BIODEGRADABLE PACKAGING DERIVED FROM NAPIER GRASS: MECHANICAL PROPERTIES

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DECLARATION

I declare that this thesis entitled “Biodegradable Packaging Derived from Napier Grass: Mechanical Properties” 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 candidature of any other degree.

Signature : 

Name : SITI NUR HIDAYAH BINTI JAMEL

Date : 18 JANUARY 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 with Honors.

Signature : 

Supervisor Name : DR. RIDHWAN BIN JUMAIDIN

Date : 28/1/2022

DEDICATION

To Al-Quran, the greatest source of knowledge

Bring me sheets of iron" - until, when he had leveled [them] between the two mountain walls, he said, "Blow [with bellows]," until when he had made it [like] fire, he said, "Bring me, that I may pour over its molten copper."

(Al-Kahf: Verse 96)

Alhamdulillah

Praise to Allah for the strength, guidance and knowledge that was given by Allah for me tocomplete this study.

&

To my beloved parents have been the strength for me and continuously support and sacrifice throughout my study &

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&

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ABSTRACT

Biodegradable material has been a significant challenge. The present problem of excessive napier grass production has resulted in waste, as only a portion of napier grass is used for certain purposes. This is one of the reasons for the study's use of napier grass fiber (NGF). Among other biodegradable materials, thermoplastic cassava starch (TPCS) has been identified as a fully biodegradable substance that can be generated by a variety of plants and is one of the most abundant renewable, biodegradable, and cost-effective resources accessible. The purpose of this study is to develop biodegradable TPCS reinforced with beeswax and NGF as well as to investigate the thermal analysis, mechanical properties, and physical properties of the materials. TPCS, on the other hand, have several limitations, including poor mechanical characteristics. A novel material composed of TPCS reinforced with beeswax and NGF has been made. To strengthen the cassava starch biopolymer's shortcomings, beeswax and NGF were incorporated at different loadings i.e., 0%, 10%, 20%, 30%, 40%, and 50% fiber content. The mixture was blended uniformly and the samples were formed using hot compression molding. The essential features of TPCS/NGF biopolymer composites were then evaluated to determine their suitability as biodegradable reinforcements. The finding shows that the tensile and flexural properties exhibit the same pattern of increasing strength and modulus, however, elongation exhibits a decreasing tendency. In terms of thermal properties, it was discovered that increasing the percentage of NGF in the TPCS matrix from 0% to 50% increased the thermal stability of the composites due to the fibers' hydrophobic qualities. The FTIR analysis demonstrates the presence of chemical bonding in the samples, whilst the SEM micrograph of the tensile fracture surface demonstrates the composite's microstructure changing as the fiber content increases. As a conclusion, the study presented preliminary data on the of TPCS/NGF composites, particularly in packaging. As a result, this material can eventually be the alternative for the non-biodegradable bioplastic, allowing natural waste to be fully used.

ABSTRAK

Bahan terbiodegradasi telah menjadi satu cabaran yang besar. Masalah pengeluaran rumput napier yang berlebihan sekarang telah mengakibatkan pembaziran, kerana hanya sebahagian rumput napier digunakan untuk tujuan tertentu. Ini adalah salah satu sebab kajian menggunakan serat rumput napier (NGF). Antara bahan terbiodegradasi lain, termoplastik kanji ubi kayu (TPCS) telah dikenal pasti sebagai bahan terbiodegradasi sepenuhnya yang boleh dijana oleh pelbagai tumbuhan dan merupakan salah satu sumber boleh diperbaharui, terbiodegradasi dan kos efektif yang paling banyak boleh diakses. Tujuan kajian ini adalah untuk membangunkan TPCS terbiodegradasi yang diperkukuh dengan lilin lebah dan NGF serta untuk menyiasat analisis haba, sifat mekanikal, dan sifat fizikal bahan tersebut. TPCS, sebaliknya, mempunyai beberapa batasan, termasuklah seperti ciri mekanikal yang lemah. Bahan baru yang terdiri daripada TPCS yang diperkuat dengan lilin lebah dan NGF telah dibuat. Untuk mengukuhkan kekurangan biopolimer kanji ubi kayu, lilin lebah dan NGF telah digabungkan pada muatan yang berbeza iaitu, 0%, 10%, 20%, 30%, 40%, dan 50% kandungan serat. Campuran diadun secara seragam dan sampel dibentuk menggunakan acuan mampatan panas. Ciri-ciri penting komposit biopolimer TPCS/NGF kemudiannya dinilai untuk menentukan kesesuaiannya sebagai bahan biodegradasi yang kukuh. Dapatan menunjukkan bahawa sifat tegangan dan lentur mempamerkan corak peningkatan kekuatan dan modulus yang sama, namun, pemanjangan menunjukkan kecenderungan menurun. Dari segi sifat terma, didapati bahawa meningkatkan peratusan NGF dalam matriks TPCS daripada 0% kepada 50% menaikkan kestabilan terma komposit disebabkan oleh kualiti hidrofobik gentian. Analisis FTIR menunjukkan kehadiran ikatan kimia dalam sampel, manakala mikrograf SEM bagi permukaan patah tegangan menunjukkan perubahan struktur mikro komposit apabila kandungan gentian meningkat. Sebagai kesimpulan, kajian membentangkan data awal tentang komposit TPCS/NGF, terutamanya dalam pembungkusan. Akibatnya, bahan ini akhirnya boleh menjadi alternatif untuk bioplastik tidak terbiodegradasi, membolehkan sisa semula jadi digunakan sepenuhnya.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Because of global environmental problems and greater knowledge of clean green alternatives, considerable effort has been made in providing environmentally safe and biodegradable textiles for the future generation of composites. The use of natural materials in composites reduces greenhouse gas emissions and carbon footprint of composites. A suitable solution would be green composites for oil-based materials (Gholampour & Ozbakkaloglu, 2020). Natural fibers are biodegradable, biocompatible, environmentally friendly and organic. Therefore, it is widely used in many applications instead of costly and non-renewable conventional fibers, such as glass fiber, carbon fiber, and aramid fiber (Syduzzaman et al., 2020). Around the last several years, people all over the world have grown increasingly aware of and worried about environmental concerns. Water pollution, air pollution, and landfill issues have all been exacerbated by the usage of non-biodegradable plastics. All of these issues have resulted in research into biodegradable materials such as thermoplastic starch (TPS), which is derived from natural resources. In 2015, the annual production of petroleum-based plastic exceeded 300 million tons, with less than 1% being bioplastic. Bioplastics advancements make it feasible to reduce the consumption of fossil fuels and plastic waste, as well as carbon dioxide emissions.

Natural fibers are having been used as raw materials to produce bio composite for replacing the plastic. Copious amount of literature is available where natural fibers has been used to produce reinforced bio-based polymeric composite (Pickering et al., 2016). Due to

its great productivity and nutritional content, Pennisetum purpureum, or Napier grass, has become the most frequently utilized fodder grass in dairy and feedlot production systems (Wadi et al., 2014). Napier grass is an easier-to-grow kind of grass that's also better suited to Malaysia's climate as well as for animal feed, the Napier grass is a good source of biomass in most tropical and sub-tropical regions (Kamaruddin et al., 2018). Additionally, natural fibers have a low density, a high specific strength, and a high degree of stiffness, and they contain different types of functional groups easy to modification (Pickering et al., 2016).

Non-biodegradable material consumption has had a huge detrimental impact on both society and the environment. Biodegradable substance is composed of a synthetic polymer derived from petroleum that is difficult to disintegrate in landfills, posing a threat to the environment. TPSs can now be seen of as a new class of low-cost, environmentally friendly polymers that can be restored to their original condition without causing pollution. TPS materials are frequently composed of a starch, glycerol, and water mixture (Nafchi et al., 2013). Recently, about 50% of bioplastic preparations were generated from starch, owing to the simplicity with which bioplastic-based starch may be manufactured and its extensive use in packaging applications. A study from Filho et al., (2020) stated that, because starch is hydrophilic, natural thermoplastic starch has the maximum solubility value.

TPS is a substance that is formed when a starch granule undergoes structural disruption (modification) due to the action of shear force and temperature in the presence of plasticizers that do not readily evaporate throughout the processing (Bastioli, 2001). According to Li et al., (2011), thermoplastic starch degrades more rapidly than native starch. The amount of glycerol in the thermoplastic starch has no discernible influence on its biodegradation behavior, but the amount of thermoplastic starch itself contributed to biodegradation through a considerable increase in TPS surface area. TPS's susceptibility to moisture and retrogradation processes restrict its applicability in a variety of applications.

Thus, it is prudent to minimize the use of non-biodegradable plastic and to promote the use of biodegradable plastic.

1.2 Problem Statement

One of the unintended consequences of technological advancements is nature's incapacity to breakdown the chemicals people make. For instance, the polythene used in shopping bags is non-biodegradable, meaning it does not naturally degrade in landfills. Non-biodegradable trash may persist for generations and wreak havoc on the ecosystem in ways that go beyond the land. Within a few decades, plastic has surpassed oil as the most polluting material in the world's seas (80% of marine litter is made of plastic), owing to its extremely slow degradability and the rising buildup of human waste products (Gewert et al., 2015). Plastics are abundant in the oceans and provide an ideal environment for bacteria to adhere and thrive. Understanding the processes of biofouling is critical for understanding the ecological effects and destiny of plastics in the marine environment (El-Rafie et al., 2014).

The deforestation caused by the extraction of wood for wood-based businesses has had an effect on the environment. Alternative fibers derived from non-wood sources will be an excellent way to avoid environmental degradation caused by tree harvesting. Haameem et al., (2016) stated that the availability of Napier grass (Pennisetum purpureum), which is classified as an agricultural waste item, indicates that it has a great potential for use as a substitute fiber. Napier grass is a member of the Phocaea family and the genus Pennisetum (Lokantara et al., 2020). This perennial grass may reach a height of 2–44 m and has leaves ranging in size from 30–120 cm. Additionally, Napier grass is used to create hedgerows to avoid soil erosion. Napier grass is abundant in structural cell wall carbohydrates, which rapidly enhance the fiber strength.

Current findings have focused on the development of environmentally friendly materials with the aim of resolving the problems created by petroleum-derived goods. Due to its renewability, complete biodegradability, and low cost, starch is a potential biopolymer for the manufacture of bio composite materials. Starch, in the form of its thermoplastic derivate (TPS), has been discovered as a viable alternative to synthetic polymers often utilized in traditional packaging. Starch by alone, thermoplastic starch (TPS) has poor mechanical qualities like low tensile strength and extreme deformations, as well as low gas permeability and poor water vapor barrier properties, which restricts its application in packaging or film (Pacheco et al., 2016). The inclusion of starch in thermoplastic starch is advantageous due to the starch's tensile characteristics and the use of glycerol as a plasticizer (Marichelvam et al., 2019). As a result, adequate modification is required to improve the material's qualities.

A few studies and research that has been conducted to enhance the capability of biodegradable material in order to replace the conventional thermoplastic. One of the studies that has been conducted by Daud et al., (2014) which utilize the usage of napier grass fiber in the composite. The chemical composition examination of napier grass revealed that it has a significant amount of cellulose and a negligible amount of lignin, resulting in a high-quality fiber. Additionally, the scanning electron microscopic study demonstrates that the condensed and packed organization of Napier fiber makes it a viable alternative fiber capable of enhancing the composite's characteristics. Thus, Napier grass, a plentiful agricultural waste item in Malaysia, has the potential to become a new and effective supply of fiber for the paper-making sector. This finding demonstrates that natural fiber may also be used as a filler in biodegradable composites.

Therefore, the main idea in conducting this study is to provide good information based on the method and procedure to improve the weakness of thermoplastic starch. Other

than that, this study also done in order to build a material that gives positive impact towards the environmental and construct a better material as alternative to petroleum-based product. This study provides the knowledge of napier grass fiber and hence, utilize the Napier grass fiber to become the reinforcement of the thermoplastic starch in order to create a fully biodegradable material with enhanced properties. This research also was conducted to gain a better understanding of how NGF influences the thermal, mechanical, and physical properties of TPCS. As should be noted, the NGF used in this study was not chemically altered or manipulated in any way.

1.3 Objective of Study

The main aim in this paper studies are: -

a) To produce biodegradable TPCS reinforced with Napier grass fiber composites.

b) To investigate the mechanical and thermal properties.

c) To produce biodegradable packaging tray of TPCS from the Napier grass fiber composite.

1.4 Significance of Study

The justification of this study are as follows:

- The outcomes of the recent study might deliver a new information regarding to the biodegradable TPCS reinforced with Napier grass fiber composite.
- The problem related to the environmental pollution might be reduced by applying the fully bio-composite material started from Napier grass fiber and TPCS.

- The problem caused by the conventional thermoplastic also can be diminished by introducing the new material from cassava starch.
- More value added to the existence of napier grass fiber by implemented beeswax and cassava starch and using it as new reinforcement material in producing bio-composite product.

1.5 Scope of Study

Based on the first objective point from this paper, the main raw materials used are cassava starch, Napier grass fiber, beeswax, and glycerol. The mixture of TPCS formed by combining the cassava starch with glycerol by referring to the suitable percentage of formulation. The glycerol act as the plasticizer in this study.

Further, for the second objective point, the Napier grass fiber is an alternative fiber derived from non-wood sources that will help minimize environmental degradation caused by tree harvesting. The availability of Napier grass (Pennisetum purpureum), which is classified as an agricultural waste item, indicates that it has a great potential for use as a substitute fiber.

Afterwards for the third objective points, the uses of Napier grass fiber reduced the conventional thermoplastic causes. Beeswax is added to the mixture of cassava starch and glycerol regarding to the suitable percentage of formulation. The function of beeswax in this study is act as the protective agent towards water absorption and moisture.

Subsequently, for the last objective points, more value added to the existence of napier grass fiber by implemented beeswax and cassava starch and using it as new reinforcement material in producing bio-composite product. The napier grass fiber was added as the reinforcement to the mixture of three raw material due to the percentage required for this study.