UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY OF FIBER ORIENTATION EFFECT ON MECHANICAL PROPERTIES OF BANANA PSEUDOSTEM FIBER

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours.

by

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APPROVAL

This report is submitted to the Faculty Of Engineneering Technology of UTeM as a partial fulfilment of the requirement for the degree of Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours. The member of the supervisory is as follow:

…………………………………………….

(Sir Mohd Azlan Bin Mohamed)

ABSTRAK

Laporan ini menerangkan kajian kesan orientasi gentian terhadap sifat mekanikal serat batang semu pisang dalam pengoptimaan kekuatan produk. Komposit ini disediakan menggunakan kaedah *Hand Lay-up* dengan tiga orientasi gentian yang berbeza iaitu 0 °, 0 ° / 90 ° dan 90 ° secara asingnya. Tujuan utama projek ini adalah untuk mencari orientasi terbaik serat batang semu pisang diperkukuhkan dengan *polyester resin* berdasarkan sifat-sifat mekanikal mereka. Gentian asli mempunyai beberapa kelebihan berbanding gentian sintetik seperti ketumpatan rendah, kekakuan dan sifat-sifat mekanikal yang sesuai serta tinggi kadar pelupusan dan pembaharuan. Selain itu, gentian asli boleh dikitar semula dan mesra alam. Kertas kerja ini mengkaji semula beberapa literasi dan dokumen sejarah mengenai sifat rencam. Tambahan lagi, projek ini menerangkan kaedah yang digunakan untuk mengekstrak gentian batang semu pisang dan proses fabrikasi serat batang semu pisang diperkukuhkan dengan *polyester resin* dengan ketara. Sampel yang disediakan tertakluk kepada ujian mekanikal seperti ujian tegangan, lenturan dan mampatan. Sampel disediakan adalah mengikut piawaian ASTM dan eksperimen dijalankan dengan menggunakan *Universal Testing Machine* (UTM). Hasil dariapada kajian seterusnya dianalisis dan dibincangkan.

ABSTRACT

This report describes the study of fiber orientation effect on mechanical behavior of banana pseudostem fiber to optimize product strength. Composites were prepared using the hand lay-up method with three different fiber orientation which are 0°, 0°/90° and 90 ° respectively. The main purpose of this project is to find the best orientation of banana pseudostem fiber reinforced with polyester resin based on their mechanical properties. Natural fibers possess several advantages over synthetic fibers such as low density, appropriate stiffness and mechanical properties and also high disposability and renewability. Besides that, they are recyclable and biodegradable. This paper review some literatures and past documents regarding to the nature of the composite. In addition, this project described the method used to extract the banana pseudostem fiber and fabrication process of banana pseudostem fiber reinforced with polyester resin significantly. The samples were subjected to the mechanical testing such as tensile, flexural and compressive test. The specimen is prepared according to ASTM standards and the experiment has been carried out by using universal testing machine (UTM). The result are then analyzed and discussed.

DEDICATION

To my beloved parents
Rose Asmarani Binti Ahmad Sukar and Mohd Hassan @ Junaidi Bin Mohd Thani

To my siblings
Muhammad Aizat, Syafiqah, Muhammad Yazid and Muhammad Danial

Thank you for your never-ending supports, continuous love, and encouragement that making me who I am today.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ASTM - American Society for Testing and Materials

CFRE – Carbon Fiber Reinforced Epoxy

GFRE – Glass Fiber Reinforced Epoxy

MEKP - Methyl Ethyl Ketone Peroxide

ISO - Organization for Standardization

UTM – Universal Testing Machine

BFRP – Banana Fiber Reinforced Polyester

CHAPTER 1

INTRODUCTION

1.0 Introduction

Final Year Project (PSM) is one of the subject that compulsory for each graduate student in order to pursuit and gained their degree. This project will conquer certain area of study related to student's field of study. The title of this project is Study of Fiber Orientation Effect on Mechanical Properties of Banana Pseudostem Fiber. This project is basically under research category in which it applies biocomposite part of banana pseudostem fiber reinforced with polyester resin.

1.1 Project Background

There are many factors that can affect the mechanical properties of the composite material. In many applications, like in aircraft parts, there is a need for high strength per unit weight (specific strength). This can be achieved by composites consisting of a low-density (and soft) matrix reinforced with stiff fibers. The strength depends on the fiber length and its orientation with respect to the stress direction. The efficiency of load transfer between matrix and fiber depends on the interfacial bond. The same scenario thus expected on biocomposite product like banana pseudostem fiber. There are various types of fiber orientation used in composite process and it is believes that those fiber orientation gives different effects towards the mechanical properties of the composite part. This project involves acquirement of banana pseudostem fiber, composite fabrication process and mechanical testing.

1.2 Problem Statement

Fiber orientation gives effect on the mechanical properties of a composite part. Each of the laminate process of composite material actually used different fiber orientation to get the best strength on product structure. For example, the manufacturing process of a boat. Most fiberglass boats are currently made in an open mold, with fiberglass and resin applied by hand (hand lay-up method). A binding medium that is not structurally sound can be stiffened and made stronger by adding another more fibrous material. These fine glass fibers are in one sense quite fragile, but when held in column by plastic resin they are also stiff and strong. From that case, the same scenario thus expected on biocomposite product which is banana pseudostem fiber. There is no yet thorough research on the effect of fiber orientation on mechanical properties.

1.3 Objective

The objective of this project is:

i. To determine the fiber orientation effect on banana pseudostem fiber compared to commercial fiber.
ii. To find the best orientation/arrangement of banana pseudostem fiber reinforced with polyester resin based on their mechanical properties.

1.4 Scope

The scope of this project are:

i. Carry out the sample preparation of banana pseudostem fiber reinforced polyester resin with three different fiber orientation.
ii. Conduct mechanical tests on these specimens in three different types of fiber orientation.
iii. Perform appropriate analysis on the mechanical test results.

CHAPTER 2

LITERATURE REVIEW

2.0 Banana Tree

The banana plant is a large perennial herb with leaf sheaths that form trunk-like pseudostems. The plant has 8 - 12 leaves that are up to 9 feet long and 2 feet wide. Root development may be extensive in loose soil in some cases up to 30 feet laterally. The inflorescence (blossom stalk) becomes through the focal point of the pseudostem. Blossoms create in groups and winding around the primary pivot. It takes about 60 - 90 days for the fruits to be mature after the first flowers appear. Each bunch of fruits consists of variable numbers of "hands" along a central stem. Each "hand" consists of two transverse rows of fruits. The fruit quality is determined by size (finger length and thickness), evenness of ripening, freedom from blemishes and defects, and the arrangement of the clusters. Quality standards may differ in various markets (Internet sources; extento.hawaii.edu).

Figure 2.1: Banana Tree

Bananas contain about 74% water, 23% carbohydrate, 1% protein, and 0.5% fat. A 4-ounce banana without the peel is a good source of vitamin B6, potassium, and fiber. Banana fruit may be eaten raw or as a cooked vegetable. Other parts of the banana plant are consumed besides the fruit. The heart of the growing pseudostem is eaten in India. In Southeast Asia, the male bud is eaten as a boiled vegetable. The banana leaves are not eaten but may be used for wrapping food in cooking. (Vigneswaran et al., 2015)

Banana (Musa sp) belongs to the Musaceae family. Over 70 species of Musa were recognized by the World Checklist of Selected Plant Families, but only few species are edible. There are two wild species of banana, including Musa acuminata and Musa balbisiana. Almost all modern edible parthenocarpic bananas come from these two species (Valmayor et al., 1999).

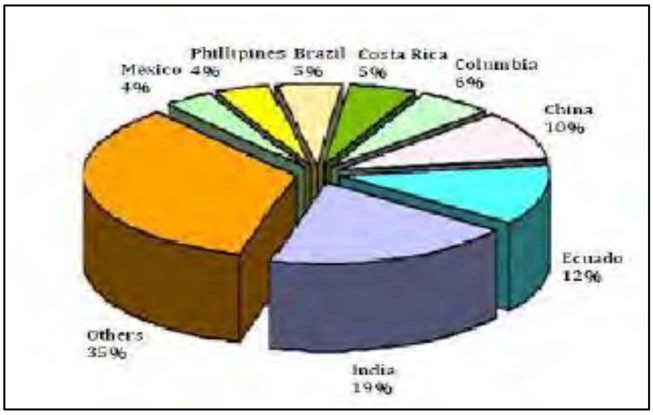

Figure 2.2: Growth % of banana around the world

Bananas are suspected to be the first fruit in the earth by some horticulturists. Their origin is placed in Southeast Asia, in the jungles of Malaysia, Indonesia or Philippines, where many varieties of wild bananas still grow today. Africans are credited to have given the present name, since the word banana would be derived from the Arab for ‘finger’. They started to be traded internationally by the end of fourteenth century. The development of railroads and technological advances in refrigerated maritime transport subsequently enabled bananas to become the most important world traded fruit (Internet sources; bananalink.org.uk).

2.0.1 Banana Pseudostem

Figure 2.3: Banana Pseudostem

The pseudostem is the part of the banana plant that looks like a trunk. It is formed by the tightly packed overlapping leaf sheaths. Even though the pseudostem is very fleshy and consists mostly of water, it is quite sturdy and can support a bunch that weighs 50 kg or more. The pseudostem continues to grow in height as the leaves emerge one after the other and reaches its maximum height when the inflorescence emerges at the top of the plant. It has been reported that banana is the second largest produced fruit in terms of quantity, contributing about 16% of the world's total fruit production (Mohapatra et al., 2010).

Therefore, every year after harvesting, a large amount of bare pseudostem is cut and left behind as waste worldwide, which ultimately causes contamination of water sources as well as can affect the environment and health of living microorganisms (Aziz et al., 2011, Hossain et al., 2011). The plant is normally tall and fairly sturdy, as a result is often mistaken for a tree. However, the trunk of the banana plant is actually a false stem or pseudostem (Stover & Simmond, 1972).

The pseudostem is normally 5 to 7.6 meters tall (varies from species to species) growing from a corm (Nelson et al., 2006). The pseudostem consists of a tender core and several outer sheaths. The tender core inside the pseudostem carries the immature inflorescence until eventually it emerges at the top. Therefore most of the nutrients of the pseudostem are present in the tender core (Jun Ma, 2015).

2.0.2 Banana Pseudostem Fiber

Apart from water, the pseudostem of banana, an herbaceous plant of the genus Musa, contains several polymers such as cellulose, hemicellulose, pectin, and lignin that constitute fibers with good mechanical properties. It has lesser amount of extractives, protein, starch, and inorganics. The bast fiber of banana has been widely recognized for its good qualities over synthetic fibers and is used for making apparels, garments, and home furnishing (Uma et al. 2005).

Table 2.1: Banana properties contents in (%) between bioextracted fiber and physically extracted fiber

Contents (%)	Bioextracted fiber	Physically extracted fiber
Moisture	9.1	9.7
Cellulose	59.3	60.6
Hemicellulose	10.2	12.4
Lignin	17.5	18.9
Ash	1.0	2.9

It is quite possible that these chemical compositions may vary with age, variety, climatic conditions, geographical location, etc. Understanding the chemical composition and physical properties of the fibers is very important to utilize them properly in composites, textiles, and pulp and paper manufacturing applications (Abdul Khalil et al. 2006; Li et al. 2010).

2.0.3 Methods of Extraction Banana Pseudostem Fiber

Banana fibers can be extricated by utilizing compound, mechanical or organic techniques. Compound strategy causes ecological contamination, while mechanical technique neglects to expel the sticky material from the fiber package surface. Organic systems yield more fiber groups than the other two strategies with no mischief to the earth. In the wake of removing the filaments, degumming is fundamental before the usage of strands. The expulsion of vigorously covered, non-cellulosic sticky material from the cellulosic part of plant filaments is called degumming (Jacob and Prema, 2008).

Table 2.2: Data weight in gm of banana materials in process of banana fiber extraction

Materials	Weight in gm
Initial weight of banana stalk sheath	270.3
Moisture of b. stalk sheath	245.5
Weight of sheath after crushing	66.6
Dry weight of sheath	24.8
Removed matter in sheath	17.5
Fibre in the sheath on dry weight	7.3

This mechanical and manual extraction of banana fibres was tedious, time consuming, and caused damage to the fibre. Consequently, this type of technique cannot be recommended for industrial application. A special machine was designed and developed for the extraction of banana fibres in a mechanically automated manner. It consisted mainly of two horizontal beams whereby a carriage with an attached and specially designed comb, could move back and forth. The fibre extraction using this technique could be performed simply by placing a cleaned part of the banana stem on the fixed platform of the machine, and clamped at the ends by jaws (Pradesh and Processing, n.d.)

Conventional retting is the rarely used alternate method of fiber extraction from pseudostem. This is a long-term process which affects the fiber quality significantly (Ganan et al. 2004). Every method followed currently for fiber extraction has serious

Figure 2.4: Cutting and dry process of banana pseudostem

limitations either due to the deterioration of mechanical property or incomplete removal of vegetable matter.

Figure 2.5: Banana Pseudostem Fiber