The Study of Anatomy and Fiber Banana Leaf as a Potential Wrapping

N. Harijati ¹, R. Azrianingsih and E. A. Prawaningtyas
Biology Department, Faculty of Mathematics and Natural Sciences, Brawijaya University, Malang
harijati@ub.ac.id

Abstract
The aims of this research were to study leaf anatomy of Musa brachycarpa, M. paradisiaca normalis, M. sapientum and M. cavendishi as well as length, width, and thickness of the leaf also number, diameter, and tensile strength of leaf fiber. Samples were taken from Dampit, Wajak and Batu, Malang, Indonesia. The leaves sample had criteria fresh, mature, and not torn. Microscopy slides which were used anatomy observation were prepared using semi-permanent method. Retting method was applied to extract the fiber, while fiber strength was measured using tensile strength tester. One way anova and Duncan test were used to analyze mean of dependent variable (length-, width-, thick-leaf; number-, diameter-, and tensile strength of fiber). T-test independent sample was used to analysis mean and diameter fiber in adaxial and abaxial site. The result showed that M. brachycarpa had the highest number fiber cell, wider diameter fiber, and more adaxial’s number fiber cell than abaxial one. The diameter of fiber 5-6 µm. M. sapietum had the longest and widest oh leaves. While the thickness of leaf was showed by M. paradisiaca. All observed species didn’t show significantly different in tensile strength test. The tensile strength had value 35x10⁻⁴-48x10⁻⁴ MPa.

Key words: diameter of fibers, number of fiber, M. brachycarpa, strength of fiber

Introduction
Food wrapping or packaging using plastic or Styrofoam that increased from year to year may threaten health unwittingly. Ingredient material that composed plastic or Styrofoam such as polystyrene, polyvinyl chloride, and acrylonitrile can act as a carcinogenic agent [1,2]. Especially acrylonitrile may function as genotoxic agent by inducing DNA strand breakage and sex chromosome non-disjunction in spermatogenesis [3]. The plastic or Styrofoam tempted people because it offered conveniences and ease as a container or wrapping of food. To avoid such hazard effects of plastic or Styrofoam, traditionally local wisdom already applied leaf as a food wrapping or packaging or container. In Indonesia, the most popular leaf as food wrapping is banana leaf. The preference has reasons include easily to find, cheap, wider leaflet, and not give color to food. Instead banana leaf, people used teak leave. However, teak leave was not popular because have rough texture surface and produce red color to food. Traditional cakes that used banana leaf as wrapping included ‘Nagasari’, ‘mendut’, ‘lemper’, and ‘lemet’. And ‘Pepes’, ‘Gadon’, and ‘Bothok were traditional cuisine that also need leaf as wrapping. Even porridge rice frequently used banana leaf as container. Telling story from one generation to other generation mentioned that not all banana leaf suitable as wrapping, only leaf from few species can be used. And almost all people mentioned that M. branchycarpa is the best for wrapping. The leaf has some excellence such as not easily to tear, flexible so easy to fold and fixed using short- thin bamboo (as staple). Others banana leaf may be used with additional treatment. They were leaf from M. parasidiaca and M. sapientum. By putting hypothesis that flexibility for leaf folding was supported by certain anatomy structure and tensile strength of fiber, we want to explore anatomy structure and tensile strength of fiber between M. branchycarpa, M. parasidiaca, M. sapietum and M. cavendishi. The last banana was not common as wrapping so it can function as reference or control.

Materials and Methods
Leaf sample preparation
Banana (M. branchycarpa, M. parasidiaca, M. sapietum and M. cavendishi) leaves were obtained from Malang district include Dampit (M. sapientum-‘Pisang Rajamala’), Wajak (M. brachycarpa-‘Pisang klutuk’), and administrative town, Batu (M. paradisiaca normalis-‘pisang Kepok’; M. Cavendishi-‘Pisang Cavendish’). Criteria leaves as sample was obtained from mature banana that not yet produce fruit. Each
species was taken from different group; one group has function as replicate. The obtained leaf was measured its length, width, and thickness.

**Slide Preparation and anatomy observation**

Leaf-anatomy slide was prepared by semi-permanent method. First, cut five pieces a 10x5 mm$^2$ from the widest banana’s leaf blade. Each piece was cut using clamp on hand microtome as much 3 slices. All slices were fixed in FAA fixative for 1 minute then were washed three times with distilled water one minute each. Finished washing, they were stained with 1% safranin (in distilled water) for one minute, followed by three time washing one minute each. Then the slice was placed on slide glass, gave one drop glycerin, put in cover glass and seal using transparent nail polish. Now the slide was ready for anatomy observation from adaxial to abaxial side as well as measuring diameter and counting number fiber cell. The pictures were taken using digital camera.

**Fiber extraction and measuring fiber strength**

The first step of fiber extraction was retting. i.e. submerge some leaves in water, added with 2 tea spoon soil to enhance decomposition non-fiber material. Submerge step was considered enough when epidermis looked peel off. The second and third steps were scuthing and hackling respectively. Measuring fiber strength was conducted using tensile strength tester (Imada, Japan) according SOP of Manufacture’s equipment.

**Data analysis**

By put in Ho was no different mean of length, width, and thickness of *M. brachyacarpa*, *M. parasidiaca*, *M. sapetum*, *M. cavendishi* as well as number, diameter, and strength of those banana, ANOVA test was applied using SPSS 17.0 for Windows. When the result was significant, Duncan post hoc was conducted. T- Independent test was run to know whether number adaxial- and abaxial fiber same or not.

**Result and Discussion**

In general banana leaf anatomy consisted of adaxial epidermis, hypodermis, palisade layer, spongy layer, bundle sheath cell, abaxial epidermis, laticifer, simple and small size cells with convex outer cell in all banana species (Fig. 1). Hypodermis was only occurred at adaxial site. It had two to three layer cells, whereas cell layer beneath epidermis had smaller size than two others layer in *M. brachyacarpa*, *M. sapetum*, *M. cavendish* (Figs 1 A, C, D). Two layer hypodermal layers only were found in *M. parasidiaca* (Fig.1B). Occurrence 2-3 layer hypodermal cell in these bananas is typical Musaceae family. In contrast with *Musa* sp., *Heliconia* sp. leaf that is same Order with Musaceae, only has one hypodermal layer. There was two size of vascular bundle, big and small. They spanned in between mesophyll cells. Hypodermal cells above big vascular bundle had two layers with reduced size cells and both end vascular bundle were capped with sclerenchyma fiber (Figs. 1 A, B, C, D). Sometimes hypodermal cell above small vascular bundle of *M. parasidiaca* had fan shape (Fig.1B). Each vascular bundle was wrapped with parenchyme bundle sheath cell. Mesophyll composed of palisade and spongy tissue. The palisade consisted of two (Figs.1A, C) to three layer cells (Figs. 1B, D), and spongy tissue was formed from irregular shape cell which some cells fuse together produced large aerenchyma(Fig.1B). The aerenchyma is located between two vascular bundles.
Traditional wisdom and practice using leave from one generation to another generation mentioned that *M. brachycarpa* (Pisang Klutuk) is the most popular and acceptable as food wrapping material, and then followed by *M. paradisiaca* (Pisang Kepok) and *M. sapientum* (Pisang Rajamala). The wisdom was supported by result length and thickness measurement of *M. brachycarpa* and *M. paradisiaca* which were not significantly different (Figs. 2A, C). And *M. sapientum* was wider and longer (Figs. 2A, B) than three others species. *M. cavendishi* was evidenced short, narrow, and thin (Figs. 2A, B, C), therefore *M. cavendishi*’s leaf was the last choice or preference as a wrapper.

![Figure 1. Cross section of banana leaves in (A) *Musa brachycarpa* ('Pisang Klutuk'), (B) *M. paradisiaca* ('Pisang Kepok'), (C) *M. sapientum* ('Pisang Rajamala'), (D) *M. cavendishi* ('Pisang Cavendish'). Note: arrow showed fan-like structure; 1.epidermis; 2.hypodermis; 3. fiber; 4.spongy tissue; 5. Palisade tissue; Ac. Aerenchyma; bsc.bundle sheath cell; L laticifer x. xylem; Ph. Phloem.](image-url)

![Figure 2. Measurement length, width and thickness of *M. brachycarpa, M. paradisiaca, M. sapientum* and *M. cavendishi*. Note: same notation that followed species showed not significantly different in Duncan 0.05 test](image-url)
The good preference of *M. branchyacarpa* as wrapper was supported by internal analysis i.e. counting of fiber number and fiber diameter. *M. branchyacarpa* had the highest number of fiber and significantly different than three other species (Fig. 3A) and higher diameter of fiber (Fig 3C). The number and diameter fiber of *M. branchyacarpa* were 274 fiber cell and 5.97 µm respectively. In the other hand *M. cavendishi* had the lowest fiber number and lower fiber diameter i.e. 68 fiber cell and 5.08 µm in diameter. Overall range diameter fiber of the leave between 5-6µm was lower than fiber in pseudo stem of banana. Because of the diameter fiber, no issue leaf fiber involved industry or composite blew in. Diameter of banana pseudo-stem at least 15 µm and potential as material greaseproof paper [9].

![Figure 3. Counting fiber number and measurement fiber diameter of M. brachycarpa, M. paradisiaca, M. sapientum and M. cavendishi.](image)

Note: same notation that followed species showed not significantly different in Duncan α 0.05 test (A,C) same notation that followed each species showed not significantly different in t-test independent sample (B,D)

However, measurement tensile strength of fiber was not different statistically for all species (Fig.4). The tensile strength of tested banana species had value 0.35-0.48 N/cm² equal with 35x10⁻⁴ 48x10⁻⁴ MPa (1N/cm² = 0.01 MPa [10]). These value was very low if compared with tensile strength of Jute (393 MPa) or pine apple (170 MPa). Therefore based on tensile strength value, banana leave was not suit for industry purpose but more a food wrapping or disposable plate [11]. These facts indicated that flexibility leaves as wrapper was more influenced by number and diameter of fiber than tensile strength of it.

People used to apply adaxial site as hinge or folding site during wrapping action. Suppose this behavior had strong reason. Based on counting fiber in adaxial and abaxial site showed that *M. Brachycarpa* had number fiber more in adaxial than abaxial site and statistically different according t-test independent sample, whereas the others not showed different in t-test for adaxial and abaxial site (Fig. 3B). Fiber diameter in adaxial and abaxial site had the similar size (Fig. 3D).
**Figure 4.** Fiber’s tensile strength of *M. brachycarpa*, *M. paradisiaca*, *M. sapientum* and *M. cavendishi*.

Note: same notation that followed species showed not significantly different in Duncan α 0.05 test

**Conclusion**

*M. branchyacarpa* has three layer hypodermal cells, two layer palisade cells, and both adaxial and abaxial fiber capped vessel bundle. The species also had more number and wider diameter of fiber. In contrast with *M. branchyacarpa*, *M. cavendishi* had fewest and narrow diameter fiber. Number and diameter size of fiber tend higher in adaxial site than abaxial site, especially in *M. branchyacarpa*. Tensile strength of all tested species not significantly different, but *M. sapietum* tend higher. In addition tensile strength, *M. sapietum* also had longer and wider leave. Based on practice using *M. branchyacarpa* as food wrapping for long time and the most reliable as food and cuisine wrapping, wider and higher number of fiber in adaxial site should be as criteria to look for others species or variety of banana as a potensial wrapping.

**References**


