme	0.800 ± 0.030^{c}	-	-	0.330 ± 0.010^{c}	
Unele Obuo odaa	2.800 ± 0.658^{a}	0.110 ± 0.020^{c}	1.100 ± 0.010^{a}	0.430 ± 0.070^{b}	
Unele Ocha	1.300 ± 0.010^{b}	-	0.800 ± 0.020^{b}	0.320 ± 0.010^{c}	$p<0.05$
Unele Ojii	0.800 ± 0.030^{c}	0.730 ± 0.183^{a}	0.600 ± 0.020^{b}	0.120 ± 0.030^{d}	
Unele Akpukpoike	0.120 ± 0.020^{d}	0.420 ± 0.100^{b}	0.800 ± 0.010^{b}	0.530 ± 0.060^{a}	
Unele Akpukpoike	0.180 ± 0.020^{b}	0.820 ± 0.030^{a}	0.400 ± 0.111^{c}	0.280 ± 0.020^{b}	

Results are in Mean ± standard deviation

* The varieties having same letters in a column indicates that they are not significantly different in their constituents.

Phenols were present in the fruits of all *M. sapientum* varieties studied (table25) in the range of 0.080 $\pm$ 0.010 to 0.635 $\pm$ 0.407mg/100g. It is present in the fruits, leaves, stems and roots of Unele Obuo odaa, Unele Ocha, Unele Ojii and Unele Akpukpoike. They are present in the fruits of all varieties (0.080 $\pm$ 0.010 – 0.635 $\pm$ 0.407mg/100g) and all parts of Unele Obuo odaa (0.100 $\pm$ 0.020 – 0.635 $\pm$ 4.07mg/100g), Unele Ocha (0.103 $\pm$ 0.057 – 0.620 $\pm$ 0.010mg/100g) UneleOjii (0.060 $\pm$ 0.020 – 0.420 $\pm$ 0.030mg/100g) and Unele Akpukpoike (0.180 $\pm$ 0.020 – 0.820 $\pm$ 0.030mg/100g). Phenols were absent in the stems and roots of UneleEgbeala and leaves and stems of Unele Mmemme.

TABLE:25 PHENOLS CONCENTRATION (mg/100g) OF VARIOUS PARTS OF THE SIX *Musa sapientum* VARIETIES STUDIED

	Fruit	**leaf**	**stem**	**root**	**P-value**
Unele Ebgeala	0.090±0.020[c]	1.200±0.030[a]	-	-	
Unele Mmemme	0.100±0.030[c]	-	-	0.900±0.010[a]	
Unele Obuo odaa	0.635±0.407[a]	0.100±0.020[b]	0.520±0.030[b]	0.330±0.010[b]	$p<0.05$
Unele Ocha	0.110±0.010[b]	0.400±0.040[b]	0.620±0.010[a]	0.103±0.057[b]	
Unele Ojii	0.080±0.010[c]	0.300±0.010[b]	0.420±0.030[c]	0.060±0.020[c]	

Results are in Mean ± standard deviation

* The varieties having same letters in a column indicates that they are not significantly different in their constituents.

4.9 Proximate study

The results of assay of the proximate and mineral composition of seven banana varieties namely Unele Egbeala , Unele Mmemme, Unele Obuo odaa, Unele Ocha, Unele Ojii and Unele Akpukpoike were summarized in tables (26-31). Moisture was found to be a constituent of all the parts of the six varieties of the *Musa sapientum* varieties studied in percentages not widely different.

The percentage of moisture constituent were in the range of 9.760 $\pm$ 0.020 – 10.980 $\pm$ 0.020% for fruits, 23.960 $\pm$ 0.520 – 38.600 $\pm$ 0.300% for the leaves, 60.400 $\pm$ 0.010 – 69.500 $\pm$ 0.010% for the stems and 28.400 $\pm$ 0.070 – 35.200 $\pm$ 0.010% for the roots.

TABLE:26 Percentage moisture constituents of the parts of six banana varieties

	Fruit	leaf	stem	root	P-value
Unele Ebgeala	11.710 ± 0.010^{a}	34.500 ± 0.690^{b}	64.500 ± 1.749^{c}	35.200 ± 0.010^{a}	
Unele Mmemme	10.970 ± 0.017^{b}	38.600 ± 0.300^{a}	69.500 ± 0.010^{a}	30.000 ± 0.020^{c}	
Unele Obuo odaa	9.760 ± 0.020^{f}	35.280 ± 0.390^{b}	64.400 ± 0.050^{c}	28.800 ± 0.010^{e}	$p<0.05$
Unele Ocha	10.377 ± 0.006^{c}	35.280 ± 0.390^{b}	65.520 ± 0.100^{c}	29.400 ± 0.030^{d}	
Unele Ojii	10.250 ± 0.010^{d}	33.160 ± 0.530^{c}	60.400 ± 0.010^{d}	28.400 ± 0.070^{d}	
Unele Akpukpoike	9.980 ± 0.020^{e}	23.960 ± 0.520^{c}	68.200 ± 0.020^{b}	33.200 ± 0.010^{b}	

Results are in Mean ± standard deviation

* The varieties having same letters in a column indicates that they are not significantly different in their constituents.

Crude proteins were found as constituents of all the parts of six varieties of *Musa sapientum* varieties studied (table27). Percentage of crude proteins constituents of the parts varied in the range of 2.700 ± 0.070 – 4.727 ± 0.006% for the fruits, 7.700 ± 0.020 – 28.600 ± 0.030% for the leaves, 2.900 ± 0.040 – 5.030 ± 0.070% for the stems, and 7.700 ± 0.030 – 11.450 ± 0.150% for the roots.

TABLE: 27 Percentage Crude Protein constituents of the parts of six banana varieties

	Fruit	leaf	stem	root	P-value
Unele Ebgeala	3.763±0.006[d]	28.600±0.030[a]	5.030±0.070[a]	9.600±0.020[b]	
Unele Mmemme	3.933±0.012[c]	7.700±0.020[c]	3.787±0.107[c]	7.700±0.030[d]	
Unele Obuo odaa	4.727±0.006[a]	13.200±0.030[c]	4.820±0.030[b]	11.450±0.150[a]	$p<0.05$
Unele Ocha	4.200±0.100[b]	13.200±0.030[c]	2.900±0.040[d]	9.177±0.049[b]	
Unele Ojii	4.640±0.010[a]	16.420±0.030[b]	4.800±0.020[b]	11.067±0.578[a]	
Unele Akpukpoike	2.700±0.070[e]	12.600±0.030[d]	3.700±0.010[c]	8.600±0.060[c]	

Results are in Mean ± standard deviation

* The varieties having same letters in a column indicates that they are not significantly different in their constituents.

Crude fibre was found as constituents of all the parts of six varieties of *Musa sapientum* varieties studied (table28). Percentage of crude fibre constituents of the parts varied in the range of 0.347 ± 0.012 – 0.540 ± 0.020% for the fruits, 5.000 ± 0.100 – 13.269 ± 0.031% for the leaves, 0.500 ± 0.040 – 1.700 ± 0.030% for the stems, and 8.470 ± 0.120 – 48.200 ± 0.120% for the roots.

TABLE: 28 Percentage Crude Fibre constituents of the parts of six banana varieties

	Fruit	leaf	stem	root	P-value
Unele Ebgeala	0.517±0.006[b]	5.600±0.020[d]	0.500±0.040[f]	8.470±0.120[f]	
Unele Mmemme	0.490±0.010[c]	5.000±0.100[e]	1.620±0.020[b]	48.200±0.120[a]	
Unele Obuo odaa	0.347±0.012[e]	6.400±0.020[c]	0.820±0.010[e]	32.600±0.010[b]	$p<0.05$
Unele Ocha	0.520±0.010[a]	6.400±0.020[c]	1.203±0.021[c]	12.633±0.560[e]	
Unele Ojii	0.420±0.010[d]	8.200±0.030[b]	0.900±0.010[d]	28.400±0.020[c]	
Unele Akpukpoike	0.540±0.020[a]	13.267±0.031[a]	1.700±0.030[a]	20.400±0.031[d]	

Results are in Mean ± standard deviation

* The varieties having same letters in a column indicates that they are not significantly different in their constituents.

Carbohydrate was a constituent of all the parts of six varieties of *Musa sapientum* varieties studied (table29). Percentage of carbohydrate constituent of the parts varied in the range of 77.01 $\pm$ 0.010 – 84.627 $\pm$ 0.065% for the fruits, 18.190 $\pm$ 0.630 – 48.243 $\pm$ 0.590% for the leaves, 20.270 $\pm$ 0.017 – 29.410 $\pm$ 0.080% for the stems, and 23.700 $\pm$ 0.100 – 43.850 $\pm$ 0.160% for the roots.

TABLE: 29 Percentage Carbohydrate constituents of the parts of six banana varieties

	Fruit	**leaf**	**stem**	**root**	**P-value**
Unele Ebgeala	77.010±0.010[f]	18.190±0.630[d]	29.410±0.080[a]	23.700±0.110[e]	
Unele Mmemme	78.030±0.010[e]	43.410±0.460[b]	20.270±0.017[f]	28.200±0.080[d]	
Unele Obuo odaa	80.100±0.050[b]	42.400±0.560[b]	28.240±0.020[b]	34.020±1.250[b]	$p<0.05$
Unele Ocha	78.770±0.020[d]	42.400±0.560[b]	25.440±0.030[d]	43.850±0.160[a]	
Unele Ojii	79.210±0.040[c]	37.300±0.600[c]	27.400±0.090[c]	30.967±0.104[c]	
Unele Akpukpoike	84.627±0.065[a]	48.243±0.590[a]	22.480±0.070[e]	31.200±0.490[c]	

Results are in Mean ± standard deviation

* The varieties having same letters in a column indicates that they are not significantly different in their constituents.

The percentage Ash constituent of parts of six of *Musa sapientum* varieties studied indicated variation in the range of 2.150 ± 0.00 – 6.620 ± 0.020% for the fruits, 8.100 ± 0.010 – 14.100 ± 0.020% for the leaves, 1.720 ± 0.030 – 2.733 ± 0.021% for the stems, and 7.830 ± 0.580 – 16.300 ± 0.040% for the roots(table 30).

TABLE 30. Percentage Ash constituents of the parts of six banana varieties

	Fruit	leaf	stem	root	P-value
Unele Ebgeala	6.620±0.020[a]	8.100±0.010[e]	1.817±0.006[d]	16.300±0.040[a]	
Unele Mmemme	5.870±0.010[b]	9.500±0.040[c]	2.450±0.020[b]	16.200±0.200[a]	
Unele Obuo odaa	4.290±0.010[e]	8.600±0.130[d]	1.720±0.030[d]	7.830±0.580[e]	$p<0.05$
Unele Ocha	5.420±0.020[c]	8.600±0.130[d]	2.733±0.021[a]	9.150±0.020[d]	
Unele Ojii	4.730±0.040[d]	12.400±0.010[b]	2.197±0.006[c]	12.800±0.040[c]	
Unele Akpukpoike	2.150±0.000[f]	14.100±0.020[a]	2.400±0.200[b]	14.400±0.220[b]	

Results are in Mean ± standard deviation

* The varieties having same letters in a column indicates that they are not significantly different in their constituents.

The percentage of Fat constituents of parts of six of *Musa sapientum* varieties studied indicated variation in the range of 0.610 ± 0.00 – 0.750 ± 0.010% for the fruits, 0.520 ± 0.010 – 1.100 ± 0.020% for the leaves, 1.240 ± 0.030 – 6.440 ± 0.020% for the stems, and 8.400 ± 0.100 – 18.400 ± 0.100% for the roots (table 30).

TABLE: 31 Percentage Fat constituents of the parts of six banana varieties

	Fruit	leaf	stem	root	P-value
Unele Ebgeala	$0.743{\pm}0.006^{b}$	$0.610{\pm}0.020^{d}$	$1.240{\pm}0.030^{f}$	$15.233{\pm}0.095^{d}$	
Unele Mmemme	$0.710{\pm}0.010^{c}$	$0.880{\pm}0.010^{b}$	$4.043{\pm}0.012^{c}$	$17.900{\pm}0.010^{b}$	
Unele Obuo odaa	$0.780{\pm}0.010^{a}$	$0.520{\pm}0.010^{e}$	$6.440{\pm}0.020^{a}$	$18.300{\pm}0.120^{a}$	$p<0.05$
Unele Ocha	$0.677{\pm}0.006^{d}$	$0.520{\pm}0.010^{e}$	$3.400{\pm}0.020^{d}$	$8.400{\pm}0.100^{f}$	
Unele Ojii	$0.750{\pm}0.010^{b}$	$0.720{\pm}0.030^{c}$	$5.200{\pm}0.060^{b}$	$17.400{\pm}0.020^{c}$	
Unele Akpukpoike	$0.610{\pm}0.000^{e}$	$1.100{\pm}0.020^{a}$	$3.300{\pm}0.020^{e}$	$12.600{\pm}0.200^{e}$	

Results are in Mean ± standard deviation

* .Means within the same column with the same subscripts were not significantly different (Duncan's test)

4.10 Mineral constituents of six varieties of banana

Table 32 indicated the quantitative mineral contents of the fruit of the six varieties of banana in miligram per one hundred grams of the fruit. Potassium was found to be the mineral occurring in highest quantity with Unele Akpukpoike banana variety having the highest content of Potassium and Unele Mmemme variety containing the least. Iron was the mineral occurring in least quantity in the six varieties. The highest quantity of iron was 0.7 Mg/100g for Unele Mmemme variety and the least quantity of 0.3mg/100g for Unele Obuo oda variety.

Table 32. Mineral constituents of Fruit of Six Varieties of Banana

	MINERAL CONSTITUENTS (Mg/100g)					
VARIETIES	POTASS-IUM	MAGNESIUM	CALCIUM	SODIUM	IRON	PHOS-PHORUS
Egbeala	226.8	35.8	9.5	7.4	0.4	22.00
Mmemme	100.2	83.8	19.4	0.8	0.7	20.80
Obuoda	222.8	23.9	6.1	0.6	0.3	12.00
Unele ocha	244	31.8	5.8	0.9	0.4	14.50
Unele Oji	180.7	40.8	11.4	1.2	0.5	18.80
Akpukpo Ike	251.6	55.4	18.8	5.2	0.6	21.00

Each value in the table is the average ± standard deviations of triplicate experiments.

4.10.1 Mineral constituents of the Stem of Six Varieties of Banana

Table 33 showed the quatities of mineral content of the stems of the six banana varieties in mg/100g of stem tissue. Potassium was the dominant mineral. The highest potassium and sodium content were recorded in the stem of Unele Mmemme (1150mg/100g) and 43.20mg/100g respectively. Unele Akpukpoike was highest in magnesium, Iron, phosphorus and calcium content.

Table 33. Mineral constituents of the Stem of Six Varieties of Banana

	MINERAL CONSTITUENTS (Mg/100g)					
VARIETIES	Potassium	Magnesium	Calcium	Sodium	Iron	Phosphorus
Egbeala	794.50	16.20	15.40	33.10	0.71	0.75
Mmemme	1150.00	12.40	7.50	43.20	1.01	0.52
Obuo oda	980.70	9.40	12.80	36.30	0.66	0.88
Unele ocha	980.70	10.80	18.20	35.60	0.77	0.10
Unele oji	1020.30	11.30	13.80	30.10	0.71	0.85
Akpukpo Ike	1112.00	17.40	20.00	28.40	0.83	1.01

Each value in the table is the average ± standard deviations of triplicate experiments.

4.10.2 Mineral constituents of the leaves of six varieties of banana

Table 34 showed the quatitative mineral contents of the leaves of six varieties in mg/100g . Sodium was the dominant mineral in the leaves. The highest sodium and potassium content were recorded in the leaves of Unele Mmemme (21.20mg/100g and 13.40mg/100g respectively) . Unele oji was highest in magnesium, Unele Akpukpoike in calcium. In phosphorus Unele Egbeala was the highest while Unele Akpukpoike was the least.

Table34. Mineral constituents of leaves of six varieties of banana

VARIETIES	**MINERAL CONSTITUENTS (Mg/100g)**					
	Potassium	Magnesium	Calcium	Sodium	Iron	Phosphorus
Egbeala	3.60	8.40	1.20	18.20	0.10	25.10
Mmemme	13.40	7.90	3.30	21.20	0.30	10.00
Unele Ocha	9.50	9.30	2.10	16.00	0.11	4.40
Unele Oji	11.10	16.20	5.40	13.40	0.20	6.40
Obuo oda	6.70	6.40	1.80	19.40	0.21	12.00
Akpukpo Ike	8.70	14.40	7.50	16.60	0.30	2.40

Each value in the table is the average ± standard deviations of triplicate experiments.

4.10.3 Mineral constituents of roots of six banana varieties

Table 35 showed the mineral content in mg/100g of the roots of six varieties of banana . Potassium was the dominant mineral. The roots generally have high values of potassium, magnesium, calcium and sodium (Table 28) with phosphorus and iron being the least.

The highest potassium content was recorded in the roots of Unele Obuo oda (1120.00mg/100g). Unele Ocha was highest in magnesium and sodium, Unele Akpukpoike in calcium and phosphorus while Unele Ocha was the least in phosphorus.

Table 35. Mineral constituents of roots of six banana varieties in Mg/100g

VARIETIES	MINERAL **CONSTITUENTS** (Mg/100g)					
	POTASSIUM	**MAGNESIUM**	**CALCIUM**	**SODIUM**	**IRON**	**PHOS PHORUS**
Egbeala	820.00	58.20	20.80	38.20	1.40	1.45
Mmemme	1040.60	33.00	12.90	41.20	1.70	1.02
Obuo oda	1120.00	29.30	17.90	35.20	1.60	1.60
Unele Ocha	1110.30	40.40	23.40	45.60	0.80	0.77
Unele Oji	930.40	38.20	17.60	39.90	1.20	1.01
Akpukpo Ike	1020.20	55.50	28.00	37.80	2.01	2.00

Each value in the table is the average ± standard deviations of triplicate experiments.

4. 11 Dichotomous K to *Musa* ey *sapientum* species

1a Finger rind color when ripe yellow, endosperm cream or yellow colour when ripe , phloem bundles present, petiole canal without curved margin, fruit endosperm color wnen unripe whitish ……………………………………………2

1bFinger rind color when ripe brown, endosperm butter color when ripe , phloem bundles absent, petiole canal with curved margin , fruit endosperm color wnen unripe golden…..……………………………………………Unele Mmemme

2aPresence of petiole canal with overlapping margins, black blotches on the pseudostem ……………………………………………………………………3

2b Presence of petiole canal without overlapping margins, without black blotches on the pseudostem 4

3a Lack of tannin in the leaves..Unele Ojii

3b Presences of tannin in the leaves.......................... ....Unele Ocha

4a Petiole canal with erect margin, root brown in colour when matured..5

4b Petiol canal without erect margin., root milk in colour when matured.................. ....Unele Egbeala

5a brown black blotches on the pseudostem ....Unele Obuo odaa

5b no blotches on the pseudostem .... Unele Akpukpoike

CHAPTER FIVE

DISCUSSION

The observation drawn from the morphological study of the six variaties of banana namely; Egbeala , Mmemme, Obuo odaa, Unele Ojii, Unele Ocha, Akpukpoike in Igbo indicates that there are gross morphological similarities of having underground stems from which adventitious roots and suckers that will form new plants arise; their leaves arise from the underground stems and with their petioles form the pseudostem and then the apparent leaf blades and complete inflorescence at maturity with persistent male floral bud which are similar.

The six varieties of *Musa sapientum* were also found to be similar in general structure of the leaves consisting of a pseudostem made of distichous arrangement of petioles of the leaves, large oblong simple leaves, color and bases of the leaves. The root colors are all white for the young roots of the six varieties and when mature the roots assume milk color except that of Akpukpoike and Obuo odaawhich became brown. The rhizomes are white in color except that of Unele Mmemme and Obuo odaawhich are pinkish in color. For all the varieties the rhizomes are smooth.

Their differences are more noticeable in their fruits in terms of sizes and number of hands, number of fingers and shape of fingers in a hand. The Unele Ojii

bears a bunch with fewer hands and second least in number of fruit, but individual fruits are small. The inflorescence axis had deformed glomerules and terminates with male floral bud in all the varieties. In the Unele Ocha, the bunch contains an increased number of hands and fruits, but the individual fruits are thinner than those of the Unele Ojii type. The Obua odaa bears a bunch containing many hands with an increased number of fruits per hand, but the fruits bigger widths. At maturity, the inflorescence is complete with presence of both hermaphrodite flowers and a persistent male bud. The highest end of the rachis bear degenerate fruits like in others by consisting of highly elongated rachis that bears scars of flower stalk bases at regular intervals and that the terminal spike at the end are still fresh.

The observation drawn from the study of the gross morphology of the pseudustem of the six varieties of banana namely: Unele Ocha, Unele Ojii, Unele Mmemme, Obuo odaa, Akpukpoike and Egbeala was that their differences were mainly noticeable in the color, shape, pigmentation, general appearance and sap of the pseudostem. Similarities in the pseudostem morphology confirm that Akpukpoike, Obuo odaa and Unele Ocha on one hand and Egbeala on the other have more common features and therefore most closely related based on their eleven related characters while those with one and two characters in common like the Unele Ocha, Unele Ojii and Obuo odaa are less related.

The observation drawn from the comparative gross morphology of petiole of six Banana varieties namely Unele Ocha, Unele Ojii, Unele Mmemme, Obuo odaa, Akpukpoike, Egbeala , indicates that the six varieties are mainly different in their petiole canal, color of petiole, length of petiole, petiole appearance and sap dripping upon cutting. The petiole differences in the morphology confirm that the varieties may not be actually closely related.

Significantly marked morphological differences exist among all the banana varieties. Morphological profiles of different varieties examined can be used as parameters for distinguishing these varieties. In summary, bunch phenotype is considered the most striking morphological trait for differentiation of clones (Swemen and Vuylsteke, 1987).

The Banana inflorescence arises from the rhizome and grows through the middle of the pseudostem to the apex of the plant. At first a large, long oval, tapering purple glued bud emerges and as it opens, white flowers appear. They are of spike type of inflorescence and clustered in whorled rows along the rachis. Each cluster is covered by a thick hood like bract, purple outside and deep red within. Banana has the complete *Musa* inflorescence, which include female flowers, neutral flowers (which do not develop into fruits and fall off during bunch maturation) and male bud at maturity. The inflorescence has many bracts (modified leaves that look like petals between rows of flowers). The flowers are spirally arranged in whorl –

like clusters along the spike, and there are slight differences in the Pedicel, Elbow of the bract, Ovule, Peak of bract, color of the bract, color of the male flower and bend of the bract while they are the same in the position of the ovary, shape of bract and arrangement of the flowers.

The fruit morphology of the six varieties of banana under study indicated considerable differences in various aspects. Measurements of finger length indicates variation from longest value of 15.4 ± 0.9cm for Unele Ocha to the least value of 8.2± 0.5cm for Unele Ojii . In the circumference Obua odaa has the hghest value of 13±0.6cm while the least of 9.6±0.78 cm for Akpukpo Ike cultivar. In distance from one hand to another ranged from the highest value of 10.4±0.36 cm for Akpukpo Ike to the least value of 6.8±0.44cm for Unele Ojii. The number of hands in the bunch varied from the highest number of 13 hands for Obuo odaa cultivar to the least number of 5 hands for Unele Ojii . The number of fingers in the hand ranged from the highest number of 16 fingers for Unele Mmemme to the least number of 13 fingers for Egbeala cultivar.

All the fruits have four faces except Unele Mmemme that has three faces.

The fruits of the six banana varieties are all oblong in shape, yellow in color when ripe except the fruit of Unele Mmemme which becomes brown in color when it is ripe. All the fruit have smooth surfaces, four (4) symmetrical line on the banana

suface for Unele Mmemme, Akpukpoike and Obuo odaa varieties and 3 to 5 lines for Unele Ojii, while Unele Ocha and egbeela varieties have 4 to 5lines and 3 to 4 lines respectively. These lines delineate the faces of fruits.

The fruit endosperms of all 6 varieties are of oblong shape, and are all rough surfaced with presence of phloem bundles in all the endosperms.

The color of endosperm when ripe is cream color for Egbeala, Unele Ojii, akpukpo ike and Obuo odaa varieties, yellow for Unele Ocha and butter color for Unele Mmemme.

The endosperm of five varieties of the Banana Unele Ocha , Unele Ojii, Obuo odaa, Egbeala are all whitish in color when unripe , while only Unele Mmemme variety alone has its endosperm colored golden . All the unripe fruits of the six varieties of banana tested sour. Phloem bundles are not present in the unripe endosperm of the six varieties. The unripe fruit of the six varieties are firm in consistency. The varieties Unele Ojii, Unele Mmemme, and Akpukpoike have non-gummy unripe endosperm while those of the Unele Ocha, Obuo odaa, and Egbeala are gummy. The surfaces of all the unripe endosperm of the six varieties of the banana are coarse. The mean weights of the endosperm of the six varieties vary with Unele Ojii having the least weight of 32.97g and Akpukpoike having the highest of 109.6g. The endosperm of fruits of Unele Ocha and Egbeala are white

when ripe, those of Unele Ojii and Akpukpoike are cream while that of Unele Mmemme is golden and that of Obuo odaa is whitish brown. Phloem bundles were present in all , except Unele Mmemme that has no phloem bundles. All the six varieties fruits are soft when ripe and are all smooth, their mean weights varied from the least of 63.40g for Unele Ojii to the highest of 114.74g for Akpukpoike.

The observation obtained from the anatomical study of the six Banana samples showed that the difference between these six varieties are mainly in their stomata distribution and the presence of lateral roots which appeared in Akpukpoike cultivar . The roots of all six varieties have similar structure, which consist of three tissue systems, one cell layer of epidermis, ground parenchyma and vascular cylinder.

Cortex of mature roots had many layers with thick walled cells in the outer part. According to Tomlinson (1969) those tissues thick walled cells constitute the periderm the tissues that form a protective layer. Cortex is composed of parenchymatous cells, with irregular shapes. The layers of cells of the cortex are many with unequal five sided structure in the six varieties. Endodermis is the boundary layer which is composed of thick cell. The cell wall of endodermis has U-like shape thickening of Suberin and cellulose materials (Esau, 1978). The endodermis thickened and had a U shape in all the varieties.

The lateral root started from pericycle to the epiblema of the roots. The root anatomy of the six varieties of *Musa sapientrum* studied are depicted in plates 1-6. Pericycle is the outer layer vascular cylinder. It is a single cell layer, and composed of meristematic cells. In mature root the function of this layer was formation of adventitious roots (Fahn, 1990). The roots of Akpukpoike banana varieties are polygonal and showed primordial adventitious root which originated from the cortex and transversed the cortex, stopping at the epidermis while they are more circular and without primordial adventitious root in other five Banana varieties. The vascular bundles are scattered and composed of xylem and phloem, which lies in the same axis (collateral and close) (Raven *et al*., 1999). An interesting aspect of the root anatomy is the concentration of vascular bundles at the central portion of the root cortex, hence the endodermis is not clearly differentiated in the six varieties studied (plates 1 to 6). Again, the epidermal cells of the root cortex of the six varieties are thin and are not well differentiated.

The phloem cells are formed alternately with vessel cells in the peripheral side of cylinder, and no pith is found. Generally in monocotyledonous root, xylem frequently forms a solid core with ridgelike projections, and strands of phloem alternate with the xylem ridge. (Esau, 1978). In Banana root phloem are widespread between the vessels in the center. So the arrangement of phloem is irregular in the central zone, and xylem did not form ridge like structure as found

generally in monocotyledonous root. This condition showed an anomalous structure (Tomlison, 1969).

Laticifer cells were scattered in the cortex and vascular cylinder zone of six Banana varieties root. Laticifers are cells or series of connected cells that contain latex, a fluid of complex composition of substances. Banana laticifer was either colorless, milk color or brown color. The types of laticifer in all Banana varieties were compound type and non-anastomotic.

The similarities in root anatomical structures such as the size and number of vascular bundles and that the epidermal cells are not well differentiated in all the six varieties showed strong specific relationships among the six varieties and therefore suggests *Musa sapientum.* Also, the differences in the root anatomical features of the six varieties (Epiblema originating from the cortex and transversing the cortex in the roots of the Akpukpoike Banana and stopping at the epidermis distinguished the varieties from the others where the lateral roots originates from the epidermis. This suggests reasons to affirm that other five banana varieties to have closer affinity genetically than with Akpukpoike.

These differences strengthen the reliability of anatomical character in systematic botany as stated by Ayensu (1970) in *Dioscorea catundata,* Poir and *Dioscorea coyenensis* Lam, Edeoga (2002) in Dioscorea species, Edeoga and Okoli (1997) in

Costaceae. Rhizome consists of epidermis, pheriphery zone and center zone. Epidermis is a single layer of dense cells, without intercellular space. In mature rhizome, many layers of periderm were found beneath the epidermis. In rhizome there was no cortex like those in monocotyledons stem. In monocotyledonous stem there is no cortex as well as stele because there is no demarcation between both areas (Esau, 1978).

Pheriphery zone consists of parenchymatic cells and small vascular bundles, with no partition between central zones. The shape of parenchymatic cells in periphery was irregular and they are of small sizes. The pheriphery zone was narrower than central zone. Small vascular bundle were scattered in the pheriphery zone. The xylem of vascular bundle consists of vessel cell and not all of bundle was protected by thick wall tissues. Central zone consists of irregular parenchymatic cells, which was wider compared with the periphery zone. The type of vascular bundle was close-collateral, because no cambium layer between the xylem and phloem were formed. The size of vascular bundle in central zone was bigger than in the pheriphery zone. In the part of the central zone the vascular bundles were even bigger. The xylem consists of vessel only, with thick wall. The phloem with thin wall was gathered in the side of vessel cells. The bundle was not protected by sheath. The size, structure, and diameter of vascular bundle varied among six Banana varieties.

The leaves have a single layer of cell in the epidermis. There was no difference observed in the other anatomical structures of the leaves of the six varieties.

The blade consisted of epidermal layer, vascular bundles and parenchyma cells. The shape of epidermis cells was pentagonal. The size of adaxial epidermal cells was bigger than that of abaxial epidermal cell. In all the six varieties hypodermis layer was found beneath the upper epidermal layer. Mesophyll (tissue between adaxial and abaxial epidermis) consisted of palisade and spongy tissues. These tissues consist of chloroplasts which contain chlorophyll pigment. There were two palisade layers found and has dense arrangement. Some of spongy cells are filled with few chloroplasts. This condition is the general structure of plantain leaf (Tomlinson, 1969). Spongy Parenchyma consists of thin walled cell, and irregularly placed. The airspace in spongy layer may be of lysigenous origin.

Vascular tissues distributed in mesophyll, consisted of small and big vascular bundles. The big vascular bundle composed of vessel, tracheid, fibre, parenchyma cells and phloem (Tomlinson, 1969). The vascular bundle of the four varieties is composed of xylem and phloem elements. The bundle surrounded by the parenchymatic or sclerenchymatic cells, was called bundle sheath. The small bundles were not protected by bundle sheath.

Stomata were found on both surfaces of epidermal layer. The type of stomata was panerophor. The shape of guard cell was kidney-like. Each stoma was surrounded by 2-4- cells. The distribution, the size and the index of stomata were varied in six Banana varieties. The stomata are more in number and closely distributed in the upper surface of the leaves than in the lower surface of the leaves of the six varieties.

Genetic Discussion

Out of the amplification products recorded, seven (7) primers gave no amplification while 3 RAPD primers revealed the relationship between these genotypes. From these three polymorphic RAPD makers that were used, 18 alleles were generated. Seven of the alleles generated were monomorphic while eleven were polymorphic. RAPD bands were manually scored from the gel profile, `1' for the presence and `0' for the absence of band and the binary data generated from all the profile, were used for statistical analysis. The similarity matrix was computed using squared Euclidean Distance (SED) that estimates all pair wise similarity in the amplification product. The dendogram (Figure: 3) was constructed by Ward's method of clustering. A pairwise comparison of the six (6) accessions shows the similarly coefficient ranges of the varieties. The dendogram generated from this data showed two similarity clustering (Figure: 3).

The first similarity cluster consisted of varieties 1, 4 and 6 (which are Obuo odaa, Unele Mmemme, and Unele Ojii). While the second similarity cluster consisted of varieties 2, 3 and 5 respectively (which are Unele Ocha, Akpupoike and Egbeala). Thus, the dendogram grouping of the samples studied, shows that all the varieties in cluster one are similar and can also be cross breed while all the varieties in cluster two are similar and can also be cross breed.

The results of the phytochemical analysis of the six varieties of *Musa sapientum* showed the presence of Phenols, alkaloids, flavonoids, saponins and tannins in varying proportions. The knowledge of presence or absence of some of these natural products in some of varieties of banana helps taxonomists to be in informed position while classifying *Musa sapientum* varieties.

Obuo odaa recorded highest saponin content in their fruit, and stem and non in their root.Saponin has the property of precipitating and coagulating red blood cells. Some of the characteristics of saponins include formation of foams in aqueous solutions, hemolytic activity, cholesterol binding properties (Eleazu *et al*., 2010) and bitterness (Sodipo *et al*., 2000). It also recorded highest concentration of flavonoids, phenol in their fruit. Egbeala recorded highest tannin in the stem, and second to the least in their leaves and none in their root and fruit. Obuo odaa has the lowest concentration of tannin in their fruit, contains no tannins in their leaves and stem while their roots have the highest concentration.Unele Ojii has the

highest concentration of tannin, saponin, flavonoid in their leaves. It also has the highest concentration of tannin in its fruit and leaf. Mmemme has the highest concentration of alkaloid in it's fruit, leaves, and third to the least in their stem and non in their root.It was observed that Egbeala fruit and root, Akpukpoike leaf, Obuo odaa stem, Unele Ocha root lack tannins while the other parts of the banana varities other than the parts mentioned above contain tannin as the most significant abundant phytochemicals in the banana varieties studied. Tannin seems to be the most abundant phytochemical in the stem of Egbeala having the highest tannin value (7.400±0.100mg). The least abundant phytchemical in the banana parts studied are flavonoid and phenol. From the results, the stem and leaves are richer in phytochemical nutrients with the Fruit being the least.

These phytochemicals found in the parts of banana plants are known to exist in large group of angiosperms and are responsible for the protection and disease resistance of this group of Angiosperm . Formally, it was taught that plants produces these chemicals to protect themselves, only, but recently it was discovered that when parts of plants are eaten by humans they can prevent or cure diseases in humans (Akunyili, 2000).

The presence of tannin in the plants implies they may have astringent properties and in addition, could quicken the healing of wounds and burns (Farquar, 1996).

Mmemme has the highest moisture contents in its stem and leaves, second to the highest in its fruit, with its roots having second to the lowest.

The moisture content in leaves showed no significant difference ($p<0.05$) between Egbeala , Obuo odaa and Unele Ocha, while that of Unele Ojii, Mmemme was significantly different from the above three. textural quality, chemical and biochemical reactions, as well as microbial growth rates are greatly affected by the moisture content of food products (Aurore *et al*., 2009).Akpukpoike has the highest crude fibre in all its parts except in the root were it is the least. In the fruit, the Egbeala recorded the highest ash content, followed in the decreasing order by the Mmemme, Unele Ocha, Obuo odaa and the lowest Akpukpoike. In the leaves the Akpukpoike recorded the highest ash content, followed in the decreasing order by the Unele Ojii, Mmemme, Unele Ocha, Obuo odaa and the Egbeala. The ash content of the six varieties was lowest in the stem, followed by the fruits, leaves and the roots. Egbeala recorded the highest ash (6.620%)contents in its fruit whereas Akpukpoike recorded the lowest (2.150%)and the difference between them was significant ($p<0.05$).In the root the Mmemme recorded the highest Crude protein content, followed in the decreasing order by the Obuo odaa , Akpukpoike Unele Ojii ,Unele Ocha and Egbeala recorded the least. In the fruit Obuo odaa

recorded the highest crude protein, followed in the decreasing order by the Unele Ojii, Unele Ocha, Egbeala and the Mmemme in the decreasing order.

In the leaves the Egbeala recorded the highest Crude protein content, followed by the Unele Ojii, Obuo odaa,Unele Ocha, Akpukpoike and the lowest the Mmemme. The Crude protein content of the six varieties was significantly different ($p<0.05$). The crude protein content obtained was comparatively higher than those recorded in literature for some other *Musa* spp. Aurore *et al*., (2009) reported .09% for cooking banana whereas Onwuka and Onwuka (2005), reported 2.8% for false horn plantain. These values may be due to environmental differences and more especially the differences in the soil used in cultivation.

Carbohydrate is highest in the fruit of Akpukpoike, followed in the decreasing order by those of the Obuo odaa, then Unele Ojii , Unele Ocha,Mmemme and the Egbeala . In the root Unele Ojii recorded the highest, followed in decreasing order by the Mmemme, Unele Ocha, Obuo odaa, and the Akpukpoike has the lowest. In the leaves the Akpukpoike recorded the highest Carbohydrate, followed by the Mmemme Obuo odaa, Unele Ocha and the Unele Ojii .

The fruit of the Akpukpoike recorded the highest crude fibre content, followed in the decreasing order by the Unele Ocha, Mmemme, Unele Ojii, Obuo odaa, and the Egbeala . In the stem Akpukpoike recorded the highest, followed in the decreasing

order by the Mmemme, Unele Ocha, Unele Ojii, Obuo odaa and the lowest in the Egbeala. The root of the Egbeala recorded the highest crude fibre, followed in the decreasing order by the Mmemme, Obuo odaa, Unele Ocha, Unele Ojii and the Akpukpoike. The leaves of the Akpukpoike recorded the highest crude fibre, followed in the decreasing order by the Unele Ojii , Obuo odaa,Egbeala , and Mmemme. Noor *et al*. (2011) , concluded that banana pseudo-stem flour is a potential functional food ingredient for products containing high dietary fiber.

The analysis of results of the mineral content of six varieties of banana showed the presence of calcium(Ca), potassium, iron(Fe), and magnesium(Mg). Unele Mmemme recorded 19.4 mg/100g, 0.7 mg/100g, 83.8 mg/100g and 20.80 mg/100g for Ca, Fe, and Mg, respectively. This indicated that the level of Ca, Mg and the Fe in Unele Mmemme fruit were significantly higher than in the Obuo odaa, Egbeala and Unele Ocha, Unele Ojii, and Akpukpoike. The most abundant mineral in the banana cultivar's fruit studied was potassium. The result agrees with Akinyosoye (1991) that banana fruit has high concentration of potassium and wide variation in potassium contents was revealed among varieties. Potassium is essential in the maintenance of cellular water balance, pH regulation in the body, and also associated with protein and carbohydrate metabolism (Eleazu *et al*., 2010). Increased intake of potassium can lower blood pressure up to 3.2mmHg; thereby reducing mortality by 8%, but on the other hand, high consumption of food rich in

potassium can cause irregular heartbeat, nausea, or slow pulse: Magnesium is an activator of many enzyme systems and maintains the electrical potential in nerves (Eleazu *et al*., 2010). Akpukpoike had the highest potassium value of 251.6 mg/100g, followed in the decreasing order by the Unele Ocha 244 mg/100g, Egbeala 226.8 mg/100g, Obuo odaa 222.8 mg/100g, Unele Ojii 180.7 mg/100g, and least Unele Mmemme 100.2 mg/100g.

Obuo odaa fruit recorded least value in most of all mineral content determined. Meanwhile for Ca, Fe, Na, P and Mg Akpukpoike fruit recorded second to the highest values and highest value in K. A range of mineral concentrations has been reported for bananas (Hardisson *et al.,* 2001; Wenkam, 1990), and these results generally agree with previous reports for P, K, and Ca. The discrepancies could be attributed to differences in morphological traits, physicochemical characteristics and environmental factors. The least occurring mineral in the banana varieties studied was Iron. Iron concentration was lowest, reflecting, lower values for iron as had been reported for the fruit (Smith *et al*., 1996). Iron carries oxygen to the cells and is necessary for the production of energy, synthesis of collagen and the proper functioning of the immune system. Its low concentration implies that banana will be an idyllic source of iron since its excess is implicated in abnormal functioning of the immune system, cell growth and the heart (Feming, 1998).

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CONCLUSION/RECOMMENDATION

There are similarities and differences in all characteristics of the six *Musa sapientum* varieties studied. Similarities in characteristics go to indicate high degree of relatedness among varieties while differences go to indicate less degree of relatedness among varieties of banana studied.

In morphological features all the varieties shared similarities in their possession of complete inflorescence at maturity with persistent male floral bud. This indicates a measure of genetical relatedness among them. In the anatomical features of the root the similarities in root anatomical structures such as the size and number of vascular bundles and that the epidermal cells are not well differentiated in all the six varieties showed strong specific relationships among the six varieties and therefore suggests that all the six varieties belong to *Musa sapiantum* specie. Also, the differences in the root anatomical features of the six varieties (Epiblema originating from the cortex and transversing the cortex in the roots of the Akpukpoike Banana and stopping at the epidermis distinguished the varieties from the others where the lateral roots originates from the epidermis. This suggests reasons to affirm that other five banana varieties to have closer affinity genetically than with Akpukpoike.

In the genetic relationship studied the first similarity cluster consisted of varieties 1, 4 and 5 (which are Egbela, Unele Mmemme, and Unele Ojii). While the second similarity cluster consists of varieties 2, 3 and 6 respectively (which are Unele Ocha, Akpupo ike and Obuo odaa).

Thus, the dendogram grouping of the samples studied, shows that all the varieties in cluster one are similar and can also be cross breed while all the varieties in cluster two are similar and can also be cross breed.

From the study of the genetic relationship it is obvious that Unele Ocha, Akpupo ike and Obuo odaa should belong to the same taxon at all levels should belong to the same taxon at all levels . The same also applies to Egbela, Unele Mmemme, and Unele Ojii .

From the results of his study it is evident that there are obvious similarities and differences in anatomical, genetical, phyotochemical, proximate, mineral and morphological features of six varieties of *Musa sapientum* studied. Such similarities and differences could proffer the keys to resolve the confuse state of affairs in classifying and naming the many existing varieties of *Musa sapientum*. The similarities in the varieties comfirm that the varieties are closely related being of the same family (Musaeceae) and the same genus Musa. The differences noted indicate that they are of different varieties pointing to possibility of their being of different species.

It is recommended that criteria that include morphological, anatomical, genetical, proximate, photochemical and mineral characteristics of these varieties should be adapted in classifying and naming them. More researches to gather information on the characteristics of all the varieties of *Musa sapientum* in the above direction are called for.

Finally, this study covered only the anatomical, mineral, proximate genetical, and phytochemical, morphological features of the six varieties. It did not study other lines of evidence such as palynology of these varieties, with views of gathering further evidences for total delimitation of these six varieties.

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APPENDIX

Appendix 1: ANOVA for Phytochemical Composition of the fruit, leaf, stem and root of Akpakpo Ike

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Alkaloid	Between Groups	2.302	2	1.151	230.220	.000
	Within Groups	.030	6	.005		
	Total	2.332	8			
Tannin	Between Groups	61.906	2	30.953	712.113	.000
	Within Groups	.261	6	.043		
	Total	62.167	8			
Saponin	Between Groups	8.945	2	4.473	262.061	.000
	Within Groups	.102	6	.017		
	Total	9.047	8			
Flavenoid	Between Groups	.712	3	.237	67.369	.000
	Within Groups	.028	8	.004		
	Total	.741	11			
Phenol	Between Groups	.713	3	.238	67.404	.000
	Within Groups	.028	8	.004		
	Total	.741	11			

Appendix 11: ANOVA for Phytochemical Composition of the fruit, leaf, stem and root of Egbeala

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Alkaloid	Between Groups	1.453	2	.727	15.245	.004
	Within Groups	.286	6	.048		
	Total	1.739	8			
Tannin	Between Groups	59.158	1	59.158	8699.647	.000
	Within Groups	.027	4	.007		
	Total	59.185	5			
Saponin	Between Groups	3.445	3	1.148	50.089	.000
	Within Groups	.183	8	.023		
	Total	3.628	11			
Flavenoid	Between Groups	.029	1	.029	5.394	.081
	Within Groups	.022	4	.005		
	Total	.051	5			
Phenol	Between Groups	1.848	1	1.848	2843.308	.000
	Within Groups	.003	4	.001		
	Total	1.851	5			

Appendix 111: ANOVA for Phytochemical Composition of the fruit, leaf, stem and root of Mmemme

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Alkaloid	Between Groups	2.753	2	1.376	2949.429	.000
	Within Groups	.003	6	.000		
	Total	2.756	8			
Tannin	Between Groups	19.588	3	6.529	351.828	.000
	Within Groups	.148	8	.019		
	Total	19.736	11			
Saponin	Between Groups	1.009	1	1.009	49.931	.002
	Within Groups	.081	4	.020		
	Total	1.089	5			
Flavenoid	Between Groups	.331	1	.331	662.700	.000
	Within Groups	.002	4	.000		
	Total	.333	5			
Phenol	Between Groups	.960	1	.960	1920.000	.000
	Within Groups	.002	4	.001		
	Total	.962	5			

Appendix 1V: ANOVA for Phytochemical Composition of the fruit, leaf, stem and root of Unele Ojii

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Alkaloid	Between Groups	5.038	3	1.679	3358.600	.000
	Within Groups	.004	8	.000		
	Total	5.042	11			
Tannin	Between Groups	36.898	3	12.299	5466.344	.000
	Within Groups	.018	8	.002		
	Total	36.916	11			
Saponin	Between Groups	9.586	2	4.793	89.290	.000
	Within Groups	.322	6	.054		
	Total	9.908	8			
Flavenoid	Between Groups	.900	3	.300	33.531	.000
	Within Groups	.072	8	.009		
	Total	.972	11			
Phenol	Between Groups	.274	3	.091	244.000	.000
	Within Groups	.003	8	.000		
	Total	.277	11			

Appendix V: ANOVA for Phytochemical Composition of the fruit, leaf, stem and root of Obno Oda

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Alkaloid	Between Groups	.837	3	.279	81.822	.000
	Within Groups	.027	8	.003		
	Total	.864	11			
Tannin	Between Groups	10.935	1	10.935	60.733	.001
	Within Groups	.720	4	.180		
	Total	11.655	5			
Saponin	Between Groups	2.160	1	2.160	1728.000	.000
	Within Groups	.005	4	.001		
	Total	2.165	5			
Flavenoid	Between Groups	1.812	3	.604	383.556	.000
	Within Groups	.013	8	.002		
	Total	1.825	11			
Phenol	Between Groups	.362	3	.121	209.565	.000
	Within Groups	.005	8	.001		
	Total	.366	11			

Appendix V1: ANOVA for Phytochemical Composition of the fruit, leaf, stem and root of Unele Ocha

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Alkaloid	Between Groups	10.724	3	3.575	41.371	.000
	Within Groups	.691	8	.086		
	Total	11.416	11			
Tannin	Between Groups	9.880	2	4.940	1402.533	.000
	Within Groups	.021	6	.004		
	Total	9.901	8			
Saponin	Between Groups	.380	2	.190	407.143	.000
	Within Groups	.003	6	.000		
	Total	.383	8			
Flavenoid	Between Groups	1.441	2	.720	3602.000	.000
	Within Groups	.001	6	.000		
	Total	1.442	8			
Phenol	Between Groups	.561	3	.187	148.530	.000
	Within Groups	.010	8	.001		
	Total	.571	11			

Appendix VI1: ANOVA for Phytochemical Composition of the fruit of six banana varieties

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Alkaloid	Between Groups	2.190	4	.547	760.333	.000
	Within Groups	.007	10	.001		
	Total	2.197	14			
Tannin	Between Groups	14.758	3	4.919	1214.685	.000
	Within Groups	.032	8	.004		
	Total	14.791	11			
Saponin	Between Groups	.205	1	.205	216.158	.000
	Within Groups	.004	4	.001		
	Total	.209	5			
Flavenoid	Between Groups	3.765	5	.753	1254.933	.000
	Within Groups	.007	12	.001		
	Total	3.772	17			
Phenol	Between Groups	.019	5	.004	10.017	.001
	Within Groups	.005	12	.000		
	Total	.024	17			

Appendix VIII: ANOVA for Phytochemical Composition of the leaves of six banana varieties

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Alkaloid	Between Groups	9.439	5	1.888	27.073	.000
	Within Groups	.837	12	.070		
	Total	10.275	17			
Tannin	Between Groups	44.554	3	14.851	5748.865	.000
	Within Groups	.021	8	.003		
	Total	44.574	11			
Saponin	Between Groups	7.874	4	1.968	3043.959	.000
	Within Groups	.006	10	.001		
	Total	7.880	14			
Flavenoid	Between Groups	1.151	3	.384	28.579	.000
	Within Groups	.107	8	.013		
	Total	1.258	11			
Phenol	Between Groups	1.600	4	.400	454.500	.000
	Within Groups	.009	10	.001		
	Total	1.609	14			

Appendix IX: ANOVA for Phytochemical Composition of the stem of six banana varieties

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Alkaloid	Between Groups	7.736	5	1.547	96.302	.000
	Within Groups	.193	12	.016		
	Total	7.929	17			
Tannin	Between Groups	62.504	5	12.501	618.508	.000
	Within Groups	.243	12	.020		
	Total	62.746	17			
Saponin	Between Groups	2.140	5	.428	12.557	.000
	Within Groups	.409	12	.034		
	Total	2.549	17			
Flavenoid	Between Groups	.287	3	.096	65.983	.000
	Within Groups	.012	8	.001		
	Total	.299	11			
Phenol	Between Groups	.139	3	.046	13.770	.002
	Within Groups	.027	8	.003		
	Total	.166	11			

Appendix X: ANOVA for Phytochemical Composition of the roots of six banana varieties

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Alkaloid	Between Groups	1.847	3	.616	1070.957	.000
	Within Groups	.005	8	.001		
	Total	1.852	11			
Tannin	Between Groups	9.938	3	3.313	29.441	.000
	Within Groups	.900	8	.113		
	Total	10.839	11			
Saponin	Between Groups	6.270	3	2.090	60.320	.000
	Within Groups	.277	8	.035		
	Total	6.547	11			
Flavenoid	Between Groups	1.046	4	.261	233.437	.000
	Within Groups	.011	10	.001		
	Total	1.057	14			
Phenol	Between Groups	1.477	4	.369	366.811	.000
	Within Groups	.010	10	.001		
	Total	1.487	14			

Appendix XI: ANOVA for Proximate Composition of the fruit, leaf, stem and root of Akpakpo Ike

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Moisture	Between Groups	5545.179	3	1848.393	27252.386	.000
	Within Groups	.543	8	.068		
	Total	5545.722	11			
Crude Protein	Between Groups	202.230	3	67.410	42800.000	.000
	Within Groups	.013	8	.002		
	Total	202.243	11			
Crude Fibre	Between Groups	321.620	3	107.207	25781.196	.000
	Within Groups	.033	8	.004		
	Total	321.654	11			
CHO	Between Groups	7624.220	3	2541.407	27521.776	.000
	Within Groups	.739	8	.092		
	Total	7624.959	11			
Ash	Between Groups	508.521	3	169.507	16143.512	.000
	Within Groups	.084	8	.010		
	Total	508.605	11			
Fat	Between Groups	426.235	3	142.078	58388.387	.000
	Within Groups	.019	8	.002		
	Total	426.255	11			

Appendix XII: ANOVA for Proximate Composition of the fruit, leaf, stem and root of Egbe ola

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Moisture	Between Groups	4313.394	3	1437.798	1626.009	.000
	Within Groups	7.074	8	.884		
	Total	4320.468	11			
Crude Protein	Between Groups	1225.084	3	408.361	242590.931	.000
	Within Groups	.013	8	.002		
	Total	1225.098	11			
Crude Fibre	Between Groups	4811.701	3	1603.900	390401.673	.000
	Within Groups	.033	8	.004		
	Total	4811.733	11			
CHO	Between Groups	6251.641	3	2083.880	20340.461	.000
	Within Groups	.820	8	.102		
	Total	6252.460	11			
Ash	Between Groups	321.757	3	107.252	10584.113	.000
	Within Groups	.081	8	.010		
	Total	321.838	11			
Fat	Between Groups	653.634	3	217.878	608031.814	.000
	Within Groups	.003	8	.000		
	Total	653.637	11			

Appendix XIII: ANOVA for Proximate Composition of the fruit, leaf, stem and root of Mmemme

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Moisture	Between Groups	5410.820	3	1803.607	79717.422	.000
	Within Groups	.181	8	.023		
	Total	5411.001	11			
Crude Protein	Between Groups	119.110	3	39.703	4607.725	.000
	Within Groups	.069	8	.009		
	Total	119.179	11			
Crude Fibre	Between Groups	2089.210	3	696.403	262793.764	.000
	Within Groups	.021	8	.003		
	Total	2089.232	11			
CHO	Between Groups	5463.252	3	1821.084	4105.008	.000
	Within Groups	3.549	8	.444		
	Total	5466.801	11			
Ash	Between Groups	82.613	3	27.538	325.408	.000
	Within Groups	.677	8	.085		
	Total	83.290	11			
Fat	Between Groups	627.948	3	209.316	56827.855	.000
	Within Groups	.029	8	.004		
	Total	627.977	11			

Appendix XIV: ANOVA for Proximate Composition of the fruit, leaf, stem and root of Unele Ojii

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Moisture	Between Groups	3842.826	3	1280.942	18169.391	.000
	Within Groups	.564	8	.070		
	Total	3843.390	11			
Crude Protein	Between Groups	274.516	3	91.505	95483.696	.000
	Within Groups	.008	8	.001		
	Total	274.523	11			
Crude Fibre	Between Groups	315.405	3	105.135	1335.754	.000
	Within Groups	.630	8	.079		
	Total	316.035	11			
CHO	Between Groups	4576.927	3	1525.642	15437.816	.000
	Within Groups	.791	8	.099		
	Total	4577.717	11			
Ash	Between Groups	185.852	3	61.951	116157.391	.000
	Within Groups	.004	8	.001		
	Total	185.856	11			
Fat	Between Groups	125.714	3	41.905	11480.733	.000
	Within Groups	.029	8	.004		
	Total	125.743	11			

Appendix XV: ANOVA for Proximate Composition of the fruit, leaf, stem and root of Obuo odaa

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Moisture	Between Groups	4631.669	3	1543.890	38621.378	.000
	Within Groups	.320	8	.040		
	Total	4631.989	11			
Crude Protein	Between Groups	169.349	3	56.450	672.886	.000
	Within Groups	.671	8	.084		
	Total	170.020	11			
Crude Fibre	Between Groups	1574.737	3	524.912	2031918.581	.000
	Within Groups	.002	8	.000		
	Total	1574.739	11			
CHO	Between Groups	5147.622	3	1715.874	20967.909	.000
	Within Groups	.655	8	.082		
	Total	5148.276	11			
Ash	Between Groups	214.006	3	71.335	14632.918	.000
	Within Groups	.039	8	.005		
	Total	214.045	11			
Fat	Between Groups	561.323	3	187.108	748430.000	.000
	Within Groups	.002	8	.000		
	Total	561.325	11			

Appendix XV1: ANOVA for Proximate Composition of the fruit, leaf, stem and root of Unele Ocha

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Moisture	Between Groups	4608.926	3	1536.309	37878.986	.000
	Within Groups	.324	8	.041		
	Total	4609.250	11			
Crude Protein	Between Groups	196.343	3	65.448	16260.248	.000
	Within Groups	.032	8	.004		
	Total	196.375	11			
Crude Fibre	Between Groups	766.330	3	255.443	557330.782	.000
	Within Groups	.004	8	.000		
	Total	766.333	11			
CHO	Between Groups	5157.022	3	1719.007	12389.243	.000
	Within Groups	1.110	8	.139		
	Total	5158.132	11			
Ash	Between Groups	226.605	3	75.535	4568.647	.000
	Within Groups	.132	8	.017		
	Total	226.737	11			
Fat	Between Groups	291.351	3	97.117	9583.909	.000
	Within Groups	.081	8	.010		
	Total	291.432	11			

Appendix 17: ANOVA for Proximate Composition of the fruit of six banana varieties

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Moisture	Between Groups	7.741	5	1.548	6966.940	.000
	Within Groups	.003	12	.000		
	Total	7.744	17			
Crude Protein	Between Groups	8.184	5	1.637	646.076	.000
	Within Groups	.030	12	.003		
	Total	8.214	17			
Crude Fibre	Between Groups	.083	5	.017	114.892	.000
	Within Groups	.002	12	.000		
	Total	.085	17			
CHO	Between Groups	106.583	5	21.317	14317.170	.000
	Within Groups	.018	12	.001		
	Total	106.601	17			
Ash	Between Groups	36.348	5	7.270	16776.185	.000
	Within Groups	.005	12	.000		
	Total	36.354	17			
Fat	Between Groups	.056	5	.011	183.655	.000
	Within Groups	.001	12	.000		
	Total	.057	17			

Appendix 18: ANOVA for Proximate Composition of the stem of six banana varieties

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Moisture	Between Groups	154.416	5	30.883	60.289	.000
	Within Groups	6.147	12	.512		
	Total	160.563	17			
Crude Protein	Between Groups	10.619	5	2.124	659.116	.000
	Within Groups	.039	12	.003		
	Total	10.658	17			
Crude Fibre	Between Groups	3.348	5	.670	1137.111	.000
	Within Groups	.007	12	.001		
	Total	3.355	17			
CHO	Between Groups	188.619	5	37.724	10778.229	.000
	Within Groups	.042	12	.004		
	Total	188.661	17			
Ash	Between Groups	2.286	5	.457	65.630	.000
	Within Groups	.084	12	.007		
	Total	2.370	17			
Fat	Between Groups	47.518	5	9.504	9775.192	.000
	Within Groups	.012	12	.001		
	Total	47.530	17			

Appendix 19: ANOVA for Proximate Composition of the leaf of six banana varieties

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Moisture	Between Groups	373.398	5	74.680	315.192	.000
	Within Groups	2.843	12	.237		
	Total	376.241	17			
Crude Protein	Between Groups	756.040	5	151.208	185152.653	.000
	Within Groups	.010	12	.001		
	Total	756.050	17			
Crude Fibre	Between Groups	138.064	5	27.613	12711.816	.000
	Within Groups	.026	12	.002		
	Total	138.091	17			
CHO	Between Groups	1689.745	5	337.949	1043.142	.000
	Within Groups	3.888	12	.324		
	Total	1693.633	17			
Ash	Between Groups	90.205	5	18.041	3006.833	.000
	Within Groups	.072	12	.006		
	Total	90.277	17			
Fat	Between Groups	.786	5	.157	471.510	.000
	Within Groups	.004	12	.000		
	Total	.790	17			

Appendix 20: ANOVA for Proximate Composition of the root of six banana varieties

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Moisture	Between Groups	112.420	5	22.484	20754.462	.000
	Within Groups	.013	12	.001		
	Total	112.433	17			
Crude Protein	Between Groups	31.088	5	6.218	102.612	.000
	Within Groups	.727	12	.061		
	Total	31.816	17			
Crude Fibre	Between Groups	3164.439	5	632.888	11040.879	.000
	Within Groups	.688	12	.057		
	Total	3165.127	17			
CHO	Between Groups	688.620	5	137.724	444.861	.000
	Within Groups	3.715	12	.310		
	Total	692.335	17			
Ash	Between Groups	193.173	5	38.635	541.101	.000
	Within Groups	.857	12	.071		
	Total	194.030	17			
Fat	Between Groups	223.289	5	44.658	3629.084	.000
	Within Groups	.148	12	.012		
	Total	223.437	17			

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ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Stomata width	Between Groups	72.503	5	14.501	6.654	.000
	Within Groups	115.506	53	2.179		
	Total	188.008	58			
Stomata length	Between Groups	34.497	5	6.899	3.456	.009
	Within Groups	105.800	53	1.996		
	Total	140.297	58			
Aperture width	Between Groups	.934	5	.187	1.998	.094
	Within Groups	4.956	53	.094		
	Total	5.890	58			
Aperture length	Between Groups	1947.213	5	389.443	1.578	.182
	Within Groups	13080.683	53	246.805		
	Total	15027.896	58			

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Stomata width	Between Groups	85.671	5	17.134	8.300	.000
	Within Groups	111.475	54	2.064		
	Total	197.146	59			
Stomata length	Between Groups	36.733	5	7.347	3.863	.005
	Within Groups	102.700	54	1.902		
	Total	139.433	59			
Aperture width	Between Groups	1.637	5	.327	2.465	.044
	Within Groups	7.175	54	.133		
	Total	8.813	59			
Aperture length	Between Groups	95.173	5	19.035	8.793	.000
	Within Groups	116.894	54	2.165		
	Total	212.067	59			

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