DEVELOPMENT AND CHARACTERIZATION ON MECHANICAL OF PINEAPPLE LEAF FIBRE REINFORCED THERMOPLASTICS SAGO STARCH COMPOSITE

MUHAMAD IRFAN ASYRAF BIN ROZLAN
B091910099

BACHELOR OF MANUFACTURING ENGINEERING TECHNOLOGY (PROCESS AND TECHNOLOGY) WITH HONOURS

2023

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MUHAMAD IRFAN ASYRAF BIN ROZLAN

**A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours**

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

DECLARATION

I declare that this “Development and Characterization on Mechanical of Pineapple leaf Fibre Reinforced Thermoplastics Sago Starch Composite” is the result of my research except as cited in the references.“Development and Characterization on Mechanical of Pineapple leaf Fibre Reinforced Thermoplastics Sago Starch Composite” have not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature :

Name : Muhamad Irfan Asyraf Bin Rozlan

Date : 11/1/2023

APPROVAL

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

Signature	:	
Supervisor Name	:	Ts. Dr. Nazri Huzaimi bin Zakaria
Date	:	12/1/2023

DEDICATION

To Al-Quran, the most significant source of knowledge

Give me metal plates" - till, having levelled [them] between both the mountains walls, he says, "Beat [with bellows]," until, having created it [like] fire, he said, "Bring it, that I could pouring over molten copper."

(Al-Kahf: Verse 96)

Alhamdulillah

Praise be to Allah for providing me with the strength, wisdom, and knowledge that I needed to accomplish this study,

&

To my loving parents for their unwavering support,

&

Ts. Dr. Nazri Huzaimi bin Zakaria, my supervisor, for his support and advise in completing this project.

&

To everyone who has helped me along the way.

ABSTRACT

Natural fibre composites have elevated material engineering research to greater levels. Natural fibres like grass, henequen, and wood have decreased petroleum-based product consumption. Pineapple leaf fibre (PALF), which has been abundantly cultivated in Malaysia, is one of the natural fibre resources. Pineapple leaf fibre (PALF), mainly from the Josapine family, contains a significant amount of cellulose and has solid mechanical qualities. As a result, the PALF from Josephine was employed as reinforced material in this work, with sago starch (SS) and glycerol as thermoplastics. Next, glycerol/starch weight fractions of 25/75 were used to make the thermoplastics sago starch (TPSS). After that, combinations of pineapple leaf fibre with thermoplastics sago starch in 10/90, 20/80, 30/70, 40/60 and 50/50 compositions were set. Prepping the mixture inside the mould will be placed in the hot press machine for a 15-minute preheating process. The mould was then hot pressed for 50 minutes at 25kg/cm^2 with a temperature of 190°C, next, cooling process for another 15 minutes. Finally, mould was removed using a hydroulic frame 10-tonne machine to obtain the final sample. Finalised piece sample will be cut into specific testing sizes using a table saw cutting machine. Multiple tests have been performed to verify the bio-composites capabilities. The results demonstrate that including 40 percentage PALF loading maximised the tensile, flexural, and stiffness toughness. However, PALF with a 10 percentage ratio produces the greatest results in impact testing.

ABSTRAK

Komposit mengunakan serat semula jadi telah membuatkan pengkaji membuat kajian ke tahap yang lebih tinggi.Serat semula jadi seperti rumput, henequen, dan serat kayu telah terbukti amat berkesan dalam mengurangkan penggunaan produk berasaskan petroleum iaitu plastik . (PALF) yang telah ditanam di Malaysia, merupakan salah satu sumber serat semula jadi. Menurut kajian, serat daun nanas (PALF), terutamanya daripada spesies Josapine, mengandungi sejumlah besar selulosa dan mempunyai kualiti mekanikal yang kuat. Seterusnya, serat daun (PALF) daripada spesies Josapine digunakan sebagai bahan penguat dalam kajian ini, dengan kanji sagu (SS) sebagai pengikat, dan ciri-ciri mekanikal komposit PALF/SS turut dikaji. Seterusnya, gabungan gliserol/kanji 30/70 digunakan untuk membuat kanji sagu termoplastik (TPSS). Selepas itu, gabungan serat daun nanas dengan kanji sagu termoplastik komposisi 10/90, 20/80, 30/70, 40/60 dan 50/50 telah ditetapkan.Setelah komposisi disediakan, bahan akan di letakkan di dalam acuan, ia akan diletakkan di dalam mesin penekan panas untuk proses pra-pemanasan selama 15 minit. Acuan kemudiannya ditekan panas selama 50 minit pada tekanan 25kg/cm^2 dengan suhu 190°C, diikuti dengan proses penyejukan selama 15 minit lagi. Akhir sekali, acuan dikeluarkan menggunakan mesin bingkai H hidrolik10 tan untuk mendapatkan sampel akhir. Sampel yang yang berjaya dihasilkan akan dipotong mengikut saiz tertentu untuk ujian yang ditentukan dengan menggunakan mesin pemotong gergaji meja. Pelbagai ujian telah dilakukan untuk mengesahkan keupayaan biokomposit. Penemuan menunjukkan bahawa 40% PALF meningkatkan kekuatan tegangan, lentur dan modulus ke tahap optimum. Walau bagaimanapun, PALF dengan nisbah 10% mempunyai hasil yang terbaik untuk ujian impak.

ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

I'd want to thank and honor Allah the Almighty, my Creator and Sustainer, for all I've received from the beginning of my existence. I'd like to thank Universiti Teknikal Malaysia Melaka (UTeM) for providing the research atmosphere. Thank you also for the financial assistance provided by Malaysia's Ministry of Higher Education (MOHE).

My thanks go to my primary supervisor, Dr. Nazri Huzaimi bin Zakaria, for all of his assistance, advice, and inspiration. His unrelenting patience in coaching and sharing invaluable knowledge will be remembered for the rest of his life.

Finally, no attempt at any level can be successfully performed without the support and guidance of my parents and friends. Given their busy schedules, I would like to thank my parents for their assistance in gathering varied material, collecting data, and guiding me on many aspects of my project. Finally, I'd want to thank everyone who has assisted, supported, and motivated me to continue my education.

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LIST OF SYMBOLS AND ABBREVIATIONS

ASTM	-	American Society For Testing Material
BC	-	Before Christ
℃	-	Celcius
CF	-	Coir Fibre
cm	-	Centimetre
DP	-	Degree Polymerization
DTG	-	Thermogravimetric
g	-	Gram
g/cm3	-	Density
G’	-	Storage Modulus
GPa	-	Gigapascal
J	-	Joule
Kg	-	Kilogram
m	-	Meter
MPa	-	Megapascal
NaOH	-	Sodium Hydroxide
NF	-	Highest Elongation
PALF	-	Pineapple Leaf Fibre
PE	-	Polyethylene
PLA	-	Poly Lactic Acid
PP	-	Polypropylene
PS	-	Polystyrene
Rs	-	Resistant Starch
t	-	Tons
TGA	-	Thermogravimetric Analysis
TPS	-	Thermoplastics Starch
TPSS	-	Thermoplastics Sago Starch
TS	-	Thermal Stability
V	-	Volume

XRD	-	X-Ray Diffraction Analysis
α	-	Amylase

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CHAPTER 1

INTRODUCTION

1.1 Background

Bio-composite (also known as green composites) materials have grown in popularity as a potential replacement for traditional materials used in production. Natural resins or natural fibres are used instead of synthetic fibres or resins to make bio-composite. Materials bio-based fibres are made from plants or animals. Plants are also utilized to create organic matrix composites such as rubber products and polyester (Karimah et al., 2021). Many bio-composites have piqued the interest of researchers because of the ease with which bio-composites may be disposed of and their capacity to change characteristics after their expiration date, which is not always possible with typical synthetic materials, and because they are regenerative and sustainable(Leão et al., 2015). Furthermore, Because of their comparable mechanical properties, bio-composites may be used to a wide variety of items. It's crucial to determine the best applications for natural fibres, such as a high-quality raw bio-composite material (Leão et al., 2015). This overview explains their features and future uses to increase natural fibres' sustainability and economic worth(Adam & Yahya, 2016).

Natural fibres are lightweight composites and reinforcing materials because of their low density and excellent strength-to-weight ratio. Fibre microstructure and chemical composition determine mechanical properties, with fibre cross-sectional area being the most variable. (Pfister & Zeeman, 2016). Because natural fibres include hemicellulose, which has hydrophilic qualities, they are less compatible with hydrophobic matrixes (Karimah et al., 2021). Higher cellulose concentration and crystallinity result in more robust fibre characteristics, whereas lignin has the opposite effect. Aside from that, fibre anatomical traits change between species, influencing the density and mechanical qualities. Environmental variables, transportation techniques, storage length and conditions, and fibre extraction all have an impact on the size and quality of natural fibres. (Karimah, 2021;John Wiley,2004).

In years, most humans have ingested two-thirds of their carbohydrate calories from starch, whereas humans take just 47% sugar provides most of their carbohydrate calories. Starches are made from seeds such as maize, waxy corn, amylose content corn, wheat, rice, and tubers or roots such as potato, sago, sweet potato, and tapioca (cassava). Food is its primary application; non-food applications include paper and textile sizing and adhesives(John Wiley et al.,2004). Greens plants produce starch as an energy storage in the form of starch granules, which vary in shape, granule size, size distribution and chemical (Zhang et al., 2014).

Starch takes on thermoplastic characteristics, there are extreme heat and high-pressure levels. Starch has thermoplastic properties like synthetic polymers, so processing processes designed for synthetic polymers can be applied to starch. Refined grain starch is thermo - mechanically processed using plasticizers glycerol, or sorbitol as well as additives such as lecithin or monoglycerides, by pounding, extruding, compression moulding, injection moulding, blow moulding, or boiling and cast in an excess water solution. to produce a thermoplastic starch (TPS) material (Zhang et al., 2014).

Next, to enhance the properties of biomaterials derived from natural biopolymers such as starch, Various polymers have been combined with plasticizing agents such as glycerol and sorbitol. (Ballesteros-Martinez et al., 2020). Glycerol and sorbitol were tested for their impact on the function qualities triticale protein. Glycerol-plasticized films have a higher moisture content at a given relative humidity than sorbitol films at the same plasticizer concentration. Sorbitol-plasticized had better solubility than glycerol-plasticized films. Relative humidity significantly impacts film mechanical properties, which vary greatly depending on the kind and dosage of plasticizer utilized. Glycerol had a higher plasticizing impact on triticale films. The tensile strength, Elastic modulus, and piercing force of the films dropped as the glycerol concentration increased(Aguirre 2013; Ballesteros-Martinez et al., 2020).Combinations of glycerol and starch weight fractions of 40/60, 35/65, and 30/70 were used to make the studied thermoplastics sago starch (TPSS)(Ballesteros-Mártinez et al., 2020).

Pineapple is a popular local fruit frequently served as food or dessert. Most pineapple eaters consume both fruit and seeds. Pineapple leaves are usually not used and are disposed of by burning or decomposition. Both Josapine and Morris pineapples are well-known for their planting in Malaysia. These two varieties of pineapple leaves have quite different physical properties. Josapine fruit is usually longer than Morris. Morris fruit is thornier than Josapine fruit, therefore it is typically less costly. With the global growth of pineapple farms, humanity realized that pineapple leaf fibre could be utilized for a variety of uses in a variety of sectors. One of the goods created from pineapple leaves is traditional fabric.(Mazalan & Yusof, 2017).

PALF is a renewable fibre resource with a more ecologically favorable chemical makeup. PALF has a better mechanical strength when used to manufacture fine yarn. The remainder of the molecular structure is expected to fit into amorphous regions. Pineapple leaf fibre (PALF) is a strong natural fibre that has properties like jute fibres in terms of specific strength, stiffness, and flexural and torsional rigidity. Because of its unique qualities, PALF has the potential to be an ideal alternative raw material for reinforcing composite matrixes in the future (Asim et al., 2015). The compositions of PALF and thermoplastic sago starch include 90, 20/80, 30/70, 40/60, and 50/50. (Zakaria et al., 2020).

Lastly, several tests were used for this composite to determine the characterization of the mechanical pineapple leaf fibre reinforced thermoplastics Sago Starch, such as tensile, flexural, and impact testing. (Zakaria et al., 2020).

1.2 Problem Statement

Petroleum loss, landfill issues, and product degradability have caused a wide spectrum of research to be done globally to find a viable answer to the challenge at hand. New materials have been discovered and tested to replace petroleum-based synthetic fibres that are difficult for enzymes or bacteria to breakdown naturally. Natural fibres, which are abundant and sustainable, have sparked the curiosity of people all over the world.

Greens, animals, and mineral fibres are the 3 types of natural fibres being studied right now. Plant fibres, primarily made from agricultural waste, may be found in almost every country. Tropical countries such as Thailand, Malaysia, and Indonesia accumulate tons of garbage from agricultural farms a year (Mathivanan et al.,2016). The pineapple industry in Malaysia is mostly concerned with fruit. It somehow creates a lot of bio waste in the form of leaves, which are mostly composted or burnt, squandering a valuable source of fibre. The burning of the leaves will cause pollution in the environment. (Sarifuddin et al.,2012).

Next, (PALF) generated from the leaves of the Josapine pineapple plant have the highest cellulose content, making the fibres mechanically sound. Pineapple leaf fibre has strong mechanical properties and may be used as fibre in polymer composites due to its high cellulose of more than 70 percent. (Rusydan & Ramli,2021).

Consequently, the combination of PALF used as a reinforcing material and starch-based with glycerol composite used as the matrix materials to generate TPSS/PALF composite may show a promising prospective result in mechanical properties primarily for plastic industry products (Adam & Yahya, 2016).

1.3 Research Objective

This project has three major objectives to fulfil:

I. To fabricate thermoplastics sago starch reinforced pineapple leaf fibre composite in different loading.

II. To investigate the mechanical properties of pineapple leaf fibre reinforced thermoplastics sago starch composite.

1.4 Scope of Research

PALF loading on the mechanical characteristics of TPSS/PALF composite have been investigated. The different PALF on the TPSS/PALF composite were chosen, and the composition ratio in the TPSS/PALF combination was set at 75:25. Using a hot press, improve the PALF characteristics prior to the TPSS/PALF composite manufacturing process. (Zakaria et al., 2020).

TPSS was created by plasticizing with glycerol in a melt blending process before compression moulding. TPSS was prepared with a glycerol/starch weight fraction of 25/75. After that, combinations of pineapple leaf fibre with thermoplastics sago starch in 10/90, 20/80, 30/70, 40/60 and 50/50 compositions were set. Prepping the mixture inside the mold will be placed in the hot press machine for a 15-minute preheating process. Mold was then hot pressed for 50 minutes at 25kg/cm^2 with a temperature of 190°C, followed by a cooling process for another 15 minutes (Zakaria et al., 2020). Finally, the mold was removed using an H frame ten tons machine to obtain the final sample. Tensile, flexural and impact tests will be used to assess the mechanical characteristics of the TPSS/PALF composite.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Composite research and use have blossomed in recent years. The emphasis is on creating and studying high-performance reinforcing materials in suitable polymeric matrices, such as polyamide, polyester, aramid, glass, and carbon fibres. These materials, on the other hand, are prohibitively expensive and non-renewable.

Because of the scarcity and high cost of petroleum-based goods, there is an urgent demand for naturally occurring alternatives. Natural fibres provide several benefits, including cheap cost, low density, strength properties, good mechanical strength properties, efficiency of separate, and biocompatible. They might be a more environmentally friendly and cost-effective alternative to synthetic glass fibres and carbon. Natural fibre-reinforced composites have received a lot of attention. (Lee & Wang, 2006).

The major drawback of natural fibres may be their watery nature, which lowers their compatibility with the hydrophobic polymeric matrix. Most research in these composite industries has concentrated on enhancing interfacial characteristics between polymer matrices and natural fillers to improve the physical and mechanical attributes of the end products (Lee & Wang, 2006). Furthermore, green composites are increasingly being used to help the composites business grow. Environmental composites are biopolymers reinforced with natural fibres that are more ecologically friendly than fibre reinforced plastics. (Sarifuddin et al.,2012).

Since pineapple leaves have a significant amount of fibre and are currently thrown, one proposed solution is to use them as post-harvest waste. In most regions where this plant is produced, the pineapple leaf is currently discarded, with only the fruit itself being consumed. When the leaves of the pineapple plant are properly removed and processed, they generate long vegetable fibres that may be utilized to make a range of goods. The fibres have a negative cost because they are currently disposed away for composting. If the chemical is turned into something more desired, this negative cost can be converted into money for producers (Leão et al., 2015).

Following that, researchers coupled various polymers with plasticizing agents such as glycerol and sorbitol to improve the qualities of biomaterials created from natural biopolymers such as starch. There is now an increasing interest in replacing or substituting synthetic packaging with renewable and biodegradable packaging materials (polysaccharides, lipids, or protein). Starch is the most often used plant polysaccharide for edible film and coating production due to its availability, low cost, and excellent film-forming properties. The optical and organoleptic properties of starch-based films are excellent. Different starches from various sources have been explored as biodegradable packaging agents or edible coatings to enhance fresh fruit shelf life, either alone or in conjunction with other biopolymers(Ballesteros-Mártinez et al., 2020).

Lastly, before being tested, the finalized sample will be chopped into a precise testing size using table saw cutting equipment. Tensile, impact, and flexural tests were performed on all samples to assess mechanical and characterization properties.