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INVESTIGATION OF PAPER MAKING PRODUCTION AS PACKAGING WITH WASTE BANANA PEEL AND EGGSHELL AS FILLERS IN PHYSICAL AND MECHANICAL PROPERTIES

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DECLARATION

I declare that this thesis entitled "Investigation of Paper Making Production as Packaging with Waste Banana Peel And Eggshell As Fillers In Physical And Mechanical Properties" is the results of my own research except as cited in the references.

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INVESTIGATION OF PAPER MAKING PRODUCTION AS PACKAGING WITH WASTE BANANA PEEL AND EGGSHELL AS FILLERS IN PHYSICAL AND MECHANICAL PROPERTIES.

ABSTRACT

A sustainable resource for papermaking might be found in the combination of eggshell fillings and residual banana peels, which is the subject of this study. Examining the effects on the mechanical and physical properties of the finished paper of this eco-friendly approach is the goal. Paper is made by mixing Waste Carton Box [5grams], Waste Banana Peel Fibers [WBP] [2 & 4 grams] with varying quantities of eggshell fillers [2 & 4 grams] and then drying the mixture in an oven $[105°C]\ in\ 4\ hours$. Using a systematic approach based on experiment and analysis, this research seeks to determine the optimal mix ratio that optimises paper quality while minimising environmental impact. The thermal characteristics and structural integrity like Tensile test, Tear test and Oven test of the paper is also examined in the research. To create more environmentally friendly papermaking processes, this study's findings support reducing resource consumption and increasing the utilisation of agricultural waste.

Keywords: Waste carton box, Waste Banana peel, Eggshell fillers, Papermaking, Sustainability, Oven application, Agricultural waste, Resource efficiency.

PENYIASATAN PEMBUATAN KERTAS PENGELUARAN SEBAGAI PEMBUNGKUSAN DENGAN SISA KULIT PISANG DAN KULIT TELUR SEBAGAI PENGISI DALAM SIFAT FIZIKAL DAN MEKANIKAL.

ABSTRAK

Sumber yang mampan untuk pembuatan kertas mungkin terdapat dalam gabungan tampalan kulit telur dan kulit pisang sisa, yang merupakan subjek kajian ini. Memeriksa kesan ke atas sifat mekanikal dan fizikal kertas siap pendekatan mesra alam ini adalah matlamat. Kertas dibuat dengan mencampurkan Kotak Kadbod Sisa [5gram], Serat Kulit Pisang Sisa [WBP] [2 & 4 gram] dengan kuantiti pengisi kulit telur yang berbeza-beza [2 & 4 gram] dan kemudian mengeringkan campuran dalam ketuhar $[105°C]\ selama\ 4\ jam.$ Menggunakan pendekatan sistematik berdasarkan eksperimen dan analisis, penyelidikan ini bertujuan untuk menentukan nisbah campuran optimum yang mengoptimumkan kualiti kertas sambil meminimumkan kesan alam sekitar. Ciri-ciri terma dan integriti struktur seperti ujian tegangan, ujian Air mata dan ujian Ketuhar kertas juga diperiksa dalam penyelidikan. Untuk mewujudkan proses pembuatan kertas yang lebih mesra alam, penemuan kajian ini menyokong pengurangan penggunaan sumber dan meningkatkan penggunaan sisa pertanian.

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Kata kunci: Kotak kadbod sisa, Kulit pisang sisa, Pengisi kulit telur, Pembuatan kertas, Kelestarian, Aplikasi ketuhar, Sisa pertanian, Kecekapan sumber.

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CHAPTER 1

1.0 INTRODUCTION

1.1 Background Study

Significant attention has been given over the last several decades to industrial sectors that damage the environment. Typically, large volumes of solid waste end up in rivers, lakes, and exhaustion. Municipal solid waste, hazardous waste, industrial non-hazardous waste, agricultural and animal waste, medical waste, radioactive waste, construction and demolition debris, extraction and mining waste, oil and gas production waste, fossil fuel combustion waste, and sewage sludge are just a few examples of the many different types of waste that exist. Waste comes in a variety of forms, including solid, semisolid, liquid, and slurry, according to Vaishnavi J. & Samuel J. (2023) in their publication Relationship Between Microbes and the Environment for Sustainable Ecosystem Services. The crucial parameter in manure that shows how materials were handled is total solid concentration.

The delicious fruit known as the banana belongs to the Musaceae family and is cultivated in tropical and subtropical regions of the world. An unnecessary banana peel is the outer skin or peel of a banana that has been thrown after it has been eaten or removed. It is categorised as non-toxic waste since it biodegrades over time and decomposes spontaneously. After eating the fruit inside, people typically throw away the peels from bananas, but they may also be recycled or utilised in several other ways. Banana peel waste is often deposited in municipal landfills, adding to the present environmental problems. However, the problem may be resolved by using its valuable components, including bio-products (Nik Alnur Auli, N. Y.; Ernie, S. R; Mazlan, M. & Mohamad Bashree, A. B. 2016). In the context of product production or creation, a filler is an inert component or substance added to a product to increase its bulk, weight, volume, or overall size. One of the most important steps in the production of paper is the pulping of raw materials, mostly wood fibres, into pulp that may be used to make paper. The two major types of pulping technologies are mechanical pulping and chemical pulping.

Each is an integrated stage in the pulping process that attempts to eliminate. Lignin and hemicellulose (Kamel et al. 2020). Both pulp yield and individual fibre strength are significantly decreased once lignin is removed. Contrarily, bleaching strengthens the connection between fibres. Contrary to those employed in pulping, chemicals utilised in bleaching of chemical pulps are more concerned with lignin removal than with the breakdown of carbohydrates. According to Pratima Bajpai, bleaching brightens existing dark chemical pulps by up to 70%, with a maximum brightness of around 92%, as stated in Biermann's Handbook of Pulp and Paper (Third Edition), 2018 edition. In contrast to mechanical pulps that have been bleached, the high brightness is still there after the lignin is taken out. Chemical pulps that have been bleached are not vulnerable to colour reversal, however high temperatures may cause some colour reversion.

When making paper, fillers are added to the pulp to enhance certain properties of the paper. Inorganic fillers are often used, including calcium carbonate, kaolin clay, titanium dioxide, and calcium. They increase opacity, brightness, and printability, among other things. Fillers fill in the spaces between the paper fibres, giving the surface a smoother appearance and improving ink receptivity. They also increase the paper's thickness, weight, and volume. By adding fillers, paper manufacturers may reduce the quantity of pricey pulp fibres needed, making the process more affordable. Additionally, fillers may enhance the paper's optical qualities and overall look. Colour powders used as paper fillers are mostly made from natural minerals. Calcium and carbon are only two of the many components that make up minerals (Wahab, 2018). For filling and coating purposes, such as in the creation of printing sheets and board, calcium carbonate pigment is utilised. Filler used as an affordable filler in the creation of beautiful opaque paper and recognised internationally for its excellent brightness and light scattering qualities. Additionally, it contributes to the creation of paper with superior brightness, gloss, and printing properties.

1.2 Problem Statement

Eggshells and plant-based pulp cannot be bleached. Bleaching removes or brightens. colour. Chemicals are often used. However, pulp and eggshells are bleach-resistant due to their composition. Bleaching pulp and eggshells separately prevent eggshell damage. After then, pulp production may take time. Each stage may take longer depending on the pulp type and production method. It's important to remember that the length of time needed for each stage in the pulp process depends on various factors, including the operation's size, and technology. Bleaching often uses environmentally hazardous chemicals. Chlorine-based bleaching treatments can release dioxins and chlorinated organic compounds, which can accumulate in ecosystems.

An innovative and sustainable way to make paper is from banana skins. Banana skins, which are often leftovers, are turned into pulp and then into paper sheets using banana peels that have been discarded. This minimises significant deforestation and helps to preserve forests. This environmentally friendly choice promotes a circular economy and reduces waste. The generated paper exhibits the creative potential of recycling natural resources since it has unique qualities and may be used for several applications. In addition, banana skins contain cellulose, a natural fibre that contributes to the strength and texture of the finished paper. Although banana skin fibres aren't as strong or long as those found in conventional papermaking materials, they can still be processed and combined with other fibres to create a variety of useful paper products. The paper made from banana skins contains more fibre because of the parchments. It is also 300 times stronger than conventional wood paper and has greater cellulose and less lignin. Banana plants grow swiftly, and banana peels are also easily accessible. Consequently, 100,000 tonnes of paper might be produced from a million tonnes of banana peels, giving us access to a larger source. Additionally, it is fire and water resistant, making it more durable and appropriate for handling objects like packaging use cases. Muhammad A. R, A. M, A. M., and Nor. A. T. (Ahmad. U. Z., 2021)

1.3 Expected Output

The goal for this project is to produce paper using waste banana peel and eggshell filler mixture to see and study the strength, brightness, and opacity of paper with existing paper in the market. Banana peel fibres' cellulose may strengthen paper. In papermaking, banana peel fibres may increase the paper's stiffness and tear resistance. Banana peel fibres may add bulk to paper, increasing thickness and opacity. On the other hand, eggshell filler may improve paper's smoothness. Eggshell filler's microscopic particles fill fibre gaps, making the paper surface more uniform. Eggshell filler may brighten paper, improving its appearance. Opacity refers to the ability of paper to prevent the transmission of light. The inclusion of eggshell fillers, with their calcium carbonate composition, may contribute to the opacity of the paper combine with oven properties study. However, it's important to note that the overall opacity will depend on the proportion of fillers used and the distribution within the paper matrix.

1.4 Objectives

In this part, there have two objectives that must be accomplish by during this research. The objective is:

- To study the characterization of waste banana peel (WBP) with eggshell fillers as making recycled paper.
- To investigate the physical and mechanical properties on oven exposure towards paper products.

1.5 Scope of Study

This project aims to create paper using waste banana peel and eggshell fillers combination and compare its durability, brightness, and strength to commercially available paper. The calcium carbonate content of eggshell fillers may add to the opacity of the paper when combined with oven characteristics. It should be noted, however, that the total opacity will depend on the percentage of fillers employed and their distribution within the paper matrix. Banana peel fibres' cellulose may strengthen paper. In papermaking, banana peel fibres may increase the paper's stiffness and tear resistance. On the other hand, eggshell filler may improve paper's smoothness. Eggshell filler's microscopic particles fill fibre gaps, making the paper surface more uniform. Eggshell filler may brighten paper, improving its appearance.

1.6 Significant of Study

Based on the research that being conducted shown that dried banana peels contain 69% proteins and 20%-30% of fibbers which the scientist believes banana peels was able to draw attention as a source of functional and nutritional compounds. Future studies are required to determine the biologically active compounds, potentials, and the multiple benefits hoped for banana peel instead of being neglected waste. (Wafaa. M. H; Hussein. A. H & Kirill. G. T. 2022). Most of the plants have a natural starch including banana peel. That is why the reason for that is by using the right method to get rid the starch to produced non starch banana peel paper. Also beside using a thermal process for heat the paper making this project going to use the oven properties as to heat the paper.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 What is Waste Banana Pell (WBP)

The term "waste banana peel" (WBP) describes the outer, protective layer of a banana fruit that is thrown away after eating. Fruit bananas are eaten all over the globe, and a large amount of the fruit's weight is made up of the peel. The banana peel is usually thrown away as organic waste after the fruit has been consumed. The components of banana peels include cellulose, hemicellulose, lignin, and other organic substances. Because of these ingredients, banana peels are high in fibre and may have a variety of uses outside food. However, banana peels are often regarded as garbage and disposed of in landfills or utilised as compost owing to their high moisture content and relatively quick breakdown.

Banana peels, while thrown away as trash, have piqued attention due to their potential as a significant resource in several businesses. Banana peels have been investigated by researchers for use in organic fertiliser, animal feed, biofuel production, and even as a raw material for the manufacture of paper and biodegradable polymers. It is feasible to reduce resource consumption, generate new revenue streams, and lessen environmental damage by coming up with creative uses for leftover banana peels. Banana peel use across a range of businesses may also aid in the advancement of circular economy and more sustainable practices.

When banana peels are considered as waste, they can be subjected to various treatment processes to extract and utilize their valuable components. Starch can be isolated from banana peels and used in food applications or converted into biofuels. The non-starch components, particularly cellulose and hemicellulose, can be processed through technologies like enzymatic hydrolysis or fermentation to produce biofuels, chemicals, or other value-added products. Additionally, the non-starch components of banana peels can also be utilized as a potential source of dietary Fiber or in the production of animal feed.

2.2 Advantages Waste Banana Pell for Paper making.

Benefits of Banana Peel Without Starch Nutritional Value, Vitamin C, vitamin B6, potassium, magnesium, and dietary fibre are all present in banana peels, which are also an excellent source of other vitamins and minerals. These nutrients may be included in your diet by including banana peels. Banana peels include antioxidants like lutein and zeaxanthin that may help shield your body from oxidative stress and lower your chances of developing chronic illnesses. Serotonin, a neurotransmitter with proven abilities to elevate mood, is found in banana peels. Your happiness and general wellbeing may be improved by eating banana peels.

Dietary fibre included in banana peels helps encourage regular bowel motions and good digestion by giving the stool more volume banana peels may be used in baking and cuisine. They may be used to produce delectable banana peel chutneys, curry additions, and smoothie blends. According to Nik Alnur Auli Nik Yusuf; Mohammad Khairul Azhar Abdul Razab; Nor Hakimin Abdullah (2018) in their journal Characterization of Bio-Polymer Composite Thin Film Based on Banana Peel and Eggshell said that this characteristic makes them potential to produce bio-polymer thin film which is more environmentally friendly due to its biodegradable abilities compared to the conventional synthetic petroleum-polymer. In addition, banana peels are agricultural waste that discarded as useless material. This waste contributed to waste management problems although they have some compost and cosmetics potentiality.

2.3 Eggshell filler as reinforcement in paper making.

Eggshell filler is a form of reinforcement used in papermaking to enhance the paper's overall quality and mechanical qualities. Eggshell powder was used as a filler in a work by Hong et al. (2015) to create composite materials made of paper. The researchers discovered that the paper's tensile strength, burst strength, and folding endurance were all enhanced by the addition of eggshell filling. According to the study's findings, eggshell powder may improve paper's mechanical qualities and help create environmentally friendly paper goods. During the production process, it entails adding finely powdered eggshells to the paper pulp mixture. This is how it goes the preparation of eggshells The eggshells are properly cleansed and sterilised to get rid of any germs or remaining egg material.

In 2020, Garg et al. examined the use of eggshell powder as a filler in recycled paperboard. Researchers found eggshell filling increased paperboard's tensile strength, rip resistance, and surface smoothness. Eggshell powder may be a cheaper and more ecological papermaking filler, according to studies. Then, with the use of specialised machinery, they are dried and powdered. The calcium carbonate, the principal component of eggshells, dominates the final eggshell powder. Eggshell filler is a form of reinforcement used in papermaking to enhance the paper's overall quality and mechanical qualities. During the production process, it entails adding finely powdered eggshells to the paper pulp mixture. This is how it goes the preparation of eggshells The eggshells are properly cleansed and sterilised to get rid of any germs or remaining egg material. Then, with the use of specialised machinery, they are dried and powdered. The calcium carbonate, the principal component of eggshells, dominates the final eggshell powder.

2.4 Composite of Paper from waste Banana Peel and Eggshell Filler

An innovative and environmentally friendly way to make paper is the composite paper, which uses eggshell filling and fibres from discarded banana peels. It is possible to combine agricultural waste with other types of garbage to create a paper product that uses both types of waste and benefits from their unique properties. Paper made from banana peel fibres could be stronger and last longer because of the cellulose-rich material they contain. Recent research suggests that banana peel fibres could be a useful raw resource for papermaking. Research by Mahanta et al. (2016), for example, found that using banana pseudo stem fibres as a reinforcing in papermaking increased the tensile strength and tear resistance of the finished product.

Eggshell filler, on the other hand, may be used as both a filler and a reinforcement in the paper composite. Calcium carbonate, the primary ingredient in eggshells, may improve the paper's mechanical properties and make it smoother, as mentioned above. Research on using eggshell powder as a filler in paperboard production has showed promising results; for example, Garg et al. (2020) found that using eggshell powder improved the tensile strength and tear resistance of the paperboard. A composite paper product that incorporates the best qualities of both materials may be made by combining residual banana peel fibres with eggshell filler during the papermaking process. The mechanical properties and surface smoothness of the paper are improved by the eggshell filler, while the material's volume and reinforcement are provided by the banana peel fibres.

CHAPTER 3

3.0 METHOD AND MATERIAL

3.1 Location of Study

From September 2023 to February 2024, a selection of the study areas is conducted at the University Malaysia Kelantan Jeli Campus' wood workshop and laboratory. The tools used in the wood workshop and lab, such as the hand sheet forming, fume hood chamber, and string hotplate.

3.2 Materials

The following materials are needed to create paper: cotton box waste, Eggshell as a filler, banana skin as the primary component, and banana skin as a secondary ingredient. Cotton box waste, banana skin powder, eggshell, beaker, stainless steel spoon, distilled water, and measuring cylinder are the items I used to observe the effects of various bleaching chemical concentrations on the paper-making process. Small and medium sized businesses (SMI) gathered fish bones and banana skin, while the banana skin and eggshell were collected. Eggshell was washed, dried, and powdered, and banana peels were baked in an oven for 24 hours to remove any moisture.

Waste banana peels (Musa paradisiac L.), eggshells and recycle box selected to do in this project for paper making. Waste banana peels were collected in the nearest area in store Kg Jedok. Meanwhile, recycle boxes were collected nearest campus and eggshells collected at store Roti Canai. For these materials eggshells and recycle box were dried at room temperature and waste banana peels was dried in oven 60° C of temperature at 24 hours.

Figures 3.2.1.: Banana Jack stage ripening

Figures 3.2.2.: Waste of eggshells

(**Source:** Best Eggshell Royalty-Free Images, Stock Photos & Pictures | Shutterstock, 2024)

3.3 METHODS

3.3.1 Preparation of waste carton box

The waste carton box was collected near UMK from mini mart then the sample carton box's shred into tiny pieces using hand and being soak using distilled water for 24 hours before used.

Figures 3.3.1.1: Waste carton box

3.3.2 Preparation powdered the waste banana peel (WBP) and eggshell filler.

Waste banana peels were put in the aluminum foil and the banana waste had been separated into two parts to facilitate this drying method. The waste was then dried in a drier or under the sun to reduce the available water content. Dried banana waste was then milled to powdered form and sieved to remove any large particle. It was later washed to remove any impurities (Kumar et al., 2023). Prior to beginning, ensure that the banana peels that will be baked into desiccants are entirely free of dirt and mold. Dividing the banana peels into smaller pieces will make the drying process go more smoothly and quickly.

Figures 3.3.2.1.: Preparation powdered of waste banana peels (WBP).

Preheat the oven to a low of around 65°C to extract moisture from the meal without sacrificing its nutritional content. To prevent adherence, place an aluminium sheet there. To ensure sufficient air circulation, arrange the banana peels in a single layer on the prepared sheet, leaving some space between them. Place the aluminium sheet into the preheated oven, keeping the door slightly ajar to facilitate the escape of moisture. To guarantee equal drying, check and turn the banana peels often. The drying process takes a whole day, and the peels are considered dry when they become crisp and brittle at that point. Make sure the dehydrated banana peels are completely cold before putting them in a tightly closed container in a dry, cold place.

Eggshells are ground into a fine, useable powder using several processes in the process of making powdered eggshell filler. To begin with, the eggshells are gathered and carefully washed to get rid of any remaining egg. The shells are usually dried after cleaning to remove any remaining moisture. Either air drying or a low-temperature oven drying procedure may accomplish this. To make the grinding procedure easier, the dried eggshells are then broken up into smaller pieces. Using a grinder or mill, the crushed eggshells are next ground into a fine powder. The eggshells are ground to the appropriate particle size 55 microns during this operation, giving them a powdery texture. To guarantee homogeneity in particle size, the powdered eggshell filler might undergo further processing or sieving. The result is a finely powdered powder that may be used for many different things. For example, it can be added to food as a calcium-rich addition, used as a soil conditioner in gardening, or used as a component in several crafts and do-it-yourself projects. Making eggshell filler is a useful process that not only recycles waste material but also produces a sustainable and adaptable component for a range of applications.

Figures 3.3.2.2.: Powder of eggshells

3.3.2 Preparation of papers with WBP and Eggshells fillers.

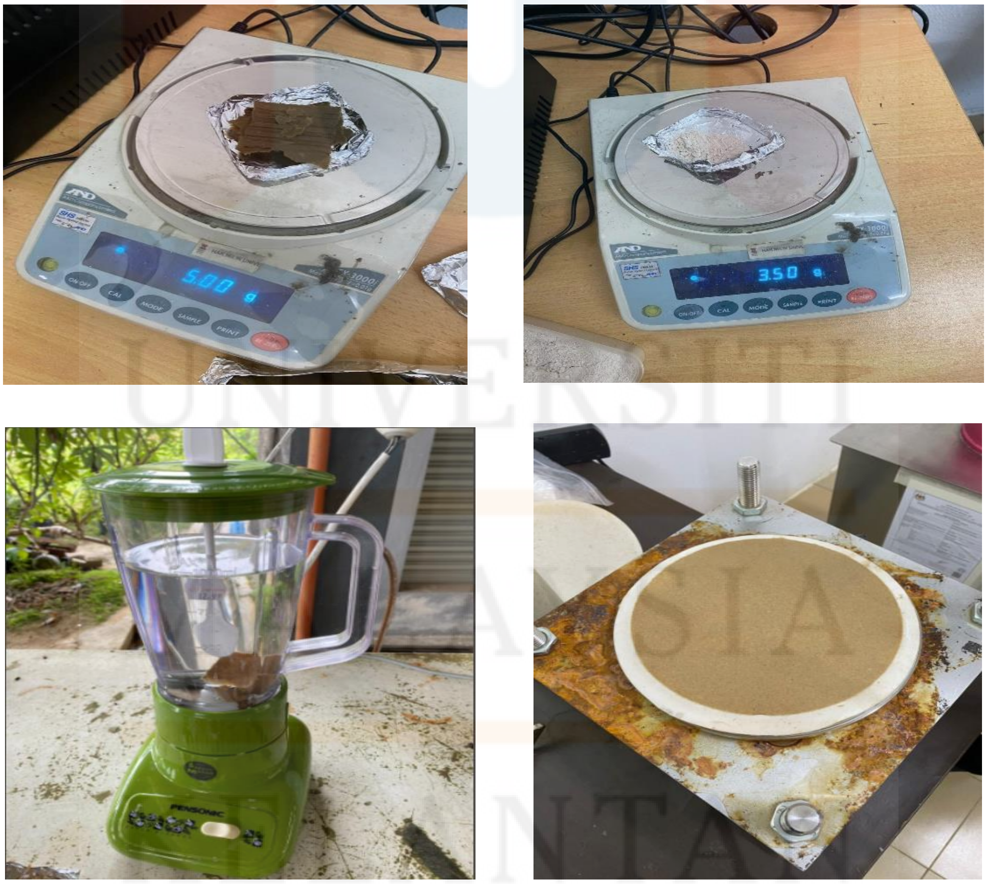
First, fill a measuring cylinder with 1000 ml of purified water to begin the paper-making process. Pour in half of the filtered water and mix for two minutes after adding all the ingredients to a blender. Stir well to combine this solution with the remaining clean water. After removing 500 cc of the mixture, continue with the hand sheet machine setup. Pour the mixture slowly into the machine after letting the water rise for 30 seconds, then push the machine button to empty the water. After the water has been removed, lay blotting paper over the fillings, and roll it to cling. Then, gently take the pulp-filled blotting paper and place it on the manual sheet pressing machine before placing the couch plate on top of it.

To remove extra moisture, fasten the pressing machine's top to the couch plate. After four minutes, carefully remove the couch plate and the pressing machine's top, separating the blotting paper from the fillings. The produced paper should be left to air dry for a few hours or until it is totally dry. Lastly, evaluate the paper's brightness with a colour reader. This procedure guarantees an efficient and methodical manufacturing process, leading to high-quality paper output.

Figures 3.3.2.1: Hand sheet machine and presser machine.

NO		CB (g)	WBP (g)	ES (g)
1.	**5CB0WBP0ES**	5 grams	-	-
2.	**5CB2WBP0ES**	5 grams	2 grams	-
3.	**5CB4WBP0ES**	5 grams	4 grams	-
4.	**5CB0WBP2ES**	5 grams	-	2 grams
5.	**5CB0WBP4ES**	5 grams	-	4 grams
6.	**5CB4WBP2ES**	5 grams	4 grams	2 grams
7.	**5CB4WBP4ES**	5 grams	4 grams	4 grams

Tables 3.3.2.2.: Tables of Parameters WBP and Eggshell papers production



Figures 3.3.2.2.1.: Preparation of papers with fillers WBP and ES

3.3.3 Physical Testing Towards Paper Production

3.3.3.1. Microscopic Testing

Microscopic testing describes the morphological and structural properties of paper and paper products in the paper industry. This method examines paper fibres, fillers, and other components under a microscope to determine its composition and quality. Microscopic analysis may reveal fibre structure, distribution, and bonding, which can assist explain paper qualities. Optical and scanning electron microscopy are used to examine paper. By visualising fibre arrangement and defects, optical microscopy gives qualitative paper structure information. SEM's higher magnification and resolution allow for detailed examination of paper components' fine structure and surface appearance. Paper research, process optimisation, and quality control benefit from microscopic testing. The stereo microscope is ideal for a detailed examination of paper fibre structure, characteristics, and composition due to its ability to provide low to intermediate magnification levels. This idea has found widespread use in many fields, including as forensic science, quality assurance, and the paper industry.

Figures 3.3.3.1.: Image of Stereo microscope
(Sources: (*Zoom Stereo Microscope*, 2024))

3.3.4 Mechanical Testing Towards Paper Production

3.3.4.1. Tensile Testing

As a basic technique for evaluating the mechanical qualities of paper and paper products, tensile testing is important to the paper manufacturing sector. Using this testing technique, paper samples are stressed to the point of failure under controlled conditions. This gives manufacturers an assessment of the material's tensile strength, elongation, and other important properties. It is crucial to comprehend these characteristics to maximise paper performance and quality. Tensile strength, which is defined as the highest force a piece of paper can bear before breaking, gives information on how long a material will last and how resistant it is to be ripping when handled and used. For situations where flexibility is essential, elongation at break a measure of how far a paper can stretch before breaking is similarly significant.

Figures 3.3.4.1: Tensile and Tear testing machine

$$Formula\ Tensile\ Strength: \frac{Maximum\ Loads\ (N)}{Initial\ Length \times Initial\ Width\ (mm^2)}$$

$$Formula\ Young's\ Modulus: \frac{Deflection\ (mL)}{Initial\ Length\ (mm^2)}$$

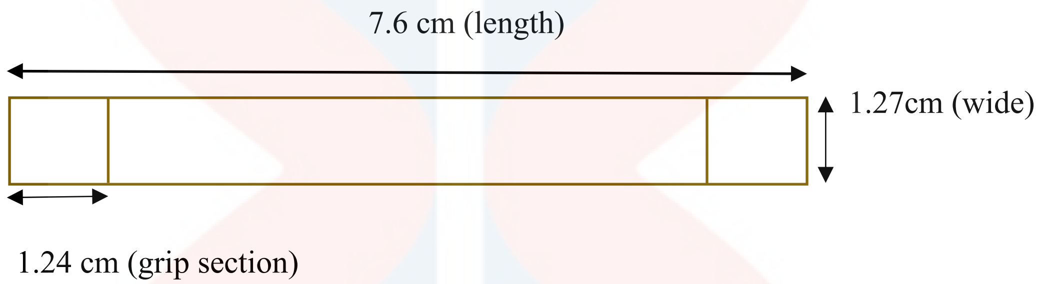


Figure 3.3.4.2.: A diagram showing how the tensile test of paper films.

Tensile strength (tensile stress) formula:

$$Tensile\ strength = \frac{H}{D}$$

Whereas,

H_{max} = Load at proportional limit (N)

D = cross sectional area of the film (mm^2)

$$\text{Elongation at break (mm)} = \frac{Fmax}{Ao}$$

Whereas,

Fmax = Elongation at maximum limit (mm)

Ao = initial length of film (mm)

The material characteristic known as Young's modulus, or modulus of elasticity, explains how a material deforms when subjected to axial or tensile stress. It is represented by the letter E and represents the ratio of strain (ε) to stress (σ) at the elastic limit of a material. A key metric in materials science and engineering for describing the elastic behaviour of materials is Young's modulus. To build structures and components that can endure a variety of pressures and stresses while preserving their intended forms and functions, engineers and researchers need to have a better understanding of how materials will behave to different kinds of mechanical loads.

3.3.4.2. Tear Testing

Tear testing, which gives information on the material's resistance to tearing pressures, is an essential part of quality control in the manufacture of paper. Tear resistance is a crucial attribute in the paper industry as it affects the robustness and functionality of paper products in a range of settings. Standardised testing techniques, such the Pendulum Tear Test or the Elmendorf Tear Test, which entail applying controlled tearing pressures to paper specimens, are often used to measure the tear strength of paper. These tests evaluate the material's resistance to ripping along a predetermined route and provide useful information for streamlining the production of paper and improving paper compositions.

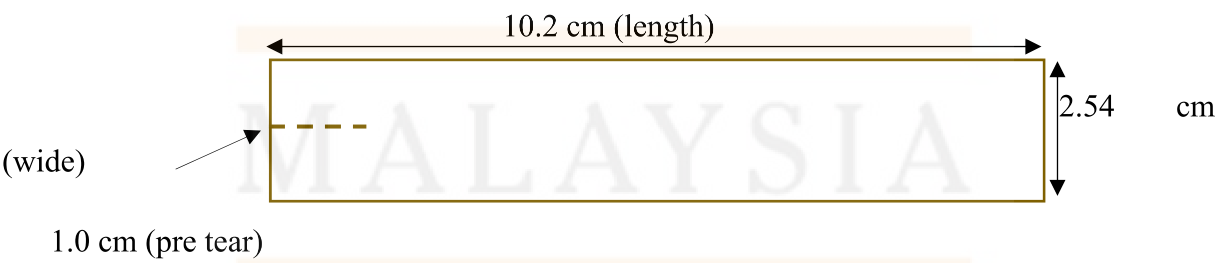


Figure 3.3.4.2.: A diagram showing how the tear test of paper films.

$$\textit{Tear Test:} \frac{Elongation\ (Deflection)\ mL}{Initial\ length\ (mm^2)}$$

Tear test formula:

$$Tensile\ strength = \frac{G}{J}$$

Whereas,

G_{max} = Load at proportional limit (N)

J = cross sectional area of the film (mm^2)

$$\text{Elongation at break (mm)} = \frac{Rmax}{Uo}$$

Whereas,

Rmax = Elongation at maximum limit (mm)

Uo = initial length of film (mm)

A sample of paper is subjected to a predetermined tearing force in accordance with TAPPI (Technical Association for the Pulp and Paper Industry) guidelines, and the outcome is quantified in terms of the force necessary to propagate the tear. For producers to choose the right raw materials, optimise processing parameters, and guarantee the creation of paper with the right tear strength for a certain application, this information is essential. Tear testing helps fulfil the various demands of businesses including packaging, printing, and publishing while also contributing to the overall quality assurance of paper goods.

3.3.4.3. Oven Drying Testing

Oven drying testing is used in the paper industry to measure paper and product moisture. To remove moisture, a paper sample is baked at a given temperature until its weight stays constant. TAPPI standards include dedicated oven-drying test methods. Oven drying is necessary because paper moisture affects its weight, strength, and dimensional stability. Oven drying moisture content helps paper product producers ensure quality and suitability for various uses. Wet environments may affect paper dimensions, durability, and microbiological growth, lowering quality and use. The TAPPI T 412 standard describes oven-drying test procedures and testing environment criteria. This paper industry-standard moisture content technique ensures accuracy and consistency.

$$\textit{Formula Moisture Content}: \frac{Initial\ Weight - Dry\ Weight\ (g)}{Initial\ Weight\ (g)} \times 100$$

Figures 3.3.4.3.: Image of oven laboratory

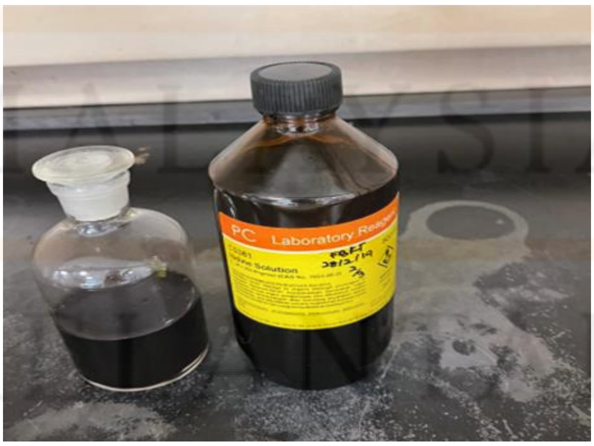
(Source: (*Universal Oven Education Lab Product | BOD Measurement System | Food & Agriculture Lab Product*, 2024)

CHAPTER 4

4.0 RESULT AND DISCUSSION

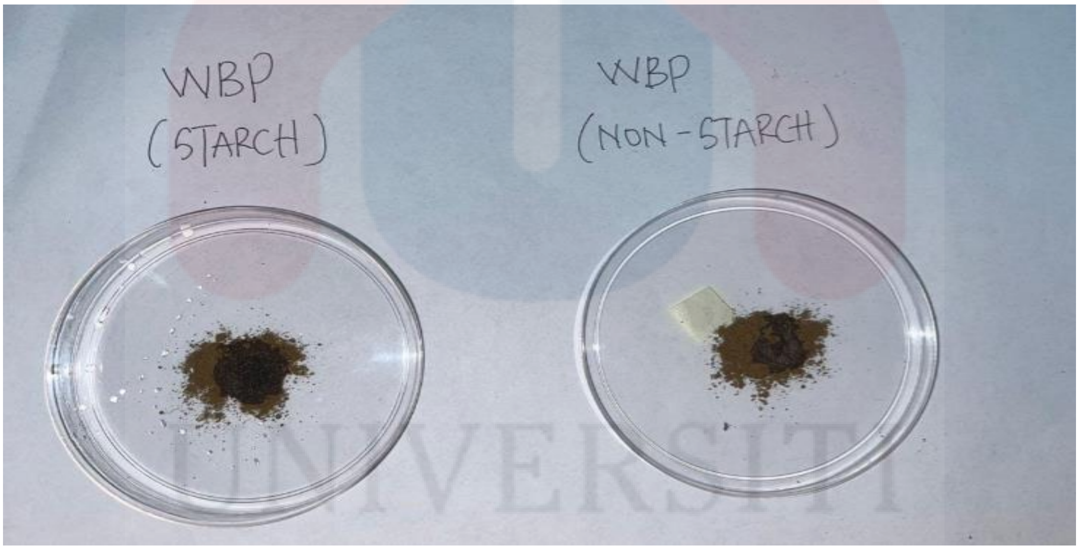
4.1 Determination of Chemical Composition of (Starch and Non-Starch) in WBP

A key ingredient in papermaking, waste banana peel (WBP) contains both starch and non-starch components, and iodine is an essential indicator for analyzing these components. Plant cells, particularly those of wood fibers, contain natural polymer starch, which might affect the papermaking process. To separate the starch from its non-starch components, this research uses iodine as a reagent. The distinctive blue-black complex that is produced by the combination of iodine and starch is what gives it its visual identity. The presence of starch often necessitates the use of an iodine solution to alter the color of the WBP sample. The concentration of starch is inversely proportional to color intensity. On the other hand, substances that do not include starch do not react significantly with iodine and are thus unaffected. When it comes to controlling paper quality, this analytical procedure is crucial since the starch content may impact the paper's strength and absorbency. Identifying the starch and non-starch components in wood-based pulp allows paper companies to optimize their processes and ensure the development of superior paper products.



Figures 4.1.1.: Iodine solution

Poured the banana peel slurry into a container to separate the starch from the non-starch. Because starch granules are dense, they will sink to the bottom of the mixture if you let it settle. With caution, remove the water, ensuring that the settled starch remains at the bottom. The starch that had settled was stirred and given more water before being allowed to settle once again. carried out the process again to ensure a mostly pure start. To remove any last bits of solid material, the fluid containing the starch was passed through a fine mesh screen or sieve. Most of the starch should be present in the liquid that is collected after passing through. To dry, spread the gathered starch out on a level surface. This was completed outside in the sun. The use of an iodine solution was then utilised to establish the presence of starch. If the test is positive, the colour will become blue-black. Since non-starch components were gathered, non-starch components are probably what are left in the sieve or mesh.

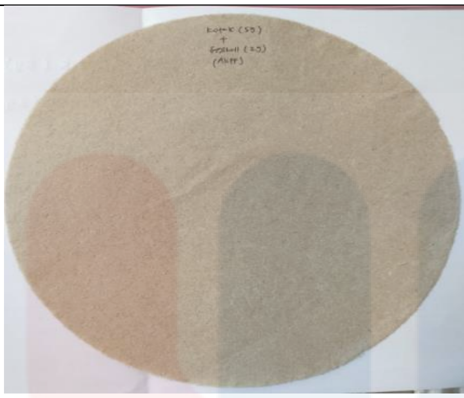
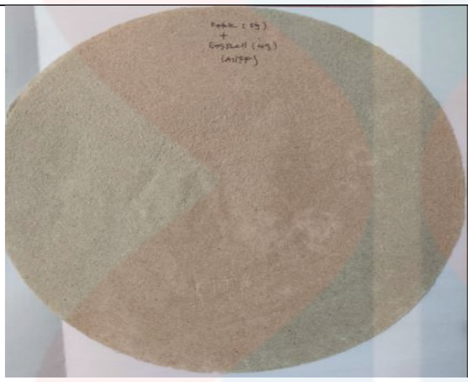


Figures 4.1.1.2.: Colour changes of starch and non-starch WBP treated with iodine solution

4.2 Physical Testing

4.2.1 Appearance testing

NO	PAPER SAMPLES	FILLERS (g)
1.		**5CB0WBP0ES**
2.		**5CB2WBP0ES**
3.		**5CB4WBP0ES**

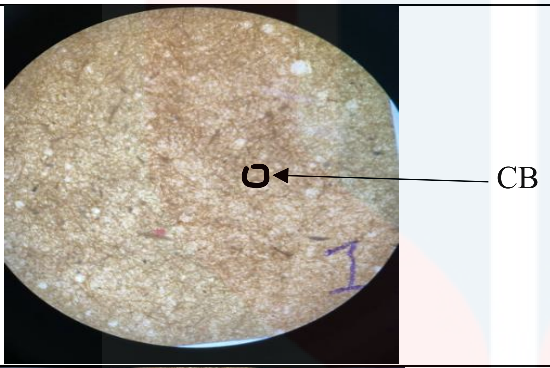
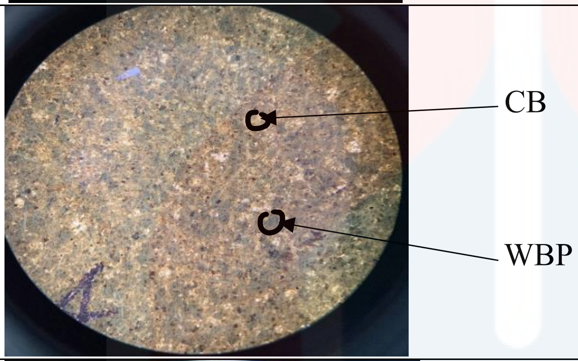
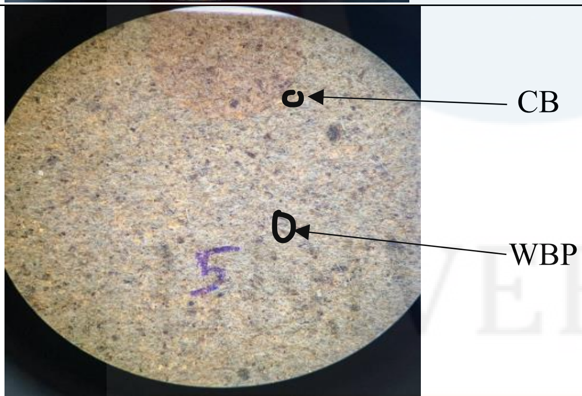
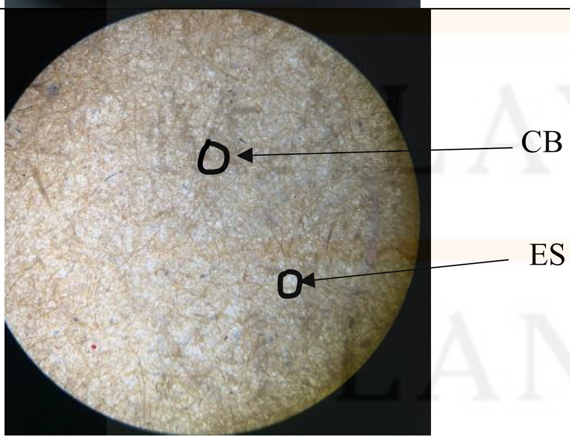
4.		**5CB0WBP2ES**
5.		**5CB0WBP4ES**
6.		**5CB4WBP2ES**
7.		**5CB4WBP4ES**

Tables 4.2.1.: Paper production with difference fillers

DISCUSSION

Eggshell, Waste Banana Peel (WBP), and Waste Carton Box (WCB) are all mixed to give each paper product a distinctive appearance. "5g WCB and 5g WBC, 2g and 4g Eggshell" is the label that is adhered to the paper that is the perfect shade of light brown. Since it is mostly composed of eggshells and waste carton boxes, the paper has a faultless look that is a light brown colour. When "5g WCB + WBP 2g" is employed, the texture of the paper becomes slightly finer and maintains a light brown hue. This is evidence that eggshell contributes to the enhancement of fineness throughout the manufacturing process. As the paper transitions from "5g WCB + WBP 4g" to "5g WCB + WBP 4g," the appearance of the paper becomes considerably rougher while still retaining an acceptable brown tone. This suggests that the extra eggshell makes the paper rougher. This illustrates how the hue is somewhat softened by the banana peel that has been discarded. In addition to imparting a more profound brown colour to the paper, the addition of 5 grammes of waste carton box (WCB) and 4 grammes of waste banana peel (WBP) helps to preserve the paper's texture. This depicts how the thickness of the discarded banana peel increases. The texture is more perfect and has a dark brown tone with traces of brightness. It is composed of 5 grammes of WCB, 4 grammes of WBP, and 2 grammes of eggshell. With these ingredients, the texture is complete. The texture of the paper is smooth, and its colour is dark brown, which indicates that it is a well-balanced blend of four grammes of waste cardboard box, four grammes of eggshell, and five grammes of waste cardboard box. In a nutshell, our paper coding system provides valuable information on the ways in which different combinations of WCB, WBP, and Eggshell influence the tactile and visual properties of paper. Additionally, it lists the compositional qualities and the applications of those properties.

4.2.2. Microscopic Testing

No	Figures Of Paper (Sterio Images)	Content In Paper
1.		**5CB0WBP0ES**
2.		**5CB2WBP0ES**
3.		**5CB4WBP0ES**
4.		**5CB0WBP2ES**

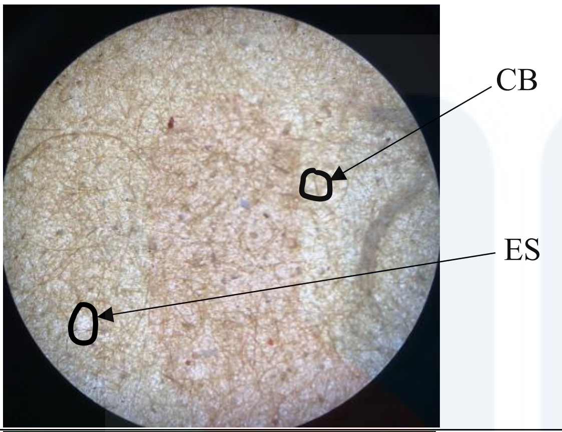
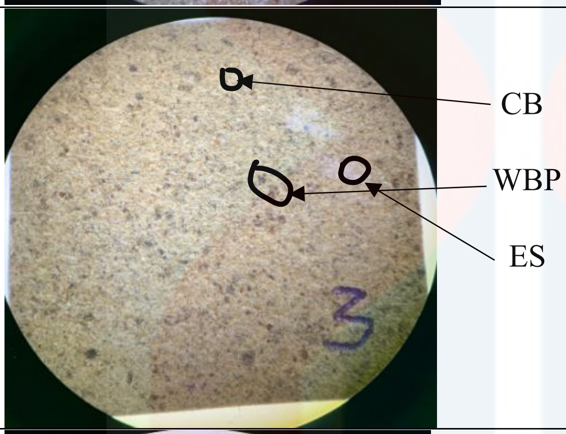
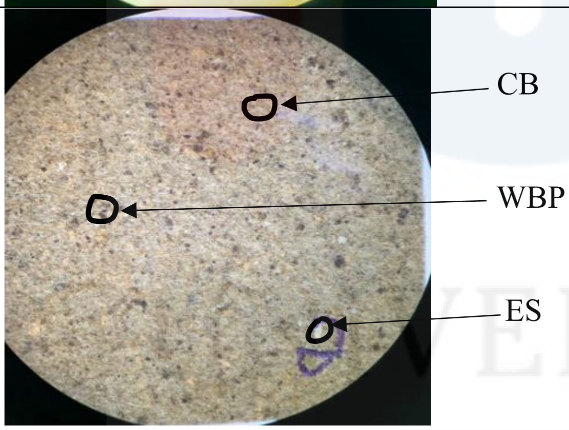
5.		**5CB0WBP4ES**
6.		**5CB4WBP2ES**
7.		**5CB4WBP4ES**

Table 4.2.2.: Images of Fiber in each sample

DISCUSSION

The first sample, which can be observed to have a colour scheme that is quite neutral, is made up completely of waste boxes that are used in the manufacturing of paper. It is quite unlikely that this paper can be used since its thickness is extremely superficial. This came about because recycled paper is produced using fibres that are removed from old box material. This helps contribute to the preservation of natural resources and decreases the effect that recycled paper has on the environment. Since fibres may be recycled and used in the manufacturing of paper, there are many recycling cycles that are now conceivable. As a result of the fact that various types of paper are manufactured using a variety of components, the appearance and feel of the fibres in each sample are distinct from one another. As can be seen from table as well as instances 4 and 5, the only types of data that are valid are WB and ES. Both instances illustrate how calcium carbonate may be dispersed over paper. The waste box mixture that is put to this paper serves the purpose of maintaining the sample's texture, which is necessary to raise the pressure that is provided by the pneumatic sheet press. Two further examples, numbered 2 and 3, are printed on the same paper using WB and WBP, but they are printed at different gramme rates. Because the paper was manufactured in a clean manner, the cellulose and fibre in both samples are readily apparent.

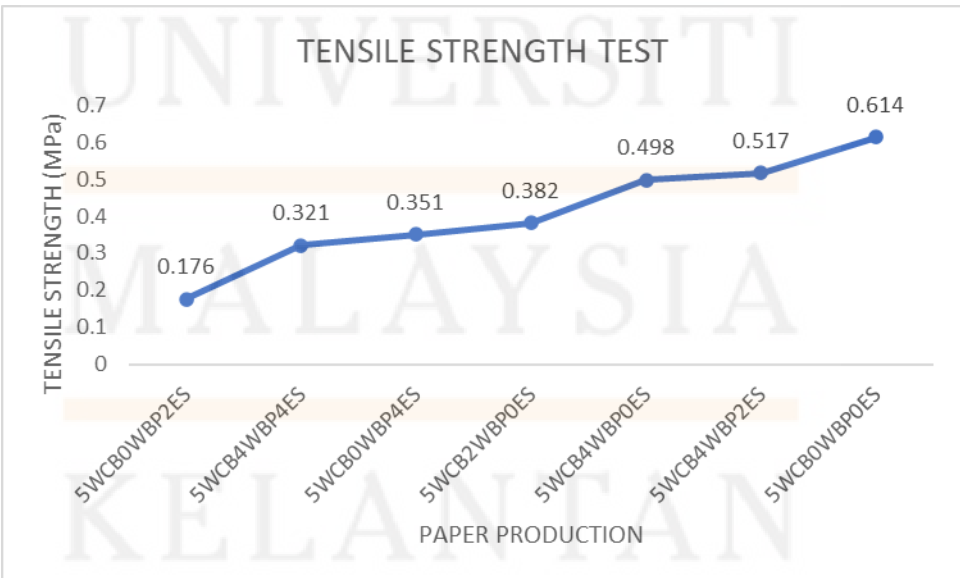
However, the fact that the grammes of the paper differs suggests that the paper has a distinct texture and colour. Unlike sample 2, there is a definite black region that includes WBP powder. This occurs in contrast to sample 2. The fact that a significant amount of cellulose is present is made abundantly clear by this indication. The last two examples, number 6 and number 7, show the whole combination, which consists of WB, WBP, and ES, on a single sheet of paper, but with varying proportions of raw ingredients per gramme. As a result of the high WBP concentration, the paper in Sample 7 is somewhat thicker than the paper in Sample 6, which results in the material having a longer lifespan. Cellulose, which can be observed as very little black dots when seen using a microscope, is found in increased quantities in ES compared to calcium carbonate.

4.3 Mechanical Testing

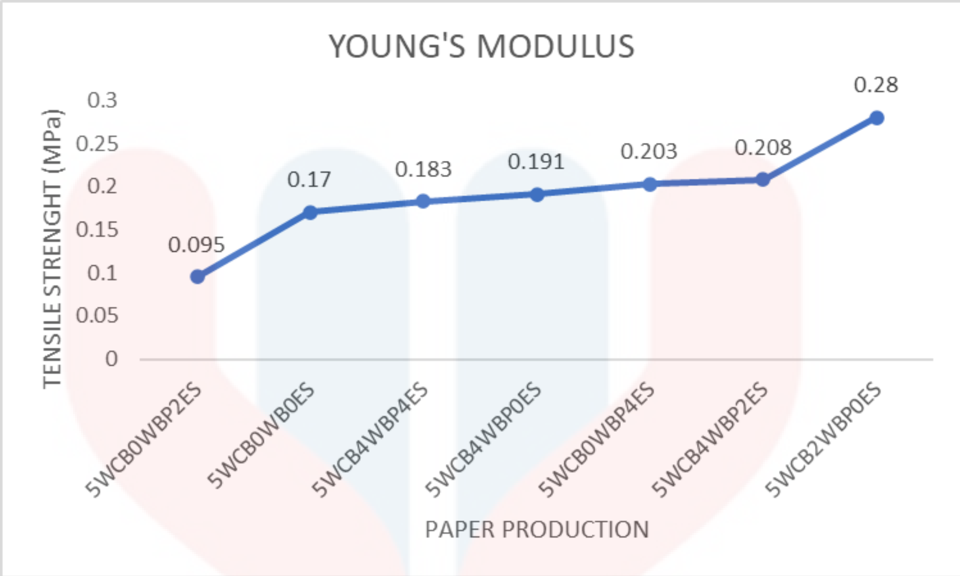
4.3.1. Tensile Testing

Sample	Speed (mm/min)	Maximum Load (N)	Deflection At Maximum Loads (mm)	Tensile Strength (MPa)
5CB0WBP0ES	20	5.9282	1.2857	0.614
5CB2WBP0ES	20	3.6941	2.1323	0.382
5CB4WBP0ES	20	4.8119	1.4524	0.498
5CB0WBP2ES	20	1.7005	0.7222	0.176
5CB0WBP4ES	20	3.3928	1.5423	0.351
5CB4WBP2ES	20	4.9880	1.5754	0.517
5CB4WBP4ES	20	3.0965	1.3889	0.321

Table 4.3.1.: Results of Tensile testing



Figures 4.3.1.: Trends in tensile strength



Figures 4.3.1.: Young's modulus of tensile strength

DISCUSSION

Eggshell (ES), waste banana peel (WBP), and waste carton box (WCB) are only a few examples of the materials whose mechanical characteristics are described in depth in the data that has been supplied. With a consistent pace of twenty millimetres per minute, we were able to determine the tensile strength of each sample.

It was determined that the WCB 5g sample was deflected by 1.2857 mm when subjected to a maximum force of 5.9282 N. It was determined that the material had a tensile strength of 0.614 N/mm, which demonstrated that it was resistant to the forces that were applied to it. By adding 2 grammes of WBP to the combination of 5 grammes of WCB, the maximum load was decreased to 3.6941 Newtons, while the deflection was increased to 2.1323 millimetres. This demonstrates that a new compromise between strength and flexibility was implemented because of this alteration.

After combining WCB 5g and WBP 4g, the maximum load was raised to 4.8119 N, and the deflection was increased to 1.4524 mm compared to before. A distinctive mechanical profile was provided by this combination in comparison to the WBP 2g modification. This was accomplished by striking a balance between load-bearing capacity and deflection. The maximum load was 1.7005 N, and the deflection was 0.7222 mm when ES 2g was applied to

WCB 5g. Both quantities were measured. The fact that this sample has a tensile strength of 0.176 N/mm makes it more deformable; yet it could not be strong enough for applications that need a larger capacity to bear and support loads.

The maximum load was raised to 3.3928 N, and the deflection was decreased to 1.5423 mm because of the addition of 4 grammes of ES to 5 grammes of WCB. This was done to obtain a similar balance between load resistance and flexibility. All the different combinations of WCB 5g with WBP 4g and ES 2g and WBP 4g and ES 4g displayed a wide range of mechanical behaviours, such as maximum loads, deflections, and tensile strengths. These findings highlight the relevance of carefully choosing material compositions in accordance with the requirements of a particular application. This is since each combination provides a unique mix of mechanical characteristics.

4.3.2.: Tear Testing

Sample	Speed (mm/min)	Maximum Loads (N)	Deflection at maximum loads (mm)	Tear strength (MPa)
5CB0WBP0ES	20	1.0305	37.3188	0.040
5CB2WBP0ES	20	0.9065	38.2489	0.035
5CB4WBP0ES	20	0.8835	3.1756	0.034
5CB0WBP2ES	20	0.6408	20.8055	0.025
5CB0WBP4ES	20	1.1299	15.4154	0.044
5CB4WBP2ES	20	0.9938	53.3056	0.038
5CB4WBP4ES	20	1.3002	20.2655	0.050

Table 4.3.2.1.: Table of tear test

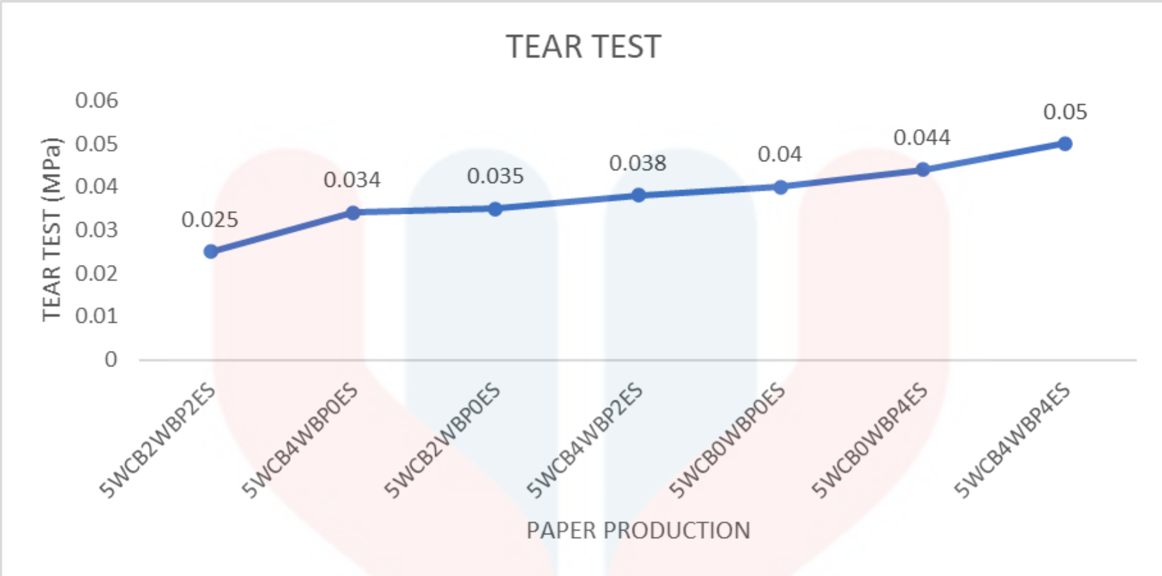


Figure 4.3.2.1: Result Tear Strength

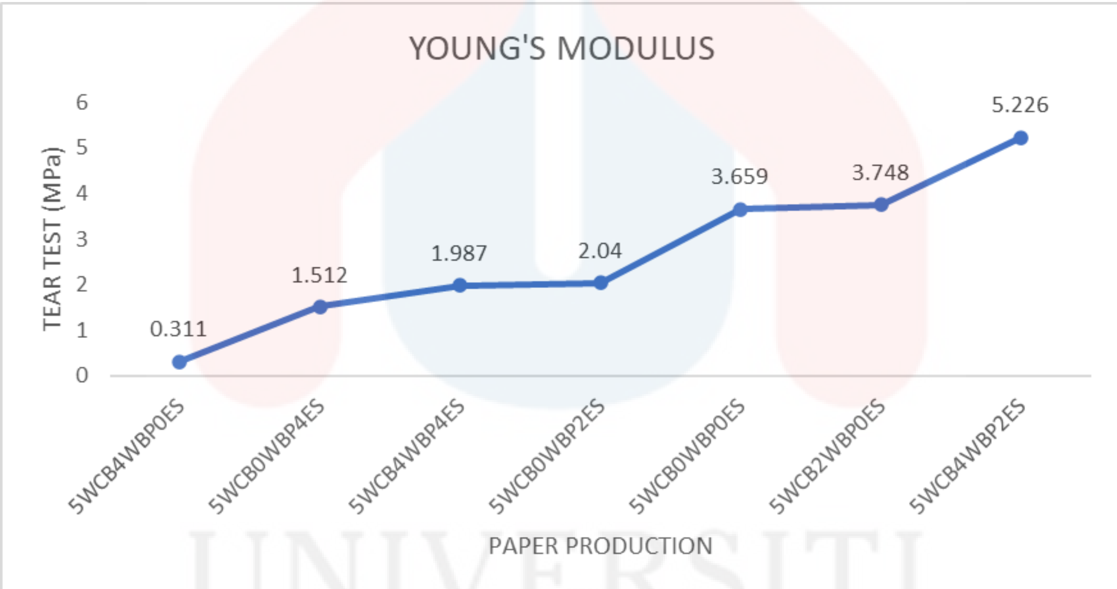


Figure 4.3.2.2: Result Young's Modulus

DISCUSSION

The outcomes of the experiments, which are indicated by several modifiers such as WCB, WBP, and ES, reveal intriguing insights regarding the mechanical characteristics of a variety of different material combinations. The maximum load, deflection at maximum loads, and rip strength were among the main features that were evaluated via a series of tests that were carried out at a constant pace of 20 millimetres per minute. A maximum load of 5.9282 Newtons was observed in the WCB 5g sample, along with a deflection of 1.2857 millimetres and a rip strength of 0.614 megapascals. One of the best indicators of this is the fact that the material's ability to carry weight and its resistance to tearing are both balanced. Using WBP 2g in conjunction with WCB 5g, the maximum load was reduced to 3.6941 N. The tear strength was measured at 0.382 MPa, and there was also a 2.1323 mm increase in deflection that was observed. As a result of this alteration, the tear strength was decreased, and the flexibility was increased; nevertheless, it seems that this was done at the expense of some load-bearing capabilities. After being mixed, WCB 5g and WBP 4g exhibited a rip strength of 0.498 MPa, a deflection of 1.4524 mm, and a maximum load of 4.8119 N. These qualities were displayed by the material. In terms of load-bearing capacity and tear strength concurrently, this mix performs better than WBP 2g.

After applying ES 2g to WCB 5g, the highest load that was achieved was 1.7005 N, the deflection was 0.7222 mm, and the rip strength was 0.176 MPa. Therefore, even though ES 2g makes materials more flexible, it does so at the expense of rip strength and load bearing capacity due to the process. Similarly, the maximum load was 3.3928 N when ES 4g was put to WCB 5g, the deflection was 1.5423 mm, and the rip strength was 0.351 MPa. All these values could be found in the table below. This combination achieves a satisfactory balance between tensile strength, pliability, and load resistance due to its composition. WCB 5g with WBP 4g and ES 2g was then provided, as well as WBP 4g with ES 4g. Both combinations were sold separately. For each of these combinations, the tear strengths, maximum loads, and deflections were all subject to variation. We found that our findings highlight the necessity of tailoring material compositions to fulfil the requirements of certain applications. This is because each combination provides a particular mix of mechanical characteristics that may be used to satisfy specific requirements.

4.3.3. Oven Drying Testing

Sample	Oven Temperature (°C)	Initial Weight (g)	Dry Weight (g) (After 4 hours)	Moisture Content (%)
5CB0WBP0ES	105	0.0645	0.0619	4.0310
5CB2WBP0ES	105	0.1034	0.0983	4.9323
5CB4WBP0ES	105	0.1269	0.1195	5.8314
5CB0WBP2ES	105	0.1027	0.0972	5.2632
5CB0WBP4ES	105	0.1030	0.0967	5.4311
5CB4WBP2ES	105	0.1479	0.1395	5.6795
5CB4WBP4ES	105	0.2341	0.2183	6.7493

Table 4.3.3 Result of moisture content

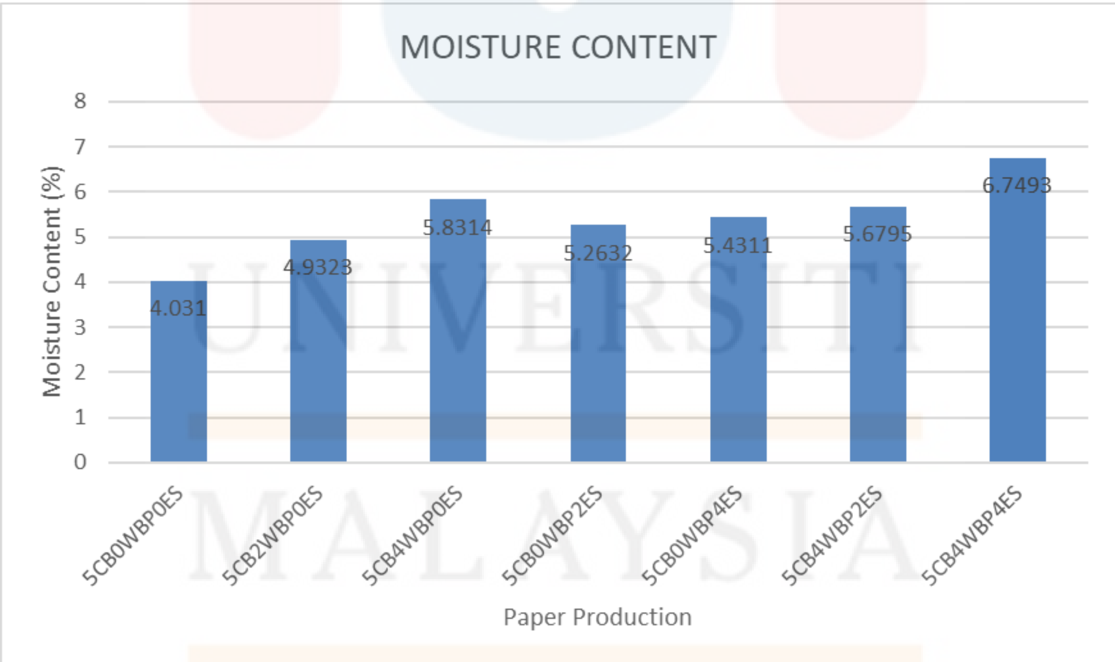


Figure 4.3.3.1: Result of Moisture Content

The information that has been supplied demonstrates the results of oven temperature testing performed on a variety of samples that have varying compositions. The initial weight, the dry weight after four hours of heating, and the moisture content of each sample are the factors that offer information on the impacts of various material combinations and how they behave under the parameters that have been described. Following the application of heat at 105 degrees Celsius, the sample that was marked "WCB 5g." had an initial moisture content of 4.03%. Due to the comparatively low amount of moisture that the sample contains, this implies that the composition of the sample is most likely to remain stable under the circumstances of the testing. The two samples had moisture contents that were considerably distinct from one another; the second sample, which was marked "WCB 5g, WBP 2g," had 4.93%. When compared to the prior sample, the incorporation of WBP, which is most likely a novel chemical, resulted in an improvement in the amount of moisture that was retained. This indicates that extra components had an influence on the overall composition.

Following the occurrence of this event, the moisture content of the third sample, which was labelled "WCB 5g, WBP 4g," climbed to 5.83%. It is possible that there is a link between the concentration of WBP and the moisture content of the sample. This is since WBP seems to increase moisture retention with successive addition. When it came to the fourth sample, which was branded "WCB 5g, ES 2g," it was found that 5.26 percent of the substance had moisture. Because the addition of ES (which is most likely another medicine) resulted in a moisture content that was identical to that of the prior sample that included WBP, this indicates that the effects of ES and WBP on the retention of moisture are likely to be comparable. The moisture content of the fifth sample, which was labelled "WCB 5g, ES 4g," was 5.43%, which was a number that was slightly higher. An increase in the amount of ES seems to be partly responsible for a larger moisture content, which lends support to the theory that various materials have variable degrees of effect on the sample's ability to retain moisture.

It was established that the moisture content of the sixth sample, which was referred to as "WCB 5g, WBP 4g, ES 2g," was 5.68 percent. There was a change in the moisture content of the sample in each instance due to the presence of ES and WBP together, which may suggest that these two components interacted with one another. In conclusion, the seventh sample, which was labelled "WCB 5g, WBP 4g, ES 4g," had the greatest moisture content, which was 6.75 percent. When compared to the individual instances, it seems that the combination of greater doses of WBP and ES results in a significant improvement in the retention of moisture. At the end of the day, the findings indicate that the composition and quantity of the extra components, namely WBP and ES, influence the amount of moisture that is present in the samples. For applications that need materials with a high moisture stability, such as the manufacturing of commodities or industries, it is essential to be aware of these distinctions.

CHAPTER 5

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Research on creating paper from non-starch byproducts like banana peel and eggshell has led to greener, more sustainable papermaking methods. Systematic research has shown that these non-traditional raw resources are good for papermaking. Fibrous banana peel and eggshell structural components improve paper quality. Oven characteristics tests have also shown the ideal conditions for turning these waste items into paper. Given its oven qualities, using non-starch waste materials like banana peel and eggshell to generate paper is a potential option to make eco-friendly, resourceful paper. This novel technique eliminates waste management issues and helps the paper sector adopt sustainable business practices. Various mechanical behaviours were found while analysing eggshell (ES), carton box (WCB), and banana peel (WBP) waste materials. The findings show that altering these components' proportions considerably impacts composite samples' tensile strength, maximum load, and deflection. WBP and WCB were combined to balance the material's strength and flexibility, showing its potential for custom qualities. ES also altered deformability, highlighting the importance of application demands. Each combination's mechanical properties underline the need to customise material compositions to applications. This research emphasises the need of knowing and controlling material combinations to attain mechanical properties for long-term, adaptable industrial processes like papermaking.

5.2 RECOMMENDATION

The study's encouraging findings on using non-starch byproducts for greener papermaking, such banana peel and eggshell, suggest that these sustainable procedures should be further studied and improved for wider industrial use. Papermaking may be made more environmentally friendly and efficient with further study into optimising the ratios of waste materials like banana peel and eggshell. Furthermore, to hasten the integration of these innovative methods into the existing paper production systems, collaboration among academics, industry players, and lawmakers is crucial. Adopting such eco-friendly practices not only addresses environmental concerns, but also aligns with the growing need for sustainable solutions in other industries. To further promote a sustainable culture inside and outside the paper industry, educational initiatives may be developed to disseminate information about the benefits of making paper from non-starch waste sources. This recommendation is to provide a path towards a more resource-and eco-conscious future in the paper manufacturing business by promoting the practical use of the study's findings.

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