Cellulosic-Based Packaging Material from Corn Husk

by

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the requirements for the
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CERTIFICATION OF APPROVAL

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Approved by,

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(Dr. Mohamad Zaki Bin Abdullah)

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Finally, I would like to thank my beloved family and friends who have been giving me inspiration and courage throughout this course in order to complete my final year project

Thank You.

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgement, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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NURUL HIDAYAH BINTI AHMAD RASSDI

ABSTRACT

The abundant agricultural waste is causing multiple problems that involve the environment, economic, and public health. This project represents an attempt to produce paper from corn husks – a discarded agricultural waste. This project aims to create a corn husk packaging material. The packaging material is then to be tested for its tensile strength and moisture absorption properties. Corn husk has no specific application after the extraction of the useful product. There is very limited studies done to produce a packaging material from corn husk. The corn husk is chosen because of its availability in the country and easily accessible. The corn husk is transformed to a packaging material by chemical pulping and paper making process. The corn husk paper will serve as packaging material for dry food and it is environmental friendly material and recyclable. The produced packaging materials are evaluated and tested using the ASTM testing standard. The packaging material with higher percentage of binder has more tensile strength and moisture absorption percentage compared with packaging material of lower percentage of binder.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Environmental packaging is widely developed and become a trend in the world packaging industry. 56.6% of Malaysia' tropical forests are used for production, leaving the rest for uses such as 'Protection' and 'Conservation' [1]. Although near half of Malaysia's forest still untouched, humans have been wasting too much paper that can lead to more deforestation. Deforestation or cutting of trees because of paper production presents multiple societal and environmental problems such as loss of biodiversity, destruction of forest-based-societies, erosion, flooding and climate change in the world. These immediate and long-term consequences of global deforestation are almost certain to jeopardize life on Earth. With the gradual deepening of the world's environmental protection awareness, we must look for new resources and adopting a new method to make packaging completely free from the growing shortage of raw wood pulp resources.

Natural fibres such as straw, hemp, kenaf, bagasse, and jute [2] have been well recognized as good replacements for wood fibre used for paper making. Wood and corn husk are similar which both of them are natural fibres. However, corn husk is categorized as natural waste because there is no application of corn husk is introduced. The idea of "Waste to Wealth" is introduced in this project. Waste to Wealth in this context means that converting waste that are going to be discarded and burned into a product that can benefit the environment and society. This project aims to develop an eco-friendly alternative of producing paper from corn husks – an agricultural waste. The corn husk is transform to a paper by chemical pulping and paper making process. The paper will be transform into a paper box for food packaging.

1.2 PROBLEM STATEMENT

Corn husk is the leafy outer covering of an ear of corn as it grows on the plant. The corn husk waste is discarded and burned because there is no specific use of the waste after the extraction of the useful product. According to United States Department of Agriculture, 100,000 metric tonnes of corn are produced in Malaysia in the year 2012. Instead of discarding the waste and jeopardizing the environment and society, a solution is introduced to overcome the problem. There is no specific application of corn husk have been commercialize in Malaysia and very limited studies were done on producing a packaging material from corn husk. Therefore this project was proposed to produce the packaging material made from corn husk.

1.3 OBJECTIVES

The objectives for this project are:

1. To determine the tensile strength and water absorption properties of the corn husk packaging material.
2. To compare the testing results of corn husk packaging material with a polystyrene box and paper box already used in market.

1.4 SCOPE OF STUDY

The study conducted will include the topics discussed but will be limited to the following conditions:

1. Though there are many kinds of plant materials that can be recycled, the study will focus on using corn husks as raw materials. This is due to its availability in the country as well as in the vicinity of the researcher.
2. The corn husk is obtained from a plantation located in FELCRA Changkat Lada, Kampung Gajah, Perak.
3. The type of corn plant is sweet corn.
4. The packaging material will be test for its strength using ASTM standard.

CHAPTER 2
LITERATURE REVIEW

2.1 PACKAGING MATERIAL AND WASTE

Materials that have traditionally been used in food packaging include glass, metals (aluminium foils and laminates, tinplate, and tin-free steel), paper and paperboards, and plastics [3]. Packaging material made from natural waste is in trend in the 21st century. Food packaging is a major component of packaging waste, representing 60% of all packaging produced in developed countries [4]. Low recycling rates and the high volume of non-degradable plastics have shortened dramatically the life expectancy of current commercial landfills and increased the demand of biodegradable packaging materials [5]. Several companies from the Europe have been known to use non-wood pulp to make paper to be used for packaging applications. The company Enviropack, EcoWare, and Vagware used bagasse as their main natural sources for their products. The application of natural waste as an alternative to wood pulp is a solution for the waste problems and upgrade of products in term of environmental packaging.

2.2 CORN HUSK

Corn husk is the leafy outer covering of an ear of corn as it grows on the plant. Corn produces at 100,000 MT in the year 2012 [6]. Hence, corn husks can be easily obtained in Malaysia. Corn husk is chosen as the main fibre component in this project because based on the feasibility report [7], it is concluded that corn husk can be used to create paper. Corn husk provided a good data in terms of fibre length. Figure 2.1 presents the components of a corn plant and Figure 2.2 shows a picture of corn husk.

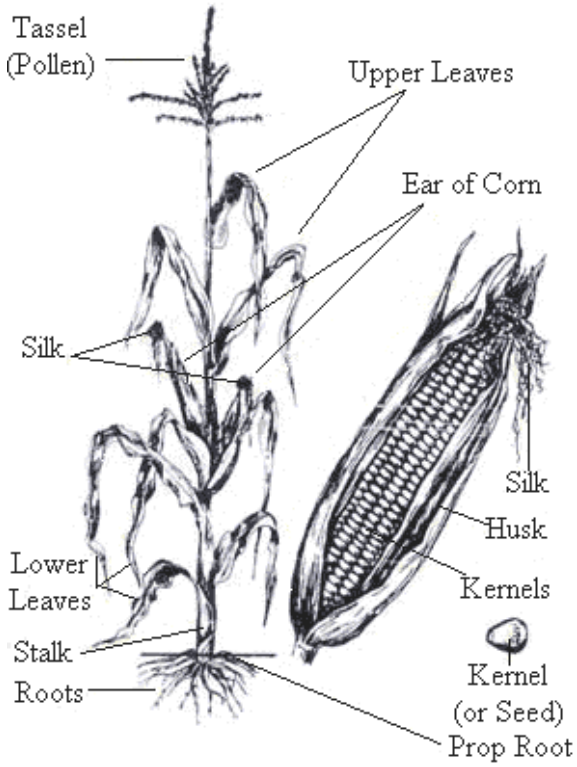

FIGURE 2.1: Parts of a Corn Plant

Figure 2.2: Corn Husk

TABLE 2.1: Chemical components of corn husk in weight percentage per kg

	Hemicellulose	**Cellulose**	**Lignin**	**Ash**	**Protein**
Corn Husk	44.5	38.2	6.6	2.8	1.9

Table 2.1 shows the chemical composition of corn husk in terms of weight percentage per kilogram [8]. Cellulose and lignin is also found in wood, hence corn husk can be used to make paper. The amount of hemicellulose and cellulose is relatively high, so it is suitable for paper making. The content of lignin and other components is also very low, so it will be easier to separate them.

TABLE 2.2: Fibre characteristics in millimetres

	Length	**Diameter**
Corn Husk	1.85	0.08
Softwoods	3.6	0.035
Hardwoods	1.2	0.025

Table 2.2 shows the fibre characteristics of corn husk compared to wood [9]. The fibres from the corn husk are classified as moderately long. It was remarked that the values indicate suitability for paper production. To increase the quality of paper, short and long fibres can be mixed and processed together.

2.3 PRODUCTION PROCESSES

2.3.1 Pulping process

Pulping process refers to separation of pulp fibres from plant material, by either mechanical or chemical processes [10]. Chemical pulping relies mainly on chemical reactants and heat energy to soften and dissolve lignin in the plant material, partially followed by mechanical refining to separate fibres. Some examples of chemical treatment are alkaline treatment, saline treatment, acetylation treatment, benzoylation treatment, peroxide treatment, and maleated coupling agents [11]. Alkaline treatment using sodium hydroxide is widely being used to modify the cellulosic molecular structure. Study by Li et al. [12] showed that alkaline treatment results in 30% increase in tensile strength and modulus. Mechanical pulping involves the pre-

treatment of natural fibre with steam prior to the separation into fibrous material by abrasive refining or grinding.

2.3.2 Paper making process

Paper making is the process whereby pulp fibres are mechanically and chemically treated, formed into a dilute suspension, spread over a mesh surface, the water removed by suction, and the resulting pad of cellulose fibres pressed and dried to form paper [13]. Chemicals added to provide special properties such as colour or water resistance.

2.4 PACKAGING PROTOTYPE MAKING

The process that can be used to make the prototype is:

Compression Moulding

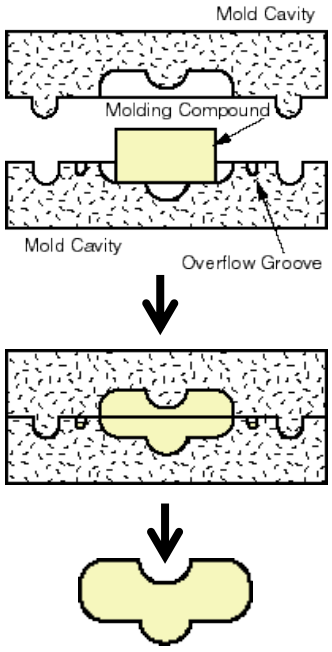

Figure 2.3: Compression Moulding Process

Figure 2.3 shows how the compression moulding process is done. Moulding compound is placed in an open, heated mould cavity. The mould is closed and

pressure is then applied to force the material to fill up the entire mould cavity. Excess material is channelled away by the overflow grooves. The heat and pressure are maintained until the material is cured. The final part after the mould is removed.

CHAPTER 3
METHODOLOGY

3.1 RESEARCH METHODOLOGY

Figure 3.1 shows the flow chart of the project's research methodology starting from the problem statement until the final report of the project.

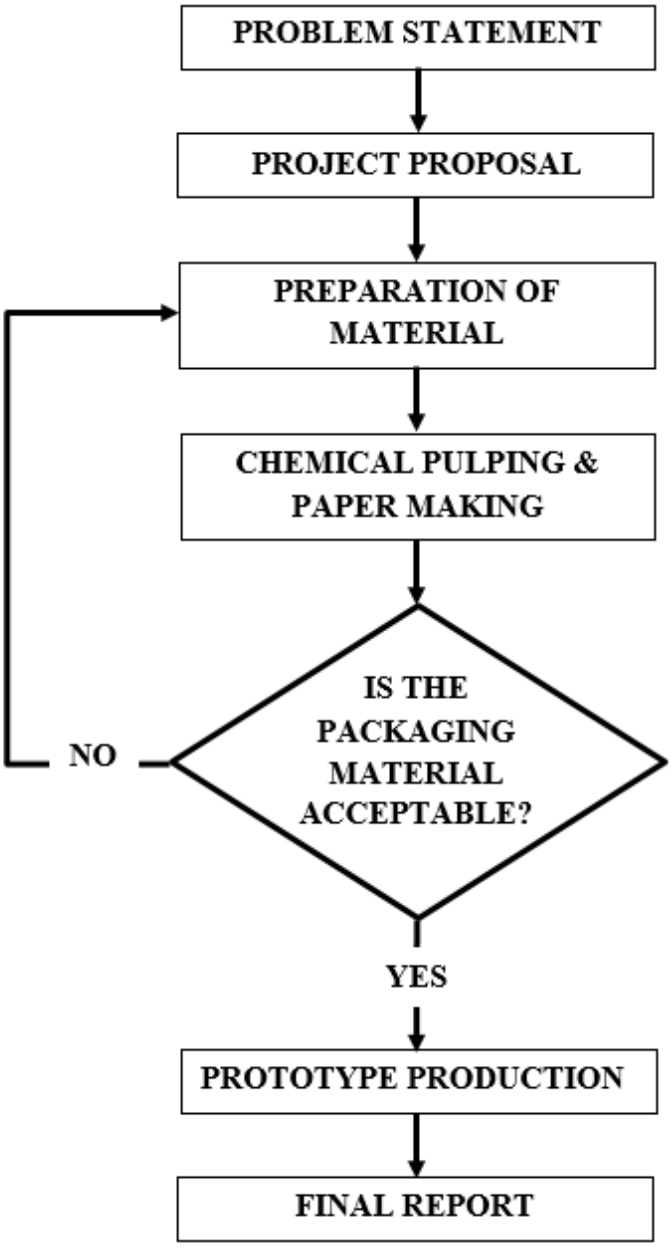

Figure 3.1: Project Research Methodology

The project will starts with background research on the topic of study of pulping and packaging. The project methodology is shown in Figure 3.1. The research is divided into 3 stages:

1) Preliminary Research

The information related to pulping process and packaging materials are collected from various sources such as books, journals, internet and articles. All the information are compiled and stored for future references.

2) Experimenting

The project then continued with project activities. The project activities are explained in Section 3.2.

3) Testing & Result Evaluation

The prototype will undergo several tests to determine the product strength. The results and data are collected and compiled.

3.2 PROJECT ACTIVITIES

The procedure to create the prototype is listed down below:

3.2.1 Mould and Deckle Construction

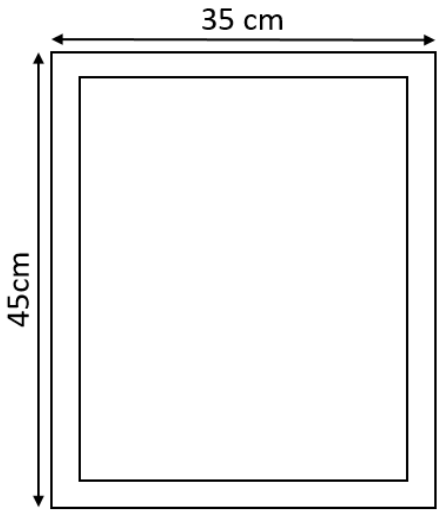

Figure 3.2: Deckle's measurement

Figure 3.3: Deckle and mould

1. The wood is cut according to their length shown in Figure 3.2. The wood pieces is arranged in a rectangle shaped and the edges are stapled together to hold the wood together.
2. The wood frames is painted in varnish to seal the wood so that it will not affect the paper colour.
3. After the frame has dried, the screen is cut according to the size of the frame. The screen is then stapled to the edges of the wood frames.
4. The netted frame is called deckle and the other is mould as shown in Figure 3.3.

3.2.2 Pulping Process

1. First, weigh 100g of corn husk waste. The corn husk is let dry out in open place overnight.
2. After the husks have dried, it is shredded to small pieces.
3. The corn husk is placed in a slow cooker for 6 hours.
4. Next, the corn husk is soaked in a concentrated sodium hydroxide solution for 6 hours.
5. After that, the treated corn husk is wash by the distilled water and lemon extract until the pH number is 7 (neutral).
6. The corn husk pulp is blended with recycled paper until it became a mushy exterior.
7. Next, the pulp is treated with cationic starch to act as dry strength additive.

3.2.3 Paper Making and Prototype Production Process

1. The deckle and mould is prepared.
2. The mush is transfer onto the deckle.
3. Dab excess water from the paper using a sponge.
4. The wet paper is then transferred to the mold for its final shape, which is the paper box for food packaging.
5. The molding method use is compression molding.

Mould Design

The mold was design and sent to Long Chin Plastic Moulding Industry to be manufactured. The mould is made of stainless steel and cost RM2500.

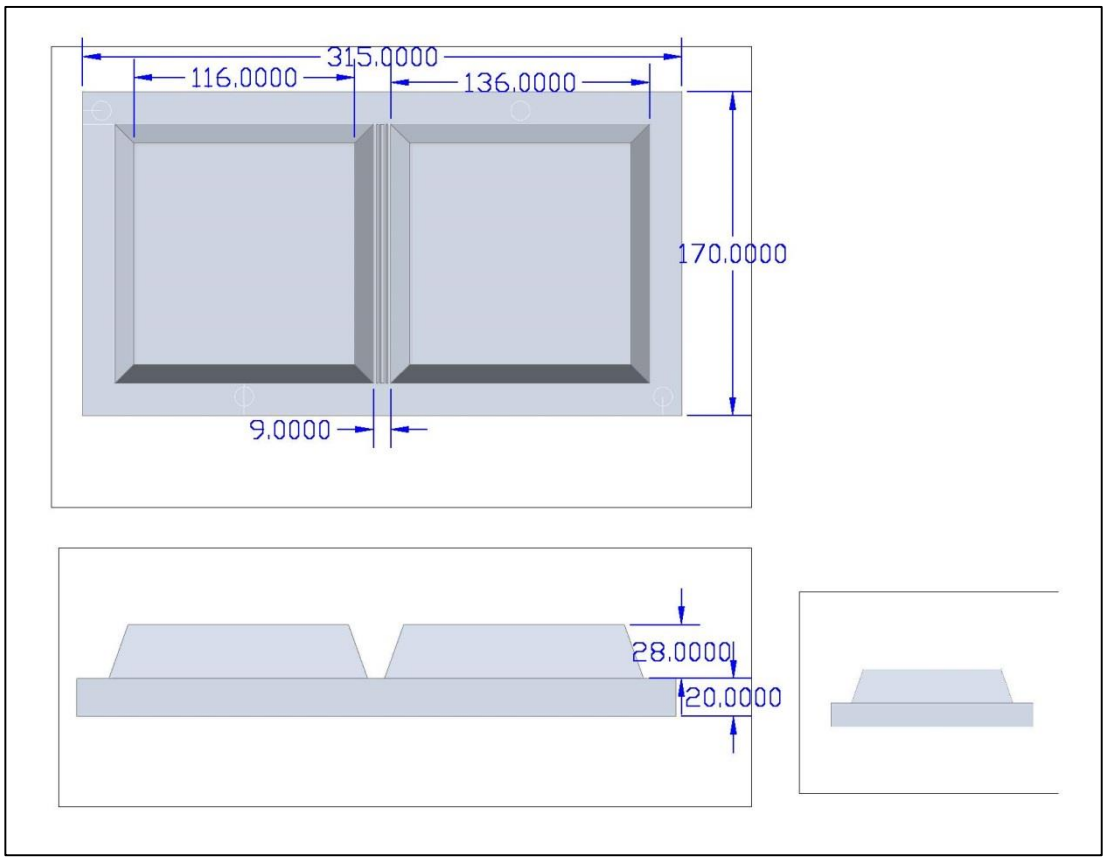

Figure 3.4: Prototype Mould Drawing (Male)

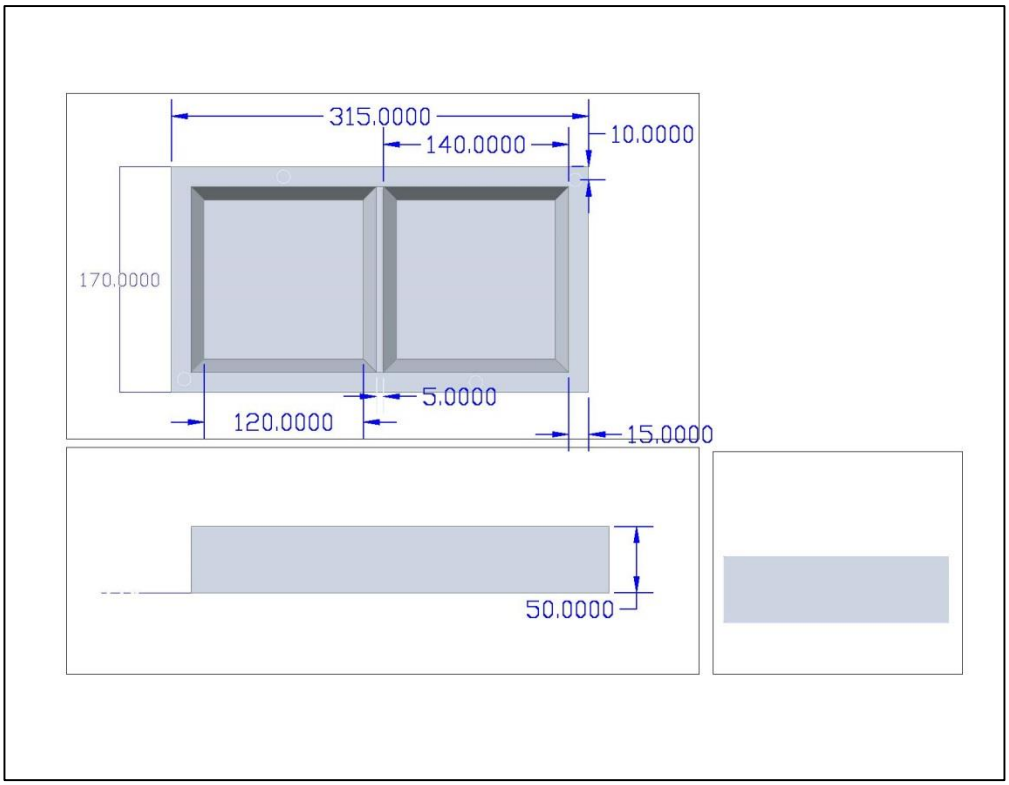

Figure 3.5: Prototype Mould Drawing (Female)

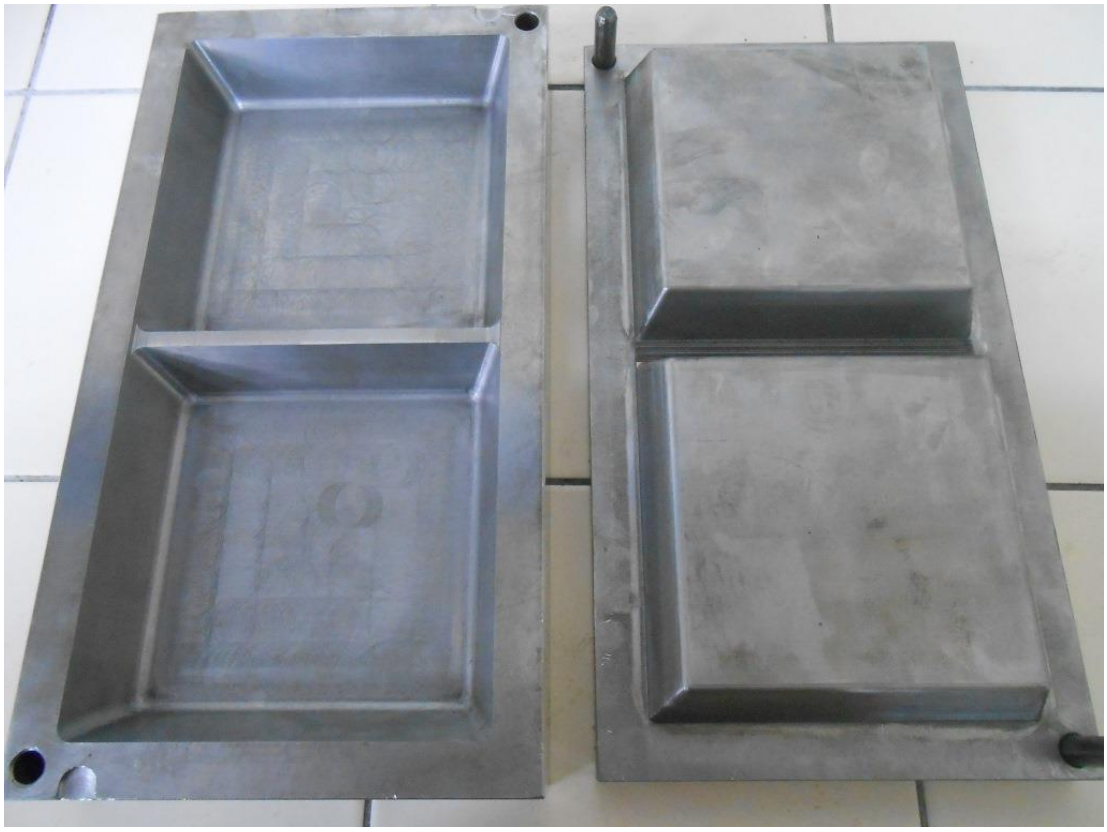

Figure 3.6: Actual Prototype Mould

3.2.4 Testing Procedures

3.2.4.1 Tensile Test

The ability to resist breaking under tensile stress is important properties of materials used in packaging applications. The force per unit area (MPa) required to break a material is the ultimate tensile strength (UTS). The packaging material form the finished prototype will be cut into a dog bone shape according to ASTM D638 Standard Type IV. The packaging material will be tested for its tensile strength and modulus of elasticity.

3.2.4.2 Moisture absorption test

Using a Mettler balance, the prototype will be tested for its water absorption for a period of time. This test is conducted by preparing 5 specimens for each paper type, and weighing them using a Mettler balance. After the date is recorded, the specimens is placed in the oven for 12 hours and after that the specimens is weighed again using a Mettler balance. After the data is recorded, the specimens is immersed in waster for another 12 hours. After that, the specimens is weighed and the data is recorded.

3.3 KEY MILESTONES & GANTT CHART

Table 3.1 shows the milestones of the project activities and their completion date. The first milestone is material and tool gathering and is expected to complete on the 13th of April. Table 3.2 shows the Gantt chart for this project starting from literature survey until the submission of hard bound dissertation.

Table 3.1: Key Milestones

Milestones	**Completion**
Material and tool gathering	13.4.2013
Mould and deckle fabrication	20.4.2013
Treatment of the fibre	06.6.2013
Prototype mould fabrication	17.7.2013
Specimen preparation	23.7.2013
Tensile test	25.7.2013
Moisture absorption test	26.7.2013
Analysis of testing result	30.7.2013

Table 3.2: FYP Gantt Chart

DETAILS	Month	JAN			FEB				MARCH				APRIL			MAY			JUNE				JULY					AUGUST		
	Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Literature Survey																														
Extracting Important Facts																														
Discussion with Supervisor																														
Material Selection and Preparation																														
Deckle Construction																														
Pulping Process																														
Paper Making process																														
Mold Design																														
Pulping Process																														
Paper Making Process																														
Protoype Production																														
Testing and Analysis																														
Prototype Production																														
Testing and Analysis																														
Pre - SEDEX																														
Submission Draft Report																														
Dissertation (Soft Bound Submission)																														
Submission Technical Paper																														
Oral Presentation																														
Submission of Project Dissertation (Hard Bound)																														

CHAPTER 4
RESULTS AND DISCUSSION

In this project, the main goals are to create a packaging material from corn husk. This chapter will explain the analysis of testing and evaluation of the produced packaging material. The testing includes material appearance evaluation, tensile strength and moisture absorption testing.

4.1 APPEARANCE

Table 4.1 shows the paper produced, it can be concluded that paper made from corn husk is a little rough and the results is also promising. After adding the recycled paper to act as an additive for binding the fibres and also in appearance, the results shows is more promising. After increasing the amount of binder to 40%, the paper created is better in appearance. Corn husk and starch alone make the paper weak and brittle thus recycled paper is added. This can be concluded that adding recycle paper make the appearance better and also increasing the strength of the paper and improve the binding effect.

Table 4.1: Packaging Material Appearance Evaluation

	Type: 70% Corn Husk 30% Starch Appearance: Rough Surface
	Type: 70% Corn Husk 20% Starch 10% Recycled Paper Appearance: Rough Surface but better than 70% Corn husk, 30% starch
	Type: 60% Corn Husk 20% Starch 20% Recycled Paper Appearance: Smooth Surface

4.2 TENSILE TEST

Using a Universal Testing Machine, tensile strength can be described by stress-strain graphs. The stress-strain curves provide a fundamental engineering description of the mechanical behaviour of paper strips when subjected to tensile stresses that distort or elongate the strips as they are pulled to failure by force applied to them [14]. Figure 4.1 shows how the procedure is conducted and Figure 4.2 shows that the specimen is cut into dog bone shape and followed the Type IV measurement for ASTM D638 standard.

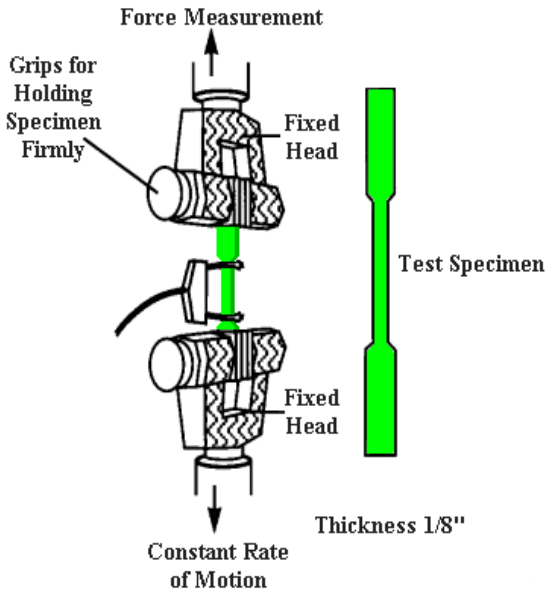

Figure 4.1: Tensile Testing Procedure

Figure 4.2: Specimens for Tensile Testing

The tensile test is conducted and the stress-strain curve is recorded. The stress-strain value does not depends on the size of the test specimen, however it depends on other factors such as the preparation of the specimen, the presence or otherwise surface detects and the temperature of the test environment and material. Tensile strength is measured as force in newton (N) per unit area in square-meters (m^2) and the unit is Pascal (Pa). 5 specimens of each type of packaging material, paper box and polystyrene box is prepared and the results are compiled below.

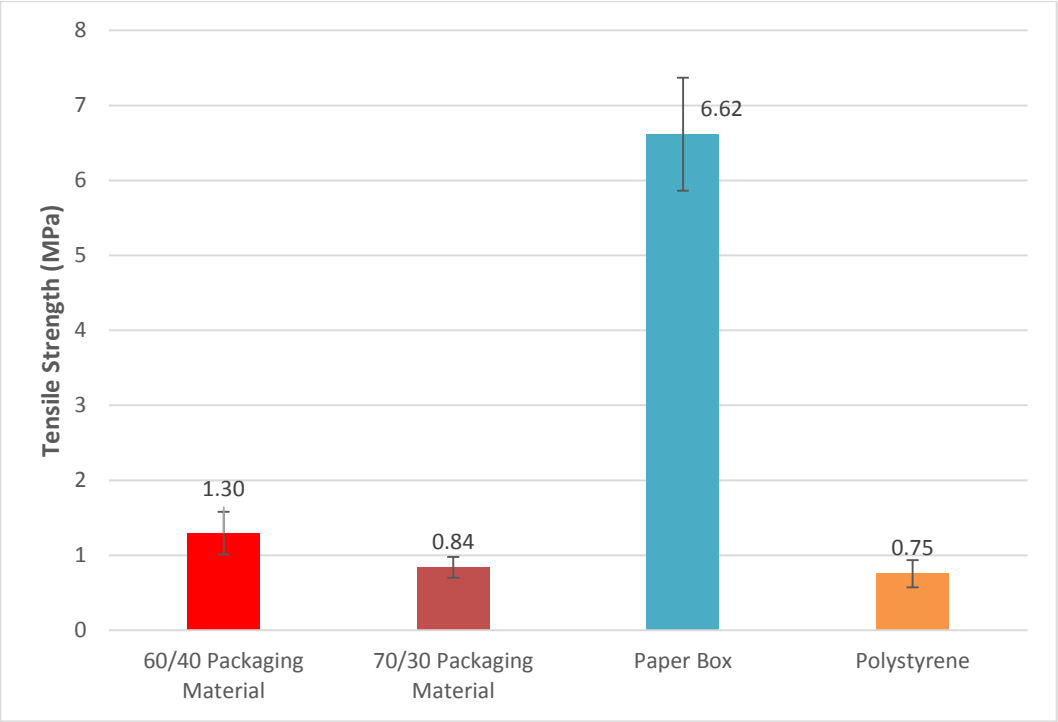

Figure 4.3: Tensile Strength of 60/40 Packaging Material, 70/30 Packaging Material, Paper Box and Polystyrene

Ultimate tensile strength is calculated using the following formula:

$$\text{Tensile strength (Pa)} = \frac{Force(N)}{Area(m^2)}$$

Figure 4.3 shows the tensile strength of 60/40 packaging material, 70/30 packaging material, paper box and polystyrene. From the chart we can see that the tensile strength of packaging material of 60% corn husk and 40% binder is 1.30 MPa and is higher than the packaging material of 70% corn husk which valued at 0.84 MPa. This proves that the material with higher percentage of binder gives higher tensile strength. Mechanical properties of the natural fibre composites depend on several factors such as the stress–strain behaviors of fibre and matrix phases, the phase volume fractions, the fibre concentration, the distribution and orientation of the fibre or fillers relative to one another [15].

The ultimate tensile strength for paper box is much higher than corn husk packaging material. This is due to the fibre of paper that is produced commercially, using machines and the processes that are much more complex compared to corn husk paper making. The type of binder that is being used also is a significant factor

affecting the strength of the paper. Some people used rosin and wax to increase the strength of paper but rosin is hard to fine and it is also more expensive compared to starch. The amount of lignin removed from the husk affects the size of the fibre bundles as well as their tensile properties [16]. Lignin, like most other substances that can separate fibres from one another, acts as a debonding agent, that lowering the strength of paper.

4.3 MOISTURE ABSORPTION TEST

This test is conducted by preparing 5 specimens for each paper type, and weighing them using a Mettler balance according to ASTM D570 standard. Figure 4.4 shows the specimens for the moisture absorption test. Figure 4.5 shows the Mettler balance used to weigh the specimens. After the data is recorded, the specimens is placed in the oven for 12 hours and after that the specimens is weighed again using a Mettler balance. Figure 4.6 shows the oven that were used in this testing procedure. After the data is recorded, the specimens is immersed in waster for another 12 hours. After that, the specimens is weighed and the data is recorded.

Figure 4.4: Specimens for Moisture Absorption Test

Figure 4.5: Mettler Balance


Figure 4.6: Oven

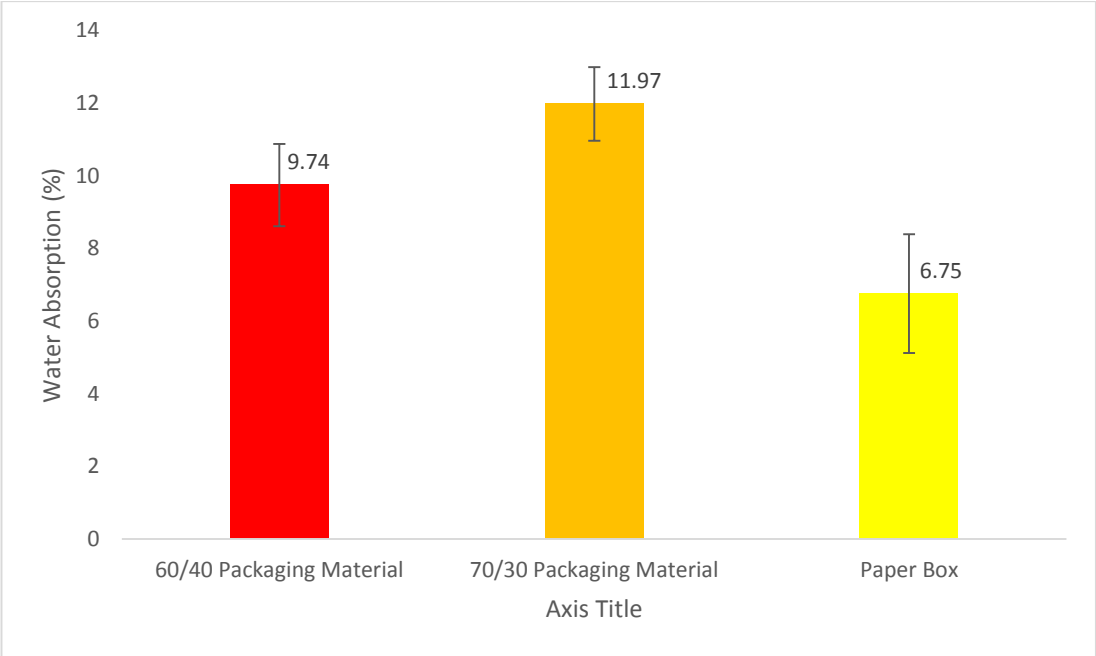

Figure 4.7: Moisture Absorption Percentage

The moisture absorption percentage is calculated using the following formula:

Percent Moisture Absorption = [(Wet weight - Dry weight)/ Dry weight] x 100

The data is presented in a bar chart as shown in Figure 4.7. Moisture in paper varies from 2 - 12% depending on relative humidity, type of pulp used, degree of refining and chemical used. Most physical properties of paper undergo change as a result of variations in moisture content. From Figure 4.7, the moisture absorption percentage for packaging material of 60% corn husk is lower compared to packaging material of 70% corn husk and paper box. This is due to the fibre/binder percentage of the material. Besides that, poor adhesion between fibre particles and binder generates void spaces around the fibre particles. These lead to higher water uptake in the packaging material. The packaging material that has higher percentage of corn husk has the highest water absorption capacity of 13.27%. The paper box have the lowest value because wood fibre contains high hydrophilic content (cellulose and hemicelluloses). Cellulose and hemicelluloses are mostly responsible for the high water absorption of natural fibres, since they contain numerous accessible hydroxyl groups.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The objective of this project is to determine the tensile properties and water absorption properties of the corn husk packaging material. From the results of the project activities, it can be concluded that corn husk can be used to make a paper to be used as packaging material. The results showed that the corn husk packaging material with higher percentage of binder provide better tensile strength and moisture absorption. The improvement is approximately 20%, however, the strength and moisture absorption percentage is lower compared to paper box. The cost of preparing the material is also cheap because the main source is a natural waste. The procedure to create the material is also very easy and environmental friendly. By applying the waste to wealth idea in this project, natural waste such as corn husk can be converted into something useful and new. Corn husk packaging material can be an example of environmental friendly material. However, in this project, there are many rooms of improvement that can be discussed to make the packaging material to be produced commercially.

5.2 RECOMMENDATION

The surface treatment used in this project is alkaline treatment. In the future, another type of chemical treatment such as saline treatment and coupling agents can be used to make the packaging material better in terms of strength and appearance. Other recommendation is to only use recycled paper as the binder instead of using a mixture of starch and recycled paper.

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