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BIODEGRADABLE PACKAGING FROM NAPIER GRASS: ENVIRONMENT PROPERTIES

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SITI ALYAA' ASYIKIN BINTI IBRAHIM

A thesis submitted
in fulfillment of the requirements for the degree of
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2022

DECLARATION

I declare that this thesis entitled " Biodegradable Packaging from Napier Grass: Environment Properties" is the result of my own research except as cited in the references. The work has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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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 with Honours.

Signature : ....

Supervisor Name : *Dr. Ridhwan bin Jumaidin*

Date : 18/02/2022

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 to complete this study

&

To my beloved parents for every support that was given to me

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&

To all people who support me throughout my journey.

ABSTRACT

Recent years have seen an increase in the need for eco - friendly products as a result of the accumulation of non-biodegradable waste, especially disposable products. As a result, several environmentally friendly materials have been established to solve this problem. Biopolymer developed from renewable resources has the potential to be a viable alternative to petroleum-based polymers due to its high biodegradability and consequently environmental friendliness. Among other biodegradable materials, cassava starch biopolymer 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. Due to widespread concern about environmental pollution, thermoplastic cassava starch is now widely study in packaging materials, with some formulations including bio-fillers or fiber to strengthen the bio-based plastic. As a consequence, Napier grass fiber is employed to reinforce a bio-based composite. Napier grass is regarded for its high yield, and resistance to insects. Additionally, this tropical perennial grass has a significant fiber reserve as a result of vegetative regeneration after stem removal. Numerous early studies on the characteristics and properties of Napier grass have been published; nevertheless, a comprehensive and in-depth examination of this tropical grass's use as a non-wood packaging replacement is nearly unknown. The aim of this study is to develop biodegradable thermoplastic cassava starch reinforced with Napier grass fiber, in order to investigate its water affinity properties, morphology, density, and environmental properties. To strengthen the cassava starch biopolymer's shortcomings, biocomposites has been developed by incorporating 0,10,20,30,40, and 50wt% of Napier grass fiber into thermoplastic cassava starch matrix. All components were mixed uniformly, and the components were formed utilizing hot compression molding. The functional properties of TPCS/NGF biopolymer composites were then evaluated to determine their suitability as biodegradable materials. The 50% of fiber has the lowest moisture content. Water absorption showed that when fiber content is increased, then the water absorbed is decreased. Water solubility testing demonstrates a decrease in weight loss when fiber content is increased. For soil burial tests, all samples were decreases as the fiber content increases. The FTIR spectrum indicates the presence of chemical bonding between fiber and matrix, whilst the SEM micrograph indicates a change in the structure of the composite as the fiber concentration increases. In general, the present study's results indicated that TPCS/NGF has the ability to significantly enhance the composite's qualities. To summarize, TPCS/NGF may be a viable alternative material for biodegradable products, such as disposable packaging trays with increased features.

ABSTRAK

Beberapa tahun kebelakangan ini telah menyaksikan peningkatan dalam keperluan produk mesra alam akibat daripada pengumpulan sisa tidak terbiodegradasi, terutamanya produk pakai buang. Hasilnya, beberapa bahan mesra alam telah diwujudkan untuk menyelesaikan masalah ini. Biopolimer yang dibangunkan daripada sumber boleh diperbaharui berpotensi menjadi alternatif yang berdaya maju kepada polimer berasaskan petroleum kerana kebolehbiodegradasiannya yang tinggi dan seterusnya mesra alam. Antara bahan terbiodegradasi lain, biopolimer kanji ubi kayu telah dikenal pasti sebagai bahan terbiodegradasi sepenuhnya yang boleh dijana oleh pelbagai tumbuhan dan merupakan salah satu sumber yang boleh diperbaharui, terbiodegradasi dan kos efektif yang paling banyak boleh diakses. Disebabkan kebimbangan meluas tentang pencemaran alam sekitar, kanji ubi kayu termoplastik kini digunakan secara meluas dalam bahan pembungkusan, dengan beberapa formulasi termasuk pengisi bio atau gentian untuk mengukuhkan plastik berasaskan bio. Oleh itu, serat rumput Napier digunakan untuk mengukuhkan komposit berasaskan bio. Rumput napier dianggap sebagai hasil yang tinggi, dan ketahanan terhadap serangga. Selain itu, rumput tropika ini mempunyai rizab gentian yang ketara hasil daripada penjanaan semula vegetatif selepas penyingkiran batang. Banyak kajian awal tentang ciri dan sifat rumput Napier telah diterbitkan; namun begitu, kajian menyeluruh dan mendalam tentang penggunaan rumput tropika ini sebagai pengganti pembungkusan biodegradasi hampir tidak diketahui. Matlamat kajian ini adalah untuk membangunkan kanji ubi kayu termoplastik terbiodegradasi diperkukuh dengan serat rumput Napier, untuk menyiasat sifat pertalian air, morfologi, ketumpatan, dan sifat persekitarannya. Untuk mengukuhkan kekurangan biopolimer kanji ubi kayu, biokomposit telah dibangunkan dengan menggabungkan 0,10,20,30,40, dan 50wt% serat rumput Napier ke dalam matriks kanji ubi kayu termoplastik. Semua komponen dicampur secara seragam, dan komponen dibentuk menggunakan acuan mampatan panas. Sifat kefungsian komposit biopolimer gentian rumput TPCS/Napier kemudiannya dinilai untuk menentukan kesesuaiannya sebagai bahan terbiodegradasi. 50% serat mempunyai kandungan lembapan paling rendah. Penyerapan air menunjukkan apabila kandungan serat meningkat, maka air yang diserap akan berkurangan. Ujian keterlarutan air menunjukkan penurunan dalam penurunan berat badan apabila kandungan serat meningkat. Selepas 4 dan 8 minggu pengebumian tanah, semua sampel yang diuji telah kehilangan berat badan dan boleh merosot. Spektrum FTIR menunjukkan kehadiran ikatan kimia antara gentian dan matriks, manakala mikrograf SEM menunjukkan perubahan dalam struktur komposit apabila kepekatan gentian meningkat. Secara umumnya, keputusan kajian ini menunjukkan bahawa TPCS/NGF mempunyai keupayaan untuk meningkatkan kualiti komposit dengan ketara. Ringkasnya, TPCS/NGF mungkin merupakan bahan alternatif yang berdaya maju untuk produk terbiodegradasi, seperti pembungkusan pakai buang dengan ciri yang dipertingkatkan.

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CHAPTER 1

INTRODUCTION

1.1 Background

Biodegradable products have been the subject of studies in recent years as a possible replacement for petroleum-based plastics in packaging applications. Biopolymers are the most promising commodity for this reason due to their biodegradability and long shelf life properties such as tolerance to chemical or enzymatic reactions (Khan et al., 2017). These issues have led to new research on the development of biodegradable materials.

Globally, plastic manufacture and distribution have been gradually rising through time. Petroleum-based plastics are often used as single-use plastics in our everyday lives since they have developed an incredible amount of utility owing to their adaptability, durability, flexibility, and toughness (Sahari et al., 2013). Furthermore, they are inexpensive on the market and readily available in any grocery shop. Marichelvam et al., (2019) stated that plastic is commonly used in a variety of sectors, most notably the packaging industry; the global output of petroleum-based plastic exceeded 300 million tons until 2015, with only 1% being bioplastic. The fast increase in plastic consumption is a result of the variety of plastic items now available on the market, which range from home and personal goods to packaging and building materials. The widespread usage of plastics has resulted in an abundance of plastic waste in the environment. Based on research about Biodegradable Tray by Ferreira et al., (2020), this could eventually result in significant worldwide problems for the environment and people, since the disintegration rate of these materials is very slow, about 100 years, owing to their hydrophobic characteristics and their ability to effectively escape quick microbial activity.

To tackle this problem, it is necessary to make a switch from petroleum-based plastic to biodegradable plastic in order to preserve a healthier environment for future generations and also to give more plastic disposal alternatives. Among biopolymers, starch is one of the most promising prospects and alternatives to petroleum-based plastics, owing to the fact that starch is fully biodegradable and plentiful in nature. It is abundant in plants such as maize, cassava, potato, and tuber, among others. According to López et al., (2019), starch is stored in plants in the granule-packed state of amorphous and crystalline. Due to widespread concern about environmental pollution, starch-based bioplastics such as thermoplastic starch (TPS) are increasingly widely employed in packaging materials, with some formulations including bio-fillers or fiber to strengthen the bio-based plastic.

Starch is mostly employed as a matrix or resin in biocomposites structures during the manufacturing of biopolymers. Numerous varieties of natural starch have been researched during the last several decades, including cassava starch, maize starch, and sugar palm starch. However, when compared to other sources of starch, cassava starch contributes the most in terms of productivity output (Jumaidin et al., 2020). Starch is a versatile material since it can be converted to chemicals such as ethanol, acetone, and organic acids utilized in the creation of synthetic polymers such as polylactic acid (PLA) (Carvalho, 2008). As well as turned to thermoplastic starch (TPS) with the assistance of a plasticizer under shear temperature conditions. Numerous research on thermoplastic starch (TPS) have been undertaken extensively and worldwide for a variety of starch sources, including cassava, potato, and maize (Bergel et al., 2017) (Asrofi et al., 2020).

Natural fibers derived from plants have enormous potential for use in the plastics, automotive, and packaging industries due to their superior properties such as low density, high specific stiffness, good mechanical properties, biodegradability, eco-friendliness, toxicological safety, and excellent thermal and acoustic insulation (Thakur et al., 2013) (Mohanty et al., 2004). Consequently, these cellulosic fibers have a lower cost of material than the beginning polymer. At the melting point of the majority of polymers, natural fibers disintegrate. As a result, it is prudent to investigate the thermal stability of natural fibers prior to contemplating their use as reinforcement in thermoplastic matrices. Rajulu et al., (2002) investigated the thermal degradation of Hildegardia, Bamboo, and Tamarind fruit fibers and concluded that they were suitable for use as reinforcements in polyolefin matrices. Yang et al., (2007) investigated the pyrolysis properties of wood materials.

Pennisetum purpureum fiber, commonly known locally as Napier grass, has 46% cellulose, 34% hemicellulose, and 20% lignin (Reddy et al., 2012). It may be harvested 3–4 months after planting and can be harvested at intervals of 6–8 weeks for up to 5 years, yielding 40 tons of dry biomass per hectare each year. Each plant produces around 40% fiber. The exceptional high modulus of these fibers was a primary rationale for their selection (Rajulu, 2009). Fibers were extracted from the internodes of Napier grass stems. Water affinity testing, environmental analysis, and physical analysis were used to achieve this.

Due to the environmental concerns associated with conventional thermoplastics, the production of biodegradable thermoplastic materials is accelerating. Biodegradable materials are both safe for the user and the climate. Thus, it is prudent to minimize the use of non-biodegradable plastic and encourage biodegradable plastic.

1.2 Problem Statement

The widespread use of non-biodegradable materials has had a detrimental effect on humanity and the climate. Non-biodegradable materials are composed of petroleum-based plastic polymers that are detrimental to the atmosphere due to their inability to dissolve in landfills. The issue arises in the landfill as these synthetic polymers persist for an extended period of time and interfere with groundwater, forming toxic substances and affecting drinking water safety (Emadian et al., 2017). In landfills, non-biodegradable materials require hundreds of years to decompose. Additionally, a disadvantage of utilizing synthetic polymers is that they contain toxic chemicals and release poisonous gases during the incineration phase. Essentially, most polymers are produced from petroleum, which requires additional fossil fuels, resulting in emissions (Marichelvam et al., 2019).

However, the downsides of natural fibers are their high moisture sensitivity, low chemical resistance, low thermal breakdown temperature, low wettability, and incompatibility with other composite materials during composite processing. Based on Singha et al., (2009) research, these effects have a major effect on the strength of the fiber-matrix interface. Thus, their inclusion into a polymer matrix requires the fibers to be treated physically or chemically to overcome interfacial incompatibility. John & Anandjiwala, (2008) stated that the use of various physical testing and chemical treatments results in a decrease in moisture absorption as well as modifications to the fiber surface. Understanding the physicochemical qualities and mechanical behavior of natural fibers is critical for optimizing the performance of composites. The majority of research has been conducted to determine the effect of fiber treatment on its chemical composition, surface morphology, crystallinity, and mechanical properties (John & Anandjiwala, 2008).