DEVELOPMENT OF PACKAGING TRAY FROM SUGAR PALM FIBER (MECHANICAL PROPERTIES)

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DECLARATION

I declare that this thesis entitled " Mechanical Properties of Sugar Palm Fiber Composite For Packaging Application " is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature :

Name : ABIGAIL LIVAN MUSI

Date : 18/01/2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology (Process & Technology) with Honours.

Signature : ....

Supervisor Name : TS KAMAL BIN MUSA

Date : 14/7/2022

DEDICATION

Praise God for providing me with the strength, direction, and knowledge I needed to finish my thesis. &

To my adoring parents and relatives for their unwavering support and encouragement.

&

To my supervisor TS Kamal Bin Musa, and Dr. Ridhwan Bin Jumaidin for their help and suggestions in conducting this study.

&

To my friends who have always been there for me.

&

To everyone who has helped me along the way.

ABSTRACT

Environmental concerns regarding non-biodegradable polymers are rapidly growing. Several ecologically friendly materials have been developed to solve these critical problems. Biopolymer is a substance that can help since it biodegrades faster and is more environmentally friendly. Due to abundant availability, low cost, biodegradability and renewability, starch is used in biodegradable polymers. Thermoplastic starch (TPS) polymers are developed from a variety of natural sources that are biodegradable and compostable. TPS has gained popularity, yet it differs from other polymers in linear and branching topologies, resulting in considerable changes to its properties. Fibers are also used in fiber-reinforced composite materials, providing structure strength and stiffness. Natural fibers are mostly agricultural waste, which is useless to burn as fuel, exacerbating environmental concerns. Sugar palm fibers (SPF) are obtained from trunk, bunch, frond, and trunk surface, known as Ijuk, have been identified as a potential reinforcing element for the production of bio-based composites. In this research, the objectives are to develop a packaging tray by using thermoplastic cassava starch (TPCS) reinforced with various amounts of SPF, by investigating the material's mechanical and thermal properties. TPCS reinforced with SPF composite was made by mixing at high speeds, followed by a hot press. Several tests were performed to evaluate different properties. A thermogravimetric analysis (TGA) test was performed for the thermal properties of the composite, tensile and flexural testing to examine the mechanical properties. Fourier Transform Infrared Spectroscopy (FTIR) and a Scanning Electrode Microscope (SEM) to examine the chemical interaction and morphological characteristics. The results shown in TGA that the TPS has lost the most weight, reducing overall thermal stability of the polymer matrix system, and as the SPF content increases, the thermal stability improves, which proves that composites with SPF of 40wt% and 50wt% has better thermal stability than the rest. In FTIR, the existence of O-H bonding in starch and fiber was indicated by the highest peak in the curve, which was at 3200–3500cm^(-1). The highest tensile strength achieved shown in tensile testing is when SPF content reaches 50%, whereas for modulus elasticity for tensile and flexural strength is achieved at the highest when SPF content at 40%. In SEM, it has shown that a high sample fiber loading has a good adhesion to the TPCS matrix but when it reaches the limit due to weak bindings between TPCS and SPF. This has proven that the TPCS reinforced with SPF composite outperforms the matrix material in terms of feature function. The SPF composite reinforced TPCS tray can be expected to be used as a biodegradable tray in the packaging industry. At the end of this study, an actual prototype of the packing tray is constructed successfully and can be considered as a fully functional prototype.

ABSTRAK

Kesedaran mengenai alam terutama disebabkan oleh polimer yang tidak terbiodegradasi kini berkembang pesat. Beberapa bahan mesra alam telah dianalisis untuk menyelesaikan masalah kritikal ini. Biopolimer adalah bahan yang dapat membantu kerana biodegradasi lebih cepat dan lebih mesra alam. Oleh kerana ketersediaan yang banyak, kos rendah, biodegradasi dan kebaharuan, kanji digunakan dalam polimer yang boleh terurai secara biodegradasi. Polimer kanji termoplastik (TPS) dibangunkan daripada pelbagai sumber semula jadi yang terbiodegradasi dan kompos. TPS telah mendapat populariti, tetapi berbeza dengan polimer lain dalam topologi linier dan bercabang, yang mengakibatkan banyak perubahan pada sifatnya. Serat juga digunakan dalam bahan komposit bertetulang serat, memberikan kekuatan dan kekukuhan struktur. Serat semula jadi kebanyakannya adalah sisa pertanian, yang tidak berguna untuk dibakar sebagai bahan bakar, memperburuk masalah alam sekitar. Serat liuk (SPF) diperoleh dari permukaan batang, tandan, pelepah dan batang, yang dikenali sebagai Ijuk, telah dikenal pasti sebagai elemen penguat yang berpotensi untuk pengeluaran komposit berasaskan bio. Objektif penyelidikan ini adalah untuk membuat biodegradasi tray thermoplastik dengan campuran lilin lebah yang diperkuat dengan pelbagai jumlah ratio SPF. TPCS yang diperkuat dengan komposit SPF dibuat dengan dicampurkan pada kelajuan tinggi, diikuti dengan tekan panas pada suhu 155℃. Beberapa ujian dilakukan untuk menilai sifat yang berbeza. Uji analisis termogravimetri (TGA) dilakukan untuk sifat terma ujian komposit, tegangan dan lenturan untuk memeriksa sifat mekanik, dan Spektroskopi Infrared Fourier Transform (FTIR) dan Mikroskop Elektrod Pengimbasan (SEM) untuk memeriksa interaksi kimia dan morfologi ciri. Hasil kajian ditunjukkan dalam TGA bahawa TPS telah kehilangan berat yang paling banyak, mengurangkan kestabilan haba keseluruhan sistem matriks polimer, dan apabila kandungan SPF meningkat, kestabilan haba bertambah baik, yang membuktikan bahawa komposit dengan SPF 40wt% dan 50wt% mempunyai kestabilan haba yang lebih baik daripada yang lain. Di FTIR, kewujudan ikatan O-H dalam kanji dan serat ditunjukkan oleh puncak tertinggi dalam lengkung, iaitu pada 3200–3500cm^(-1). Kekuatan tegangan tertinggi yang dicapai ditunjukkan dalam ujian tegangan adalah ketika kandungan SPF mencapai 50%, sedangkan untuk keanjalan modulus untuk kekuatan tegangan dan kekuatan lenturan dicapai pada tahap tertinggi ketika kandungan SPF pada 40%. Di SEM telah menunjukkan bahawa pemuatan serat sampel yang tinggi mempunyai lekatan rendah pada matriks TPCS ketika mencapai had kerana pengikatan yang lemah antara TPCS dan SPF. Ini telah membuktikan bahawa TPCS yang diperkuat dengan komposit SPF mengungguli bahan matriks dari segi fungsi ciri. Dulang TPCS dengan campuran komposit SPF diharapkan dapat digunakan sebagai dulang biodegradasi dalam industri pembungkusan. Pada akhir kajian ini, prototaip sebenar dulang pembungkusan dibina dengan jayanya dan boleh dianggap sebagai prototaip yang berfungsi sepenuhnya.

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LIST OF SYMBOLS AND ABBREVIATIONS

SEM	-	Scanning Electron Microscope
SPS	-	Sugar palm starch
TPS	-	Thermoplastic starch
TPCS	-	Thermoplastic cassava starch
TGA	-	Thermo-gravimetric Analysis
PMC	-	Polymer Matrix Composite
NFTC	-	Natural Fiber Reinforced Thermoplastic Composites
SPF	-	Sugar Palm Fiber
SPFC	-	Sugar Palm Fiber Composites
FTIR	-	Fourier Transform Infrared Spectroscopy (FTIR)

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CHAPTER 1

INTRODUCTION

1.1 Background

In current times, plastic pollution has remained being one of the issues at the core of the challenges infecting the current situation of this universe. Annually, higher than anticipated of eighty million tons of plastic related wastes are dumped into the sea. There is about 5 trillion pieces of plastic trash are disposed and found in all the water reservoirs in the whole world (Godswill & Gospel, 2019). An alternative method to produce more eco-friendly polymer to handle the current issue is by using green materials and fully biodegradable composite which can most likely solve polymer waste disposal problems (Sahari et al., 2013b).

Composite is defined as a fusion of different materials with unsimilar physical and chemical characteristics (Jogur et al., 2018). Research from Yashas Gowda et al., (2018) found that composite materials are one of the materials which properties improve and enhance in terms of stiffness, strength, cost effective, density and sustainability. In today's time, starch, an example of a natural resource, has become popular and highly demanded for the development of biopolymer to replace the conventional polymer, mainly because of its renewability, biodegradibility, cost-effective and attainability (M. L. Sanyang et al., 2016).

Due to starch's potential to show good mechanical characteristics and attribute, shear stress and thermoplastic behaviour under high temperature, it is considered as the most ideal source for producing bio-degradable polymer and composite (Lomelí-Ramírez et al., 2014; Mo et al., 2010; M. L. Sanyang et al., 2016). In addition, fibers are the key components of reinforcements that play a crucial role in the mechanical properties of a material. Natural fibers have numerous advantages, such as low cost, high density, recyclability biodegradability and con-siderable efforts are being made to tap their full potential (Edhirej et al., 2017).

The recyclable nature of these materials is a benefit since it reduces disposable waste and therefore costs less (Gowda et al., 2018). Glycerol is the most often used plasticizer for starch. Thus, a recent study into the impact of glycerol concentration on the physical and thermomechanical characteristics of starch revealed that starch with an appropriate quantity of plasticizer showed improved mechanical qualities (Sahari et al., 2012)(Muhammed L. Sanyang et al., 2015).

1.2 Problem Statement

Environmental issues have risen to the top of the priority list in today's society. One of the sources of these environmental problems is packaging waste. Packaging waste accounts for a significant portion of solid waste, raising environmental concerns. One of the most difficult problems the packaging industry has in its attempts to create bio-based primary packaging is the development of a polymer with durability that matches the shelf-life of the product being packaged. In order to be effective during storage, the bio-based packaging material must maintain its mechanical and barrier characteristics while being stable. It must also operate effectively throughout the whole storage period till disposal. (Kumar, 2017).

In addition, According to (Nik Baihaqi, 2021) Sugar palm fiber is a by product of the agricultural sector.Furthermore, agro-waste may be utilised as a source of reinforcement in a range of biomaterial applications. Sugar palm fiber may be found in a wide range of goods and applications. Sugar palm fiber, in particular, can be utilised to create composite materials.

Starch is a naturally occurring element with easily degradable properties. It does, however, have a number of shortcomings, most notably in terms of mechanical and thermal performance. (Zuo, 2015) Meanwhile, sugar palm fiber may aid in the improvement of the mechanical and thermal strength of starch when used in conjunction with it (Nik Baihaqi, 2021). The development of biodegradable goods derived from sugar palm fiber and starch is thus necessary.

As a result, the primary objective of this research is to create a biodegradable thermoplastic cassava starch/beeswax composite that is reinforced with Sugar Palm leaf fibre. The objective of this research, apart from that, will be to investigate the mechanical and thermal properties of a biodegradable thermoplastic cassava starch/beeswax composite reinforced with Sugar Palm fibre. As a consequence of this study, the amount of waste generated by sugar palm will be decreased, and the trash will be transformed into new biodegradable material.

1.3 Research Objective

The primary goals of this thesis and analysis are as follows:

I. To produce biodegradable tray from thermoplastic cassava starch reinforced with Sugar Palm fiber composite.

II. To investigate the mechanical properties of biodegradable thermoplastic cassava starch reinforced with Sugar Palm fiber composite.

III. To determine the thermal properties of biodegradable thermoplastic cassava starch reinforced with Sugar Palm fiber composite.

1.4 Scope of study

Cassava starch, sugar palm fiber, beeswax, and glycerol were the primary organic materials utilized in this investigation. By referring to the required percentage of formulation, a Cassava starch, sugar palm fiber, beeswax, and glycerol were the primary organic materials utilized in this investigation. In this study, the plasticizer is glycerol. Beeswax is added to the cassava starch and glycerol mixture at the appropriate proportion for the formulation. The purpose of beeswax is to act as a protective agent reduce the water absorption and moisture. Then, corresponding to the desired amount of percentage for this study, sugar palm fiber is added as a reinforcement to the combination of three basic materials. The hot compression moulding process will be used to create a thermoplastic starch composite with beeswax reinforcement and sugar palm fiber. Tensile, flexural, and density tests will be used to investigate mechanical properties, while thermogravimetric analysis (TGA) will be used to determine thermal properties and Fourier-Transform Infrared Spectroscopy (FTIR) will be used to determine the chemical structure of the material composite and scanning electron microscopy (SEM) is to observe the morphology of a material composite.

1.5 Structure of Thesis

This research is formatted in accordance with the guidelines developed by Universiti Teknikal Malaysia Melaka (UTeM) for the publication of this report. This article is divided into six sections: an introduction, a review of a literature, a methodology section, results and discussion, and a conclusion. The layout is detailed as follows:

Chapter 1

This chapter discusses the study's purpose in detail and highlights the issue that prompted this report. This chapter discussed the importance and nature of the research and function.

Chapter 2

This chapter justifies the extensive literature review conducted by a previous report on the subject of this thesis. Additionally, this chapter discusses the research void identified by an analysis of previous studies.

Chapter 3

This chapter discussed the methods utilized in this study in terms of material planning, testing procedures, and data collection.

Chapter 4

This chapter summarized the findings and discussion of the thermoplastic cassava starch reinforced with sugar palm leaf fiber composite testing. The chapter discusses the outcome in depth.

Chapter 5

This chapter summarizes On Thermoplastic Cassava Starch Reinforced by Sugar Palm Fiber Composite, the results of the thesis are discussed, as well as suggestions for further investigation.