



Morphological and Anatomical Characteristic of Pisang Awak (*Musa paradisiaca* cv. Awak) in West Kalimantan

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Abstract

Indonesia is the origin and center of diversity of banana. One of an edible banana in Indonesia is Pisang Awak (*Musa paradisiaca* cv. Awak). In West Kalimantan, the ripe Pisang Awak has been processed into *sale* (dried banana). The aims of this research were to describe the morphological and anatomical character of Pisang Awak in West Kalimantan, Indonesia. In this study, Pisang Awak were collected from Padang Tikar I village, Batu Ampar Sub-district, Kubu Raya district, West Kalimantan. Morphological characterizations were conducted by following the instruction on Descriptors for Banana (*Musa* spp.) from IPGRI. The root, leaf blade, and petiole were fixed in FAA solution. Root, leaf, and petiole anatomy preparats were made by paraffin method. The lamina of Pisang Awak consisted of adaxial epidermis, two hypodermis layers, two palisade layers, spongy layer, bundle sheath cell, abaxial epidermis, laticifer. The petiole of Pisang Awak composed of three tissue systems, i.e., epidermis layer, parenchyma tissue and vascular tissue. The root of Pisang Awak consists of two epidermis layers, parenchyma and vascular cylinder. In the future, morphological and anatomical character in Pisang Awak could be applied as the basis of information for breeding programs of banana cultivars and classification.

How to Cite

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INTRODUCTION

Musaceae is cultivated for different purposes, such as a vegetable, fruit, medicine, and for cosmetics (Amnuaysin *et al.* 2012). *Musa* is divided into two groups, they are seeded bananas (wild), which consists of approximately 70 species (Häkkinen & Väre, 2008) and seedless bananas (edible bananas), which includes approximately 500 cultivars (Valmayor *et al.*, 2002). Indonesia is the origin and center of diversity (Daniells *et al.*, 2001) of banana. Approximately, not less than 325 cultivars of bananas were found in Indonesia (Valmayor *et al.*, 2002).

One of the edible bananas in Indonesia is Pisang Awak (*Musa paradisiaca* cv. Awak). Pisang Awak is one of the most vigorous and hardy cultivars of bananas of the Eumusa series. Pisang Awak is triploid cultivar and it belongs to the ABB genomic group (Valmayor *et al.*, 2002). Pisang Awak has many uses. The unripe fruits of Pisang Awak were used for making high fiber flour. It was reported that Pisang Awak flour has higher total dietary fiber and caloric content. In Thailand, the floral buds of Pisang Awak are used in various culinary preparations (Bakry *et al.*, 2009). In Indonesia, especially in West Kalimantan, the ripe Pisang Awak has been processed into *sale* (dried banana).

However, morphological and anatomical characteristics of Pisang Awak data are not available yet. Morphological and anatomical characteristics are crucial in plants classification (Sumardi & Wulandari, 2010). The anatomy of the vegetative organs can provide valuable evidence in taxonomic research (Simáo & Scatena, 2001). Cahyanto *et al.*, (2010) used morphological and anatomical character to describe the diversity of *Mangifera indica* cultivars in Subang West Java. In banana, morphological and anatomical character were used to describe five Indonesian banana cultivars (*Musa* spp.) based on their level of ploidy (Sumardi & Wulandari, 2010). The aims of this research were to describe the morphological and anatomical character of Pisang Awak in West Kalimantan, Indonesia. In the future, its morphological and anatomical character could be applied as the basis of information for breeding programs of banana cultivars and classification.

METHODS

Samples were collected from Padang Tikar I village, Batu Ampar Sub-district, Kubu Raya district, West Kalimantan. Morphological characters of Pisang Awak were documented with a

digital camera.

Morphological characterizations were conducted by following the instruction on "Descriptors for Banana (*Musa* spp.)" from International Plant Genetic Resources Institute (IPGRI, 1996). Morphological character records include plant's general habit; pseudostem characteristics; petiole characteristics; leaf characteristics; peduncle characteristics; male bud characteristics; male flower characteristics; and fruit characteristics.

Anatomy of vegetative structures, samples (root, leaf blade, and petiole) were prepared using paraffin method. The root, leaf blade, and petiole were fixed in FAA solution (formaldehyde : acetic acid glacial : ethanol 70 % (5:5:90)) for 24 h. The root, leaf blade, and petiole were dehydrated and cleared using serial solutions of Johansen I - VII (Johansen, 1940), then embedded in paraffin wax and sliced using a rotary microtome at 10 µm thickness. Sliced of the root, leaf blade, and petiole was stained using 2 % safranin and 1% alcian blue, and then observed under light microscope. Data analysis was done descriptively based on the morphological character record from field and anatomical character record used light microscope result with table and pictures.

RESULTS AND DISCUSSION

The morphological characteristics of Pisang Awak (*Musa paradisiaca* cv. Awak)

Leaf habit of Pisang Awak is drooping. *Pseudostem* color of Pisang Awak is green, Straight with erect margins of petiolar canal leaf margins. 113-190 x 34- 58 cm of *Leaf*, upper surface dark-green, lower surface green, midrib dorsally green-yellow, midrib ventrally green, and both side rounded of leaf bases. 46-55 cm *Peduncle*, 3-5 width, green-color. Lanceolate *Male bud*, normal male bud, slightly pointed apex, tinted with yellow, revolute bract behavior, lifting one at a time on male bract, and rachis position falling vertically. Compound tepal cream with yellow lobes and pink pigmentation, translucent white free tepal, rectangular, triangular apex; five stamen, yellowish, white filament; curved under stigma style. *Fruit* is 7-9 cm long with 10-14 fruits per hand in two rows, straight and apex lengthily pointed with without any floral relicts, green peel on immature fruit but yellow peel on mature fruit (Table 1 and Figure 1). Banana has complete type of leaf, because the leaf has midrib, petiole and lamina.

Pisang Awak is different to *M. paradisiaca* cv Kluthuk susu (ABB genome) in its petiol canal leaf. The petiol canal leaf of *M. paradisiaca* cv

Kluthuk susu is the close type (Sumardi & Wulandari, 2010) while petiol canal leaf of Pisang Awak is straight with erect margins type. Fruit morphological appearance of Pisang Awak had similarity to Pisang Raja Bandung (Hapsari & Lestari, 2016). Pisang Raja Bandung is triploid cultivar and it belongs to the ABB genomic group (Hapsari *et al.*, 2015). Pisang Raja Bandung has small to medium fingers with waxy greenish to yellow peel color, tasted sweet with slightly acidic, suitable for cooking and dessert banana (Hapsari & Lestari, 2016). However, Pisang Awak had a difference to Pisang Raja Bandung in the apex of fruit type and remain of flower residual. Pisang Raja Bandung has the bottled-necked apex of fruit type and base of the style prominent (Hapsari & Lestari, 2016) and Pisang Awak has lengthily pointed apex of fruit type and without any floral relicts (Table 1 and Figure 1).

Table 1. Morphological characteristics of *Musa paradisiaca* cv. Awak in West Kalimantan

Description	<i>Musa paradisiaca</i> cv. Awak
Leaf habit	Drooping
Pseudostem Height (m)	1.80 – 3.75
Pseudostem color	Green
Sap color	Watery
Position of sucker	Vertical growth
Petiol canal leaf III	Straight with erect margins
Leaf blade Length (cm)	113-190
Leaf blade width (cm)	34-58
Color of leaf upper surface	Dark Green
Color of leaf lower surface	Green
Shape of leaf base	Both side rounded
Color of midrib dorsal surface	Green-yellow
Color of midrib ventral surface	Green
Peduncle length (cm)	46-55
Peduncle width (cm)	3-5
Peduncle colour	Green
Rachis position	Falling vertically
Male bud type	Normal
Male bud shape	Lanceolate
Bract apex shape	Slightly pointed

Color of bract external face	Red-purple
Color on the bract apex	Tinted with yellow
Male bract lifting	Lifting one at a time
Bract behavior before falling	Revolute
Compound tepal basic color	Cream
Compound tepal pigmentation	Presence of pink
Lobe color of compound tepal	Yellow
Free tepal color	Translucent white
Free tepal shape	Rectangular
Free tepal apex shape	Triangular
Style exertion	Same level
Style shape	Curved under stigma
Ovary shape	Straight
Number of fruit	10-14
Fruit length (cm)	7-9
Fruit shape	Straight
Fruit apex	Lengthily pointed
Remains of flower relicts	Without any floral relicts

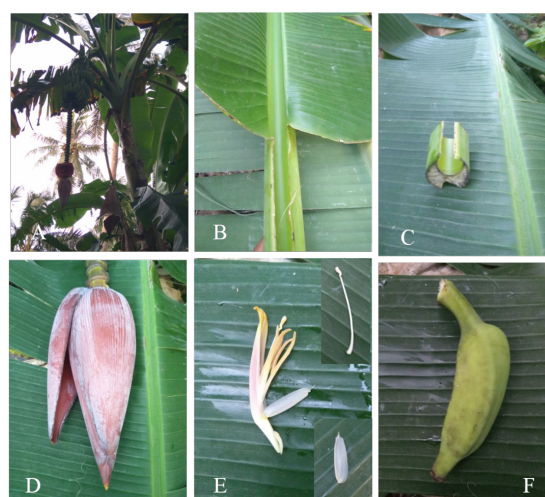


Figure 2. *Musa paradisiaca* cv. Awak morphology: bunch (a), the shape of leaf base (b), petiol canal leaf III (c), male bud shape (d), male flower with free tepal and style shape (e), fruit (f).

The anatomy characteristics of Pisang Awak (*Musa paradisiaca* cv. Awak)

Lamina

The lamina of Pisang Awak consisted of the adaxial epidermis, hypodermis, palisade layer, porous layer, bundle sheath cell, abaxial epidermis, laticifer. The shape of epidermis cells is rectangular. The size of the adaxial epidermis and abaxial epidermis is not different. In Pisang Awak, hypodermis layer was found at the adaxial and abaxial site, two layers in adaxial and one layer in abaxial (Figure 2A). The two layers of hypodermal were found in *M. paradisiaca* cv Kluthuk susu (Sumardi & Wulandari, 2010) and *M. paradisiaca* cv Kepok (Harijati *et al.*, 2013). The three layers of hypodermal were found in *M. branchyacarpa*, *M. sapientum* and *M. cavendish* (Harijati *et al.*, 2013). The one layer of hypodermis was found in Pisang Penjalin and not found in *M. balbisiana* cv Kluthuk warangan, *M. acuminata* cv Ambon warangan, *M. paradisiaca* cv Raja nangka (Sumardi & Wulandari, 2010). The condition of 2 until 3 layers hypodermal cells in bananas is typical of the Musaceae family. However, leaves of *Heliconia* sp (Musaceae), only have one hypodermal layer (Triplett & Kirchoff, 1991). In *Heliconia angusta* and *Heliconia velloziana*, the uniseriate abaxial hypodermis shows cells smaller than the adaxial one (Simão & Scatena, 2001). The hypodermis layer only occurred at the adaxial site in *M. paradisiaca* cv Kepok, *M. branchyacarpa*, *M. sapientum* and *M. cavendish* (Harijati *et al.*, 2013). Hypodermis layers in the leaf can use as taxonomic evidence in plant.

The presence of hypodermis in the leaves of family Myrtaceae is vital in the separation of these taxa (Al-Edany & Al-Saadi, 2012). In *Musa sapientum*, hypodermis is responsible for the unrolling of young leaves (Skutch, 1930). Rundel *et al.* (1998) reported that the hypodermis could decrease the influence of the sunlight in the photosynthetic tissue. Simão & Scatena, (2001) reported that the hypodermis could be performing both functions, i.e. unrolling of young leaves and could decrease the influence of the sunlight in the photosynthetic tissue.

Mesophyll consisted of the palisade and spongy tissues. In Pisang Awak, two palisade layers were found and had dense arrangement (Figure 2A). The two palisade layers were found in *M. branchyacarpa* and *M. sapientum* (Harijati *et al.*, 2013). Spongy tissue of Pisang Awak was formed irregularly shaped cells, which fused together produced an aerenchyma. The aerenchyma of Pisang Awak was located between two vascular bundles (Figure 2A). This condition also found

in Penjalin, Kluthuk warangan, Ambon warangan, Raja nangka and Kluthuk susu (Sumardi & Wulandari, 2010), *M. branchyacarpa*, *M. sapientum*, *M. paradisiaca* cv Kepok and *M. cavendish* (Harijati *et al.*, 2013) and general condition in banana leaf (Tomlison, 1969).

Vascular tissues were distributed in the mesophyll. The vascular bundle of the Pisang Awak is composed of xylem and phloem. The vascular bundle of Pisang Awak surrounded by the sclerenchymatic cells. This condition also found in Penjalin, Kluthuk warangan, Ambon warangan, Raja nangka and Kluthuk susu (Sumardi & Wulandari, 2010).

Laticifer of Pisang Awak was found in association with vascular bundles (Figure 2A). Laticifer is a cell or cell group or vessel that contains latex or sap cells (Beck, 2010). Sumardi & Wulandari, (2010) reported that the location laticifer in palisade layer and cell in vascular bundles. However, Harijati *et al.*, (2013) reported that the laticifer cell located in abaxial site just below the epidermis. In banana, exuded latex from laticifer was used of standard methods of measuring water relations in relation to drought tolerance (Turner & Thomas, 1998).

Petiole

The petiole of Pisang Awak composed of three tissue systems, i.e., epidermis layer, parenchyma tissue, and vascular tissue. Epidermis layer formed of a single layer, with the compact cell, rectangular shape. The parenchyma cells were found in the middle part of the petiole (Figure 2B). In *M. acuminata* cv. Penjalin and *M. acuminata* cv Ambon warangan, a single layer of epidermis was found, with the compact cell, rectangular shape and protected by the cuticle. The position of parenchyma cells was irregular and seen in the middle part of the petiole; there were big airspace and the parenchyma cells filled with air. The shape of air parenchyma cells was star-like (Sumardi & Wulandari, 2010). Fiber bundles were found in Pisang Awak (Figure 2B). Fiber bundles were found close to the abaxial vascular system in *Heliconia velloziana* and *Heliconia angusta*. Fiber bundles are continuous cylinder in *H. velloziana* and discontinuous in *H. angusta* (Simão & Scatena, 2001). The distribution of fibers present in leaves and scape, can be of taxonomic use in Heliconiaceae (Simão & Scatena, 2001).

H. velloziana and *H. angusta* had the vascular bundles form 1-3 discrete vascular systems: the first form of vascular system is a main vascular system, between two arcs of air-canals, creating a single extensive arc; the second is abaxial vascu-

lar system, generally forming more than one arc; and the third is an adaxial vascular system, forming an only small arc (Simão & Scatena, 2001). Pisang Awak had two form of vascular systems i.e. main vascular system and abaxial vascular system.

Root

The root of Pisang Awak consists of three tissue systems, epidermis, parenchyma and vascular cylinder. Pisang Awak had two epidermis layers (Figure 2C). The one to two epidermis layers also found in *M. acuminata* cv. Penjalin and *M. paradisiaca* cv Raja nangka (Sumardi & Wulandari, 2010). Cortex of Pisang Awak root has many layers with thick-walled cells in outside surface; this layers called periderm (Tomlison, 1969). The function of periderm was a protected layer. Cortex composed of irregular parenchyma cells and big airspace. The big airspace called lacunae (Swennen & Oritz, 1997). The presence of aerenchyma, which is continuous from shoots to roots, enhances the diffusion of air from the leaves to the roots to support respiration (Evert, 2006). The airspace also found in *M. acuminata* cv Penjalin, *M. balbisiana* cv Kluthuk warangan, *M. acuminata* cv Ambon warangan, and *M. paradisiaca* cv Kluthuk, but did not found in *M. paradisiaca* cv Raja nangka (Sumardi & Wulandari, 2010).

The development of air-canals in *Heliconia angusta* and *Heliconia velloziana* roots respond to decrease of oxygen concentration in the soil, created by temporary flooding, this condition increases ethylene concentration in roots of plants, which in turn increases the cellulose activity, resulting in aerenchyma development (Kawase & Whitmoyer, 1980). The development of aerenchyma in roots is an adaptation to moist condition (Simão & Scatena, 2001).

The endodermis of Pisang Awak consists of one layer which composed of the thick cell and the position between cortex and vascular cylinder. The endodermis wall composed of lignin and suberin (Cutler *et al.*, 2007).

In Pisang Awak root the vessels scattered at the center of root. The phloem cells were formed alternately with vessel cells. However, in root of Kluthuk warangan, some of vessels were surrounded by tracheid cells. The arrangement of phloem irregular in the central zone, and xylem did not form ridge-like structure, it showed the anomalous structure (Sumardi & Wulandari, 2010).

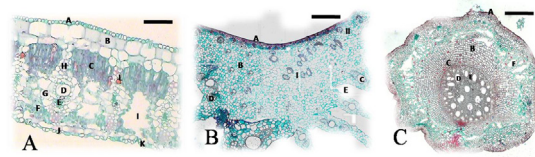


Figure 2. Anatomy of Pisang Awak (10x magnification). Leaf (A). a adaxial epidermis; b, hypodermis; c, palisade tissue; d, xylem; e, phloem; f, spongy tissue; g, bundle sheath; h, sclerenchyma; i, airspace; j, abaxial epidermis; k, stomata; l, laticifer. Petiole (B).a, epidermis; b, parenchyma cells; c, xylem; d, phloem; e, airspace; f, fiber; I, main vascular system; II, abaxial vascular system. Root (C). a epidermis; b, cortex; c, endodermis; d, vessel; e, phloem; f, airspace. Bar 100µm

Potential Uses of Pisang Awak

Padang Tikar I villager have used the ripe fruit into *sale* (dried banana). The unripe fruits of Pisang Awak were used for making high fiber flour. In Thailand, the floral buds of Pisang Awak are used in various culinary preparations (Bakry *et al.*, 2009). Pisang Awak (ABB genome) in Oman showed to be well adapted to dryness (De Langhe, 2002). ABB varieties are showing good palatability and high productivity in the natural germplasm (Ravi *et al.*, 2013).

In the future, the anatomy of the vegetative organs in Pisang Awak could be applied as the basis of information for classification Pisang Awak and breeding programs of local banana cultivars especially for drought resistance in banana cultivars.

CONCLUSION

Leaf of Pisang Awak has both side rounded for shape of leaf base with two layers of hypodermal cells, two layers of palisade cells and laticifer in association with vascular bundles. Petiole of Pisang Awak has straight with erect margins for petiol canal leaf type with a single layer of epidermis, compact cell, and rectangular shape. The parenchyma cells were found in the middle part of the petiole. The root of Pisang Awak has two epidermis layers, many layers of the cortex, endodermis, vessels scattered at the center of root and phloem cells were formed alternately with vessel cells. Furthermore, the presence of hypodermis in the leaves of family Musaceae is vital in the separation of these taxa. In the future, morphological and anatomical character could be applied

as the basis of information for breeding programs of banana cultivars and classification.

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