



Foliar Morphological and Micromorphological Variation of *Dioscorea* Species in Terengganu, Malaysia

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ABSTRACT

Dioscorea species are recognised for their production of tuberous roots and are referred to as "ubi" by the local population in Malaysia. The tubers of *Dioscorea* are commonly consumed by individuals residing in the East Coast region of Peninsular Malaysia as their primary food source. These tuberous roots are particularly abundant during the monsoon season, typically observed in local markets from October to December. Due to the availability and potential of this *Dioscorea* species, a study about the variation in morphological and micromorphological study of the leaves of three species of *Dioscorea* in Terengganu was conducted in order to identify the variation in their morphological and micromorphological characteristics. The selected species are *D. esculenta* (ubi itik), *D. alata* (ubi besar), and *D. hispida* (ubi gadong). The collection has been done in the Kuala Berang Terengganu area. The leaves morphological characteristics such as leaf colour, leaf type, leaf shape, leaf size, leaf margin and hairiness of adaxial and abaxial surface and shape of leaves and petiole were recorded. The morphological descriptors were suggested by the International Plant Genetic Resources Institute (IPGRI) / International Institute of Tropical Agriculture (IITA). The foliar anatomical studies of selected *Dioscorea* were followed by the standard tissue sectioning procedures and the observation was done by using light microscopy. The morphological study shows the variations in leaf shape, leaf base, and leaf size but they have the similarity in term of leaf margin shape and leaf attachment which is all species are petiolate. The micromorphological study shows the presence of non-glandular and uniseriate trichomes which is only obtained in the *D. esculenta* and *D. hispida*. Hence, this study contributes to the information on these species, especially for classification and identification of *Dioscorea* species.

Keywords: *Dioscorea*, morphology, foliar anatomy

ABSTRAK

Spesies *Dioscorea* biasanya dikenali kerana mempunyai akar berubi dan dirujuk sebagai "ubi" oleh penduduk tempatan di Malaysia. Ubi *Dioscorea* lazimnya dimakan oleh penduduk yang tinggal di kawasan Pantai Timur di Semenanjung Malaysia sebagai sumber makanan utama mereka ketika musim tengkujuh berikutan jenis akar berubi ini banyak terdapat semasa musim tersebut dan biasanya ditemui di pasar di Kawasan tempatan daripada bulan Oktober sehingga bulan Disember. Oleh kerana mudahnya

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kedapatan dan potensi spesies *Dioscorea* ini di Kawasan pantai timur, satu kajian tentang variasi kajian morfologi dan mikromorfologi daun bagi tiga spesies *Dioscorea* di Terengganu telah dijalankan bagi mengenal pasti variasi ciri morfologi dan mikromorfologinya. Spesies yang dipilih ialah *D. esculenta* (ubi itik), *D. alata* (ubi besar), dan *D. hispida* (ubi gadong). Kutipan sampel telah dilakukan di kawasan Kuala Berang Terengganu. Ciri-ciri morfologi daun seperti warna daun, jenis daun, bentuk daun, saiz daun, bentuk tepi daun dan kehadiran bulu pada permukaan adaksial dan abaksial serta bentuk daun dan petiol daun telah direkodkan. Deskriptor morfologi yang dirujuk adalah seperti yang dicadangkan oleh Institut Sumber Genetik Tumbuhan Antarabangsa (IPGRI) / Institut Pertanian Tropika Antarabangsa (IITA). Kajian anatomi foliar *Dioscorea* terpilih diikuti dengan prosedur keratan tisu standard dan cerapan imej keratan dilakukan dengan menggunakan mikroskop imbasan cahaya. Hasil kajian morfologi menunjukkan variasi bentuk daun, petiol daun dan saiz daun tetapi kesemua spesies mempunyai persamaan dari segi bentuk tepi daun dan pelekatan daun iaitu kesemua spesies adalah mempunyai petiol. Kajian mikromorfologi pula menunjukkan kehadiran trikom atau rerambut bukan kelenjar dan uniseriat namun hanya ditemui pada *D. esculenta* dan *D. hispida*. Oleh itu, kajian ini menyumbang kepada maklumat tentang spesies ini untuk pengelasan dan pengenalpastian.

Kata kunci: *Dioscorea*, morfologi daun, anatomi daun

INTRODUCTION

Dioscorea is belong to the family of *Dioscoreaceae* which is also known as yam. This genus commonly harvested for their tuber as alternative carbohydrate sources instead of rice and wheat. This genus approximately consists of 600 species (Trimanto & Hapsari, 2015). According to Kumar et. al. (2017), some common species are *Dioscorea esculenta*, *D. hispida* and *D. alata* and these species are considered as the earliest angiosperms that originated from Southeast Asia and the Indo-Malayan region.

Dioscorea esculenta is also known as lesser yam, Ubi Torok or Ubi Itik and it is native to tropical Asia such as South China, North Vietnam, North Thailand, Laos, Myanmar, India (Assam), Malaysia, Philippines, and New Guinea and it is known to have been grown in southern China for at least 1700 years (Lim, 2016). Meanwhile *D. hispida* is commonly called as intoxicating yam or Ubi Gadung and it is usually can be found grows wild in South-East Asia countries such as in Malaysia, Indonesia, Papua New Guinea, Philippines and India. Furthermore, *D. alata* is generally known as winged yam or Ubi Badak and this species can be considered as the first cultivated *Dioscorea* species in Southeast Asia hence it has the largest distribution worldwide (Muimba-Kankolongo, 2018).

According to the vegetables and cash crops statistics of Malaysia by the Department of Agriculture in Peninsular Malaysia, in 2017, there is about 900.97 metric tons of tubers were produced in Terengganu and in the amount is doubled for 2018 which is the yield has been increased to 1831.04 metric tons. The results show that the tuber of *Dioscorea* can be considered to have the market demand and thus, it the potential value of these tubers are indicated. Additionally, Padhan and Panda (2020) reported that the *Dioscorea* species is recognized as the fourth most important

tuber after potatoes, cassava and sweet potatoes and they has contributed about 10% of the total roots and tubers production worldwide.

Dioscorea has high yield potential, easy to propagate, resistant to pests and diseases and has long storability, however, the identification of different taxa of *Dioscorea* still not adequate as Raman et al. (2014) reported that *Dioscorea* species are still poorly characterized and they also reported that the ability to differentiate the variation characteristics of tubers and rhizomes of five species of *Dioscorea* based on their micromorphology and anatomy may help in the characterization of these species. Therefore, these morphological and micromorphological studies is crucial and can contributed for further research of *Dioscorea* in Malaysia. In addition, the morphological and anatomical studies of these species enables us to discern variations in their characteristics and assess the potential of *Dioscorea* species as for food industry such as for *Dioscorea* flour production. Moreover, this knowledge is essential as one of the approaches to conserving and preventing the extinction of these species.

MATERIALS AND METHODS

Fresh leaf samples of *Dioscorea alata*, *D. hispida*, and *D. esculenta* were collected on from Kuala Berang, Terengganu area (Table 1) and the specimen voucher were placed in IIUM Herbarium. Fresh samples were identified by referring to local experts, herbarium specimens, reference books, and related journals. Field data such as the Global Positioning System (GPS) and morphological characteristics of the collected leaves specimen collected were noted during field trip. The coordinates for the plant sampling are listed in Table 1. The leaves morphological characteristics such as leaf colour, leaf type, leaf shape, leaf size,

leaf margin and hairiness of adaxial and abaxial surface and shape of petiole were recorded. The morphological descriptors were suggested by the International Plant Genetic Resources Institute (IPGRI) / International Institute of Tropical Agriculture (IITA). The foliar parts used for micromorphological studies is leaves. The histology methods were proposed by

Johansen (1940) and Azahana (2020) with some modifications. The leaf laminae and petioles of the collected sample were taken by sectioning method and stained in Safranin and Alcian blue, mounted in Euparal after dehydration, and images will be captured using a video camera (JVC) attached to a Leica Diaplan Microscope using AnalySis Docu Software.

Species	Local name	Coordinate
<i>Dioscorea esculenta</i>	Ubi Torok or Ubi Itik	5°04'21.8"N 102°59'58.0"E
<i>Dioscorea alata</i>	Ubi Gadung	
<i>Dioscorea hispida</i>	Ubi Badak	5°04'47.9"N 102°59'50.5"E

Table 1: GPS Coordinates of the *Dioscorea* collection collected in Kuala Berang, Terengganu area.

RESULTS AND DISCUSSION

MORPHOLOGICAL STUDIES

Dioscorea esculenta

Habit: Climber (Figure 1(a)). **Shape:** cordate. (Figure 2(a)) **Margin:** entire. **Apex:** caudate. **Bases:** cordate. **Size:** The length of the leaves is between 6.2cm to 7.3cm. The width of the leaves is between 7.3cm to 9.5cm. **Colour:** bright green. **Leaf attachment:** petiolate. **Hairiness of adaxial surface:** **Hairiness of abaxial surface:** Smooth hairiness occurs. **Petiole shape (Figure 4.6c):** semi-circle shape.

Dioscorea alata

Habit: Climber (Figure 1(c)). **Shape:** Sagittate. (Figure 2(b)) **Margin:** entire. **Apex:** caudate. **Bases:** sagittate. **Size:** The length of the leaves is between 9.7cm and

13.5cm. The width of the leaves is between 6.4cm and 7.8cm. **Colour:** bright green. **Leaf attachment:** petiolate. **Hairiness of adaxial surface:** no **Hairiness of abaxial surface:** no. **Petiole shape:** Winged shape.

Dioscorea hispida

Habit: Climber. (Figure 1(b)) **Shape:** obovate. (Figure 2(c)) **Margin:** entire. **Apex:** cuspidate. **Bases:** rounded. **Size:** The length of the leaves is between 11.8cm and 17.4cm. The width of the leaves is between 7.1cm and 10.0 cm. **Colour:** dark green. **Leaf attachment:** petiolate. **Hairiness of adaxial surface:** presence of soft hairs. **Hairiness of adaxial and abaxial surface:** presence of soft hairs. **Midrib shape:** have a U-shape at the adaxial and concave shape at the abaxial. **Petiole shape:** round shape.

Characteristics	Species		
	<i>Dioscorea esculenta</i>	<i>Dioscorea alata</i>	<i>Dioscorea hispida</i>
Habit	Climber	Climber	Climber
Shape	Heart shape	Sagittate	Obovate
Margin	Entire	Entire	Entire
Apex	Caudate	Caudate	Cuspidate
Base	Cordate	Sagittate	Rounded
Colour	Bright green	Bright green	Dark green
Size	Width: 7.3 - 9.5cm Length: 6.2 - 7.3cm	Width: 6.4 - 7.8cm Length: 9.7 - 13.5cm	Width: 7.1 - 10.0cm Length: 11.8 -17.4cm
Leaf attachment	Petiolate	Petiolate	Petiolate
Hairiness of abaxial and adaxial surface	Present	Absent	Present of soft hairs
Midrib shape	Adaxial: U-shape Abaxial: Concave	Adaxial: U-shape Abaxial: Concave with keel	Adaxial: U-shape Abaxial: Concave
Petiole shape	Semi-circle	Pentagram	Rounded

Table 2: Morphological characteristics of *Dioscorea* species.



Figure 1: Habit of *Dioscorea* species. A) *Dioscorea esculenta*, B) *D. hispida*, C) *D. alata*

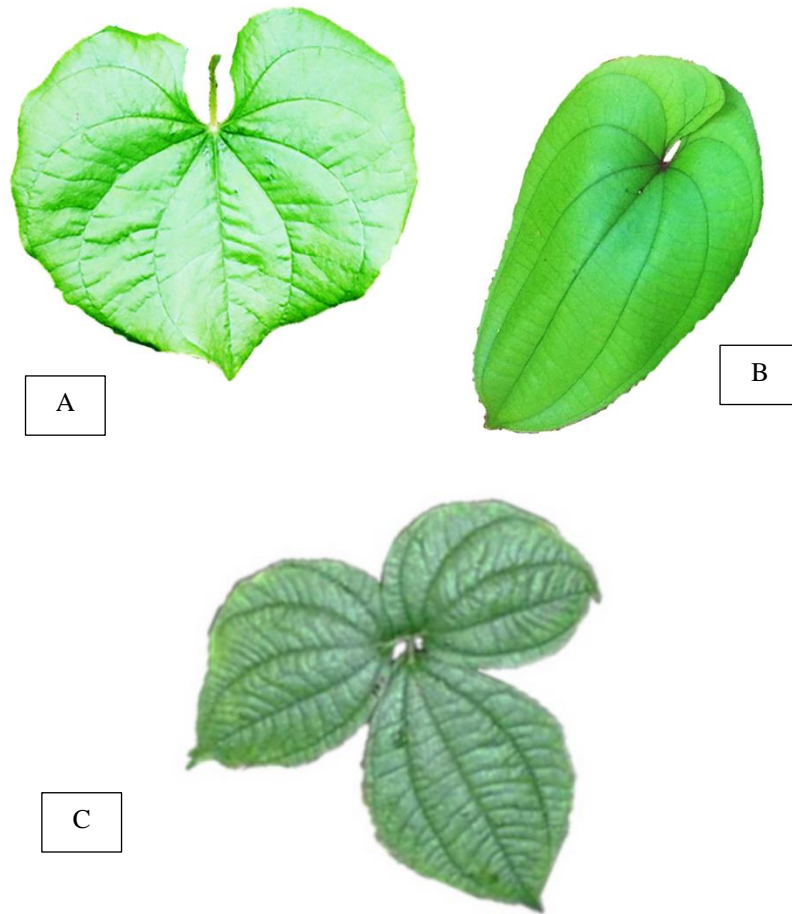


Figure 2: Leaf shape of *Dioscorea* species. A) *Dioscorea esculenta*, B) *D. alata*, C) *D. hispida*

FOLIAR MICROMORPHOLOGICAL STUDY

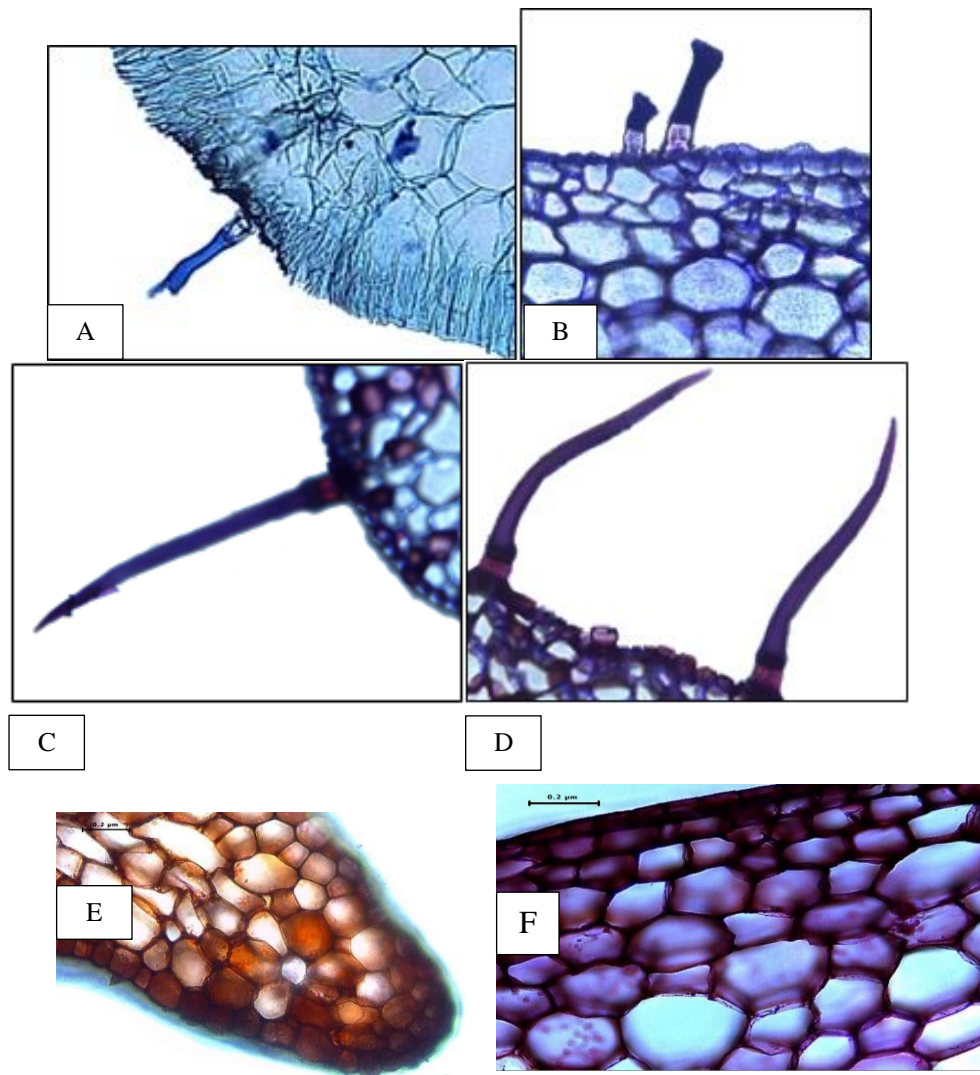


Figure 3: A) Trichome at the midrib of *Dioscorea esculenta*, B) Trichome at petiole of *D. esculenta* C) Trichome at the midrib of *D. hispida*, D) Trichome at the petiole of *D. hispida*. E) No occurrence of trichome at the Midrib of *D. alata* F) Absence trichome at the petiole of *D.alata*.
Magnification Scale: A), B) C), D), E), F): 40X

Characteristics	Species		
	<i>Dioscorea esculenta</i>	<i>Dioscorea hispida</i>	<i>Dioscorea alata</i>
TRICHOME			
Availability	Present	Present	Absent
Shape	Rectangular and straight	Conical and straight	-
Type	Simple	Simple	-
Glandular	Absent	Absent	-
Number of cells	Multicellular	Unicellular	-
Seriate	Uniseriate	Uniseriate	-

Table 3: Trichome characteristics of *Dioscorea* species.

All three species, *Dioscorea esculenta*, *D. alata*, and *D. hispida*, share common traits in their habit, margin, apex, and leaf attachment. They are all climbing plants, displaying a characteristic caudate apex, and having leaves with entire margins. Additionally, these species are petiolate, meaning their leaves are attached to the stem via leaf stalks. *Dioscorea esculenta* is characterized by its heart-shaped leaves with cordate bases, giving them a unique appearance. In contrast, *D. alata* has arrowhead-shaped leaves with sagittate bases, setting it apart from other species within the *Dioscorea* genus. On the other hand, *D. hispida* exhibits elliptical leaves with rounded bases, providing a distinctive feature differentiating it from both *D. esculenta* and *D. alata*. Both the adaxial and abaxial leaf of *D. hispida* and *D. esculenta* also has a hairy surface, while only *D. alata* has smooth leaf surface. The morphology and anatomy of *D. hispida* has been studied by Tajuddin et al. (2013) and they also reported that the leaf surface of *D. hispida* is covered with rough, bristly, and hairy surface.

Additionally, when it comes to leaf size, *D. esculenta* features relatively smaller leaves, measuring between 6.2cm to 7.3cm in length and 7.3cm to 9.5cm in width. In comparison,

D. alata has larger leaves, ranging from 9.7cm to 13.5cm in length and 6.4cm to 7.8cm in width. *Dioscorea hispida*, however, displays the largest leaves among the three species, measuring between 11.8cm and 17.4cm in length and 7.1cm to 10.0cm in width. However, *Dioscorea esculenta* and *D. alata* have a bright green colour while *D. hispida* has a dark green colour. This may be due to the different surroundings and nutrient availability as *Dioscorea esculenta* and *D. alata* which are commonly cultivated and grows under full sunlight area meanwhile *D. hispida* usually grows wild and typically can be found at shaded area under canopy of forest and bushes. These differences in leaf shape and size are crucial for distinguishing these yam species and have implications for both botanical classification and potential agricultural applications.

The trichome of *Dioscorea esculenta* shown in Figure (3A and B) which has rectangular straight shape while *D. hispida* shown in Figure (3A and B) which show that *D. hispida* has conical straight shape trichome. This finding is similar to the previous study by Zhao and Chen (2016), in which they found that *Dioscorea esculenta* and *D. hispida* have simple-type, nonglandular, and uniseriate trichome. The occurrence of trichome *D. esculenta* and *D.*

hispida, may be due to the habitat of these species which commonly grow in the wild and need more protection from herbivores and pathogens. Meanwhile, there is no trichome in the matured leaves and petiole of *D. alata* may be due to the species which is usually cultivated and not exposed to the extreme conditions.

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CONCLUSION

Dioscorea species exhibited variability in both morphological and micromorphological features. Certain physical properties, such as the form of the leaves, the base of the leaves, and the shape of the petioles, can serve as diagnostic features for distinguishing different species within the *Dioscorea* genus. Hence, these data can serve as a valuable resource for future investigations on *Dioscorea* species.

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