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NEGROS ORIENTAL STATE UNIVERSITY
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Kagawasan Avenue. Dumaguete City, Negros Oriental, Philippines 6200
Phone: (63) (35) 225-9400 Fax: 225-4751 Email: president.office@norsu.edu.ph www.norsu.edu.ph
ISO 9001 5965 18Q19869

DEVELOPMENT OF A SUSTAINABLE PAPER BAG MADE OF KAPOK FIBERS (Ceiba Pentandra), PAPER WASTES, AND SUGARCANE LEAVES (Saccharum Officinarum)

A Business Research Paper

Presented to the Faculty and Staff

Of Negros Oriental State University

Mabinay Campus

In Partial Fulfillment

of the Requirement for the Bachelor of Science in Business Administration Major in Human Resources Management

Proposed by:

Karl E. Awit

Melchizedek Cadano

Jenny Rose L. Martinez

Shecaynarose Romano

Mary Claire B. Serveza

2024

APPROVAL SHEET

This undergraduate innovation study attaches here entitled "**DEVELOPMENT OF SUSTAINABLE PAPER BAG MADE FROM KAPOK FIBERS, PAPER WASTES, AND SUGARCANE LEAVES**'' prepared and presented by Karl E. Awit, Melchizedek Cadano, Jenny Rose L. Martinez, Shecaynarose A. Romano, and Mary Claire B. Serveza is hereby accepted with a rating of _____.

GLADY MAE A. ERIDA
English Critic

_____
Date signed

NOVA CORCIEGA, MAEd
Adviser

_____
Date signed

GLADY MAE A. ERIDA
Member, Interrogation Board

_____
Date signed

COCON B. RUSINA, JR.
Member, Interrogation Board

_____
Date signed

DR. CARLITO A. ACABAL
Member, Interrogation Board

_____
Date signed

Accepted as partial fulfillment of the requirements of the Degree Bachelor of Science in Business Administration.

Approved:

ENGR. ARCIE S. NOGRA, PH. D.
Campus Administrator/Research Coordinator

_____
Date signed

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ACKNOWLEDGEMENT

The researchers would like to give thanks and honor to all, especially to the Almighty God for His protection and guidance. The researchers Karl E. Awit, Melchizedek Cadano, Jenny Rose L. Martinez, Shecaynarose Romano, and Mary Claire B. Serveza are grateful to the following individuals who assisted them in any manner to complete this study:

To the parents, Mr. and Mrs. Awit, Mr. and Mrs. Cadano, Mr. and Mrs. Martinez, Mr. and Mrs. Serveza, and Mr. and Mrs. Romano, for their undying love, support, and understanding, which motivated them to finish their research paper;

To the researchers' friends and acquaintances who supported and motivated the researchers during the process of making the research;

To Ms. Nova B. Corciega**,** the innovation adviser, who contributed a lot in the completion of this paper through sharing her insights and knowledge;

To Mrs. Glady Mae A. Erida**,** English critic, who made corrections and suggestions especially in the grammar aspects on this innovation study;

The panelists, Mrs, Glady Mae A. Erida and Mr. Cocon B. Rusiana,Jr., for the valuable suggestions and comments that leads to the success of this study;

To Ms. Mabelle for lending a helping hand in printing our manuscripts;

Finally, to Mr. Carlito Cabual, the course adviser, for the guidance throughout the whole semester, sharing his valuable insights about the study, and encouraging us to deliver excellent research.

The Researchers,

Karl E. Awit

Melchizedek Cadano

Jenny Rose L. Martinez

Shecaynarose Romano

Mary Claire B. Serveza

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Abstract

This research investigates the potential of sugarcane leaves (Saccharum officinarum), kapok fibers (Ceiba pentandra), and paper wastes, specifically bond papers, as sustainable raw materials for handmade paper bags. The papermaking process prioritized environmental responsibility by minimizing chemical use and relying on renewable, compostable resources. Calcium carbonate is incorporated as a filler, while sodium carbonate facilitates fiber breakdown and softening. To evaluate the quality of the produced paper, researchers employed simple tests. Paper strength was assessed through weight capacity measurements, while visual inspection evaluated texture and glue application on the finished paper bags. The 6x9 inch paper bags demonstrated a promising average weight capacity of 1078 grams, with a maximum recorded weight of 1505 grams. This suggests their potential to handle moderate to heavy loads. The paper quality received a mean score of 2.23, indicating a moderate thickness with minimal surface irregularities. Glue application achieved a mean score of 2.30, signifying a generally uniform application with minimal imperfections. These findings provide evidence supporting the viability of using kapok fibers, sugarcane leaves, and wastepaper together to create paper suitable for sustainable paper bag production. The approach offers a potential solution for waste management and a reduction in reliance on traditional paper sources.

CHAPTER I

THE PROBLEM AND ITS SCOPE

Introduction

The global proliferation of plastic waste poses an urgent threat to our environment, with staggering figures revealing the extent of its impact. Annually, over 350 million tons of plastic waste inundate our ecosystems, with a concerning 0.5%—equivalent to 12 million tons—finding its way into our oceans (Ritchie, et.al, 2023). The enduring nature of plastic, taking anywhere from 20 to 500 years to decompose, underscores the gravity of its consequences, perpetuating environmental harm for generations to come. In the Philippines, there is an estimated 2.7 million tons of plastic waste produced annually and a significant portion of it ends up in landfills and the ocean (Arowana, 2023). In an article published by Wicaksono in Visual Capitalist, Philippines is estimated to emit 35% of the ocean's plastic. Despite the convenience of plastics in everyday life, their detrimental effects on both nature and human health necessitate urgent mitigation efforts.

One of the uses of plastic is as a packaging material which people use every day, contributing to the growing case of plastic pollution in the world. In locales such as Mabinay, where the prevalent use of plastic as a packaging material prevails, the consequences of improper waste disposal reverberate throughout the community. Most people who use plastic bags do not practice proper plastic waste disposal which affects our environment resulting in plastic pollution and exposure to its toxic properties. As a solution, a lot of places have introduced the use of paper bags and other sustainable packaging methods in the market. Paper bags have been an integral part of our daily lives for decades, serving as a versatile and reliable packaging solution. From carrying

groceries to serving as gift bags, paper bags have stood the test of time due to their practicality, affordability, and eco-friendliness.

To make paper bags, the production of excellent quality papers is necessary. Papers are usually made of wood pulp, fabric, cotton, bamboo, and paper wastes. In this innovation, the researchers want to promote a sustainable paper bag that benefits both humans and nature by creating a unique version that is made of both non-wood and non-plant materials such as sugarcane leaves, kapok fibers, and paper wastes – resulting in an eco-friendly product that can be a counterpart to the use of plastic in the market. This way, the purpose of sugarcane leaves, which are currently deemed as a waste for the community and usually end up being burned, can be elevated. The materials being used also promote waste management and utilization of the local produce in the community.

Moreover, the researchers advocate for waste management practices and the utilization of locally sourced materials, fostering a symbiotic relationship between human needs and ecological balance. Through this endeavor, the researchers aspire to usher in a new era of sustainable packaging, where paper bags serve as tangible symbols with the commitment to a greener, more sustainable future.

Objectives of the Study

This research has its objectives to accomplish. The following objectives are:

1. To analyze the environmental impact of handmade paper bags compared to plastic bags and explore their potential as a sustainable alternative.

2. To create awareness and influence people to use an eco-friendly product and reduce the usage of plastic bags.
3. To develop innovative packaging solutions using paper bags that minimize environmental impact throughout their life cycle, from raw material sourcing to end-to-end life disposal or recycling.
4. To investigate the effectiveness of incorporating sugarcane leaves, kapok fibers, and wastepaper into a paper through a handmade process.
5. To test the quality of the produced paper bag from its appearance to strength.

Statement of the Problem

This study aims to develop a sustainable paper bag. This research specifically answers the following:

1. What is a sustainable paper bag?
2. What are the materials needed to make the innovation?
3. What is the process followed in making the paper bag?
4. What is the overall cost of making the paper bag?
5. How durable and effective is the innovation?
6. What are the improvements made before the completion of the paper bag?

Significance of the Study

This study is a significant endeavor in developing a sustainable paper bag made from kapok fibers, sugarcane leaves, and paper waste. The study will be significant in the following areas:

The researchers

This study can be a stepping stone for studies and innovation that involve with production of paper made of non-wood materials that will be turned into paper bags. This can also be the basis for new learning to arise and for future studies.

The consumers

This study encourages consumers to opt for paper bags to adopt sustainable practices and invest in environmentally responsible packaging solutions.

The environment

This study can be a stepping stone for people to recognize the idea of making paper bags from non-wood materials through a combination of sugarcane leaves, kapok fibers, and paper waste, potentially helping the environment by reducing plastic waste and the growing cases of forest depletion.

The community

This study will be significant to the local community of Mabinay by introducing a way of elevating the use of different local resources such as sugarcane and kapok.

Scope and Limitations

This study deals with making sustainable paper that could be used for paper bags and other packaging uses that could be used in the market instead of plastics. The study is limited to the

handmade process of paper making and does not investigate the detailed chemical composition of making the paper and its pulping process.

The innovation is only limited to the paper bag that is made of sugarcane leaves, kapok fibers, and paper wastes specifically used bond papers with the use of calcium carbonate as the only filler to the process and sodium carbonate used for breaking and softening the fibers of the raw materials. It is also limited to produced paper bags in size 6x9 inches that will be used also for the testing. The durability of the paper bags is optimized to handle weight within reasonable limits for typical packaging requirements while efforts are made to optimize the durability of the paper bags, their performance under extreme conditions or heavy loads and water resistance are not fully addressed.

The study focused on the production of paper with resources, especially the raw materials, available from Mabinay, Negros Oriental. Upon unavailability, the researchers did other means of acquiring lacking necessary materials. External factors such as fluctuations in raw material availability or environmental conditions may impact the research outcomes but were not extensively analyzed. By defining a clear scope and outlining specific limitations, this research aims to contribute valuable insights into the development of sustainable packaging solutions using locally sourced materials and traditional craftsmanship techniques.

Definition of Terms

Calcium Carbonate – a mineral used as a filler in the process of making the paper to enhance paper condition.

Cooking - the process of boiling the raw materials before blending to soften it.

Deckle – a material used to sift the pulp made by wood frames and fine screens.

Fibers - a material that is composed of thin and continuous strands. Plant fibers are elongated which will need to be softened and break down in the process.

Kapok Fibers – is a silky cotton-like substance and originates from the kapok tree, which is also known as ceiba Kendra. Commonly known as "Dol-dol" in the Philippines.

Lignin - the structural support to the cells of the plants.

Non-plant Materials – raw materials that are not based on plants, e.g., paper wastes and rags.

Non-wood Materials – raw materials used in making the pulp which is not based on wood, e.g., fibers from plants.

Paper Bag – a bag used for carrying different things such as groceries and other things.

Papermaking - the process of making the paper.

Pulp – the outcome after the raw materials undergoes the pulping process.

Pulp Slurry- the mixture that is made when the pulp is mixed with the water. It can have the same texture as a smoothie.

Pulping - is the process of refining and grinding the raw materials used that will eventually form into a pulp slurry mixture. Involved in this process is the shredding, cooking, beating, and blending of the raw materials.

Raw Materials – are the materials from nature used for pulping (e.g., sugarcane leaves and kapok fibers).

Wood/Wood-based Materials – raw materials based on wood.

Waste Materials – are materials deemed wastes for many that are used in this research such as sugarcane leaves and paper wastes.

Review of Related Literature

To make the paper bags, the first thing to consider is the raw paper; its materials, the chemicals to be added, and the tools in making it. Commonly, papers are made of cellulose or fibers from wood; softwood (pines, etc.) and hardwood (birch, oak, etc.). Meanwhile, papermaking and the paper industry have been evolving for centuries, and in the modern generation, the industry aims to develop a sustainable and environmentally friendly process and products, especially with the problem of forest depletion due to the obtaining of wood that has affected the environment. In response, studies about making paper from different raw materials arise considering non-wood materials such as the usage of wastes from processed sugarcane, cogon grass, agricultural wastes, and even banana peelings. The main raw materials of pulp and papermaking are classified into three; non-wood, wood, and non-plant (e.g., wastepaper, linen rags, etc.) (Liu, et al., 2018).

A significant part of papermaking is the pulping. Pulping is the process of refining and grinding the raw materials used that will eventually form a pulp slurry mixture. To make sure that the quality of the pulp is enough to make into a paper, the raw materials should have low lignin content, abundant fibers, and minimal impurities. By far, wood is the predominant source of papermaking fiber because of the quality and high cellulose it contains. On the other hand, non-wood plant stems differ from wood in containing less total cellulose, less lignin, and more other materials (Britt, 2020). This means that it is easier to pulp with milder treatment needed, unlike

wood where different hard chemicals are needed such as sodium hydroxide for pulping and other chemicals needed for fillers.

There are two types of pulping methods: chemical pulping and mechanical pulping. Chemical pulping is pulping using chemicals to separate the fibers of the plant while mechanical pulping uses physical force to pulp. Some paper manufacturers also use chemical-mechanical pulp which is a pulping process that separates fibrous materials by combining three ways chemical, heat, and mechanical (CNBM, 2018). One method under the chemical pulping is the use of washing soda or soda ash (sodium carbonate) to cook the raw materials before pulping. Sodium carbonate is primarily used in the paper industry to adjust pH levels during the pulping process, enhancing the breakdown and removal of lignin from cellulose fibers (Petronaftco, 2024). This results in a stronger, purer pulp, leading to higher-quality paper products. This way, it will break the plant fibers which will be easy to blend after.

However, one non-wood material alone may have tensed and stiff paper as a result, thus it is needed to incorporate another kind of plant for another source of fiber (Britt, 2020). In this research, the researchers will be using both non-wood and non-plant materials as sources of fiber and pulp. Sugarcane and kapok fibers have been tested by different researchers as both potential materials for pulping and papermaking. Non-plant materials such as paper waste will be added too to minimize the waste by transforming it into a new paper again and to ensure the durability of the product.

Sugarcane (Saccharum officinarum**)** is one of the large products in the Philippines specifically in Negros Occidental and its neighboring towns. Mostly, its wastes are deemed unusable yet in an article published by China National Building Material (CNBM) International in

2018, sugarcane bagasse, the pomace from the squeezed sugarcane, is pulped and made into paper. In some instances, the pulp is even mixed with other materials such as paper waste to make the paper. On the other hand, according to Ekael Mbise (2021), sugarcane leaves, which are commonly discarded and burned, are one of the potential materials for pulp and paper making and have low lignin content – the structural support to the cell of the plants. Plants like sugarcane, specifically its leaves, that have low lignin content help with making high-quality paper and have advantages such as ease in pulping, reduced chemical usage, higher pulp yields, and even greater environmental sustainability since it doesn't need a high amount of chemicals and has a low impact to the environment. Sugarcane leaves have limited existing studies compared to sugarcane bagasse as a material for papermaking. It has been mentioned above that for better pulp yields, one characteristic that raw materials have should be high fiber content. Sugarcane leaves have shorter fibers compared to wood and sugarcane bagasse thus incorporating another source of fiber is necessary.

Meanwhile, the fiber from the Kapok tree (ceiba pentandra), commonly known in the Philippines as "Dol-dol", that is cultivated widely in Southeast Asia can be a quality pulp source for papermaking. Kapok fibers contain a high cellulose content (around 54%) suitable for paper production. Compared to other non-wood materials, kapok has a lower lignin content, making it easier to pulp with milder chemicals. In a study made by Chaiarrekij, et. al. in 2011, it was found that paper made with kapok pulp exhibits good tensile and burst strengths, making it ideal for packaging applications. The study also found that kapok pulp improves the water-repellency of the final paper product.

It has been practiced for years to add fillers to the papermaking process to improve the quality and properties of the paper from its brightness to its thickness and strength. The most common fillers used in the paper industry were ground calcium carbonate, kaolin, precipitated calcium carbonate, talc, and titanium dioxide. Calcium carbonate obtained from its natural sources is used as a filler in a variety of products, such as paper, ceramics, glass, plastics, and paint. It is a white powder or colorless crystal that can be found on limestones, eggshells, marbles, and chalk (Britannica, 2024), Due to its accessibility, it will be incorporated in the process of papermaking as a filler because it plays a vital role in the paper industry, providing benefits such as cost reduction, brightness enhancement, pH adjustment, sizing, coating improvement, calendaring, and retention aid (Zohdy, 2023).

Prior Arts

Below are the prior arts used in this research. It consists of three prior arts that are related to the study.

Table 1.0 Prior Arts

PRIOR ARTS				
	PRIOR ART 1	PRIOR ART 2	PRIOR ART 3	PROPOSED INNOVATION:
Name of the innovation	KAPOK 1: CHARACTERISTICS OF KAPOK FIBER AS A POTENTIAL PULP SOURCE FOR PAPERMAKING	HANDMADE PAPER FROM FIBERS OF ABACA (Musa textiles) STRIPPING REFUSE PARTS AND THE PRODUCT PRODUCED	A NOVEL PROCESS OF MAKING PAPER FROM GARDEN WASTE	DEVELOPMENT OF A SUSTAINABLE PAPER BAG MADE OF KAPOK FIBERS, PAPER WASTES, AND SUGARCANE LEAVES
Patent Number	Corpus ID: 30792804	PH2/2019/0505560	202011032620	
Inventors	Chaiarrekij, et.al.	Morales, et. al.	Dr. Lovleen	
Ingredients/Materials:				
Water	✓	✓	✓	✓
Sodium Hydroxide	✓		✓	
Baking Soda			✓	
Paper wastes		✓		✓
Abaca fibers		✓		
Dried Plant Leaves			✓	
Eucalyptus leaves			✓	
Rice Husks			✓	
Sugarcane Leaves			✓	✓
Kapok Fibers	✓			✓
Calcium carbonate				✓
Hydrogen Peroxide			✓	
Sodium Hypochlorite			✓	
Sodium Carbonate				✓

The researchers opted to use the necessary materials in making the paper bag and considering its availability in the area. Incorporating in this study too are some materials that are used in papermaking yet not used in the prior arts mentioned above. The materials used were chosen upon their availability in Mabinay with consideration to its local resources that may be utilized. Other raw materials such as abaca fibers, rice husks, dried plant leaves, and eucalyptus leaves are not essential for this study since the researchers aimed to produce paper out of sugarcane leaves, kapok fibers, and paper wastes. Some prior arts also used different chemicals such as hydrogen peroxide, sodium hydroxide, sodium hypochlorite, and baking soda which are different chemicals used in as fillers in papermaking to enhance the quality of the paper. Since this research aims to produce a paper with fewer chemicals to be used as part of protecting the environment, researchers opted for chemicals that are locally available and are like other chemicals, essential and commonly used in papermaking.

Materials

Sugarcane Leaves (leaves from *Saccharum officinarum*)

Sugarcane leaves are possible to be a raw material in papermaking. The leaves that will be used from sugarcane leaves are wilted or dried ones. The leaves must be shredded and beaten properly to form a pulp slurry consistency so it will not leave too texturized surface on the paper and will incorporate fully with other materials.

Kapok Fibers (fibers from *Ceiba pentandra*)

Just like other cotton, kapok fibers are introduced as be potential material for papermaking. Incorporating it will enhance quality of the paper, especially in terms of its strength.

Paper Wastes

The paper wastes, aside from its effectivity to be transformed back into new papers, will also act as an additional binder for the other two materials, the kapok, and the sugarcane, to ensure that the two raw materials will effectively incorporate together. Specifically, the paper wastes used in this research are used bond papers.

Sodium Carbonate (*Na2CO3*)

Pulping the raw materials will not be possible without the help of a chemical. Sodium carbonate will act as an agent to soften and break the fibers of the sugarcane leaves and kapok fibers to form a good-quality pulp. It is not possible to pulp both raw materials by just blending and soaking them into water thus the need for sodium carbonate.

Water (*H2O*)

Water is essential in papermaking. The raw materials will use water in soaking it and it is also used in pulping and easy sifting of the paper.

Calcium Carbonate (*CaCO3*)

Calcium carbonate will serve as a sizing agent during the papermaking process. This just not help with the visual of the paper but will also help with thickness and strength.

Glue

This will be used as an adhesive in making the paper bags.

Table 2.0 List of Raw Materials

Materials	Quantity
Kapok Fibers	100 g
Paper Wastes	400 g
Sugarcane Leaves	300 g
Calcium Carbonate	15 g
Sodium Carbonate	10 - 15 g (in every boiling and soaking)

The papermaking process employed in this research incorporates a precisely formulated blend of five distinct materials. This blend adheres to a specific ratio of 20:80:60: 3:2-3.

Research Methodology

The research methodology for making the sustainable paper bag is planning, designing and assembly, constructing, testing, and revising.

Phase 1: Planning

In this phase, this involves planning on what are the goals in developing the product, what it aims for, researching, and the possible activities associated with making the product.

Phase 2: Gathering

This involves with knowing the tools for making the paper and its availability and gathering all the materials and tools for the papermaking process.

Phase 3: Papermaking Process

This phase involves making the paper using gathered materials and tools. Batches of paper will be made in this stage. The process involved different steps from preparation of the raw materials to drying the paper. First, after being chopped and meticulously washed, the fibers are soaked in separate containers to soften. The sugarcane leaves receive an additional treatment where the lignin core is removed. Following the soaking stage, both materials are boiled with water and sodium carbonate to further enhance their pliability. The boiled fibers are then blended for uniformity before being pounded into a rough pulp. This rough pulp is further refined by blending it with soaked paper waste. To achieve the desired paper consistency, calcium carbonate is incorporated into the refined pulp mixture, which is then carefully drained using a deckle. The final stage involves pressing the drained pulp to remove excess water, followed by drying it under direct sunlight. Once completely dry, the paper can be embellished with fragrances, patterns, or designs for a customized touch.

Phase 4: Testing

The paper will eventually be tested through different testing methods to ensure that it is of the best quality and will be suitable for making it into a paper bag. If errors occur, the researchers will go back to the process of making revisions. The researchers used two testing methods which are the simple load/strength test and simple visual test.

- The simple load/strength test assessed the amount of weight the formulated paper bag could carry through the sandbag method. The weight will be measured by grams through a hanging scale.
- The simple visual test assessed the paper quality and glue application of the paper bag through a specific scoring method.

Table 3.0 Scoring for Paper Quality Test

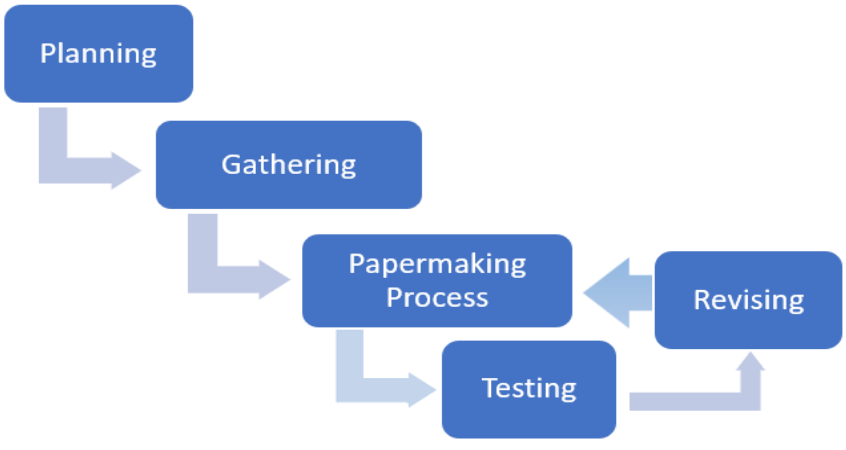
LEGEND (for Simple Visual Test)	
Test	Score
Paper Quality Test	1: Thin, has Tears, and Flimsy 2: Moderate Thickness and Bumps 3: Thick and Sturdy
Glue Application Test	1: Large gaps and Uneven Application 2: Minor gaps/imperfections and uniform application 3: Tight, Secure, and Complete coverage

Phase 4.5: Revising

This phase involves revising the process or adding different materials to improve the product when errors might occur.

Exhibit 1.0

Research Methodology



CHAPTER II

DEVELOPMENT OF THE PRODUCT

This chapter delves into the development of a sustainable paper bag crafted from sugarcane leaves, kapok fibers, and recycled paper waste. It offers a comprehensive look at the planning process, outlining the necessary tools and outlining the different stages involved in creating the bag. This includes a cost analysis to ensure feasibility and details the revisions made to optimize the design and functionality of the final product, ensuring an excellent outcome.

Strategy

This study follows the research methodology in producing the product. The research methodology comprises four phases; the planning, gathering, papermaking process, and testing and revising which are crucial steps in the production of the paper.

Definition of Sustainable Paper Bag

This innovative paper bag is designed to be a gentle touch on the environment. Instead of traditional, potentially harmful packaging materials, it relies on utilizing local resources. A sustainable paper bag is made of sugarcane leaves, the fibers from kapok trees, and even paper wastes are all given a new life. The researchers have meticulously formulated a handmade process that minimizes the use of chemicals with renewable materials and compostable products. This eco-friendly approach not only reduces waste but also transforms it into a sustainable packaging solution.

Gathering

In this section, the raw materials and tools used and the total cost of producing the paper bag are discussed.

Table 4.0 List of Tools

Tools	Usage
Deckle	This is used in sifting the pulp to turn it into a paper.
Large basin	This is where the pulp will be put together with the water.
Blender/Food Processor	Blender will help with finding the pounded materials to form into a fine pulp from having a rough pulp.
Fabric	This is where the sifted pulp is put for drying
Scissors	For cutting
Compressor	Used in compressing the wet paper to flatten and squeeze the water out. This can be made of slab and screw but can also be heavy objects stacked above the wet paper.
Water Sponge	Used in absorbing excess water

Table 5.0 List of the Materials Used and Their Cost

Materials and Tools	Cost
Sugarcane Leaves	---
Kapok Fibers	---
Paper Wastes	---
Calcium Carbonate	50
Sodium Carbonate	32
Glue	60
Deckle	304
Electricity	150
Fabric	76
Total	697

Papermaking Process

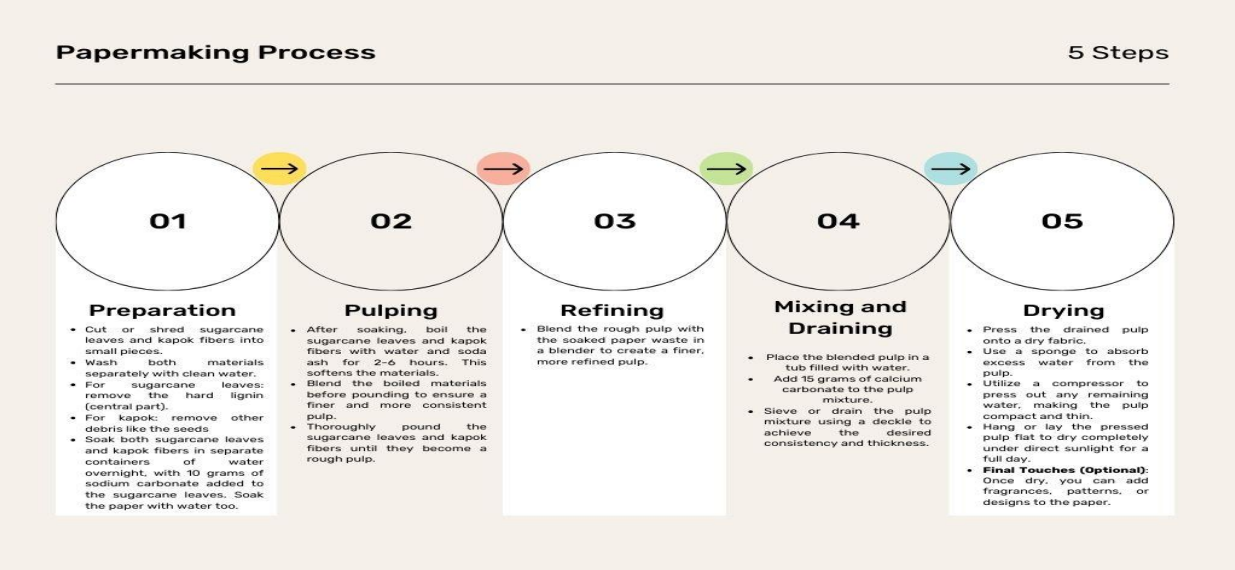
The production of a quality paper bag relies on the process of making the paper and the raw materials used. In this study, the process will be following a handmade method of creating paper thus the process is made simple. A sustainable process may be of help with improving the production of paper with the aim of both catering to the needs of humans and at the same time, protecting the environment.

Instruction:

1. **Preparation:**
    - Cut or shred sugarcane leaves and kapok fibers into small pieces.
    - Wash both materials separately with clean water.
    - For sugarcane leaves: remove the hard lignin (central part).
    - For kapok: remove other debris like the seeds
    - Soak both sugarcane leaves and kapok fibers in separate containers of water overnight, with 10 grams of sodium carbonate added to the sugarcane leaves. Soak the paper with water too.
2. **Pulping:**
    - After soaking, boil the sugarcane leaves and kapok fibers with water and soda ash for 2-6 hours. This softens the materials.
    - Blend the boiled materials before pounding to ensure a finer and more consistent pulp.
    - Thoroughly pound the sugarcane leaves and kapok fibers until they become a rough pulp.

3. **Refining:**
    - Blend the rough pulp with the soaked paper waste in a blender to create a finer, more refined pulp.
4. **Mixing and Draining:**
    - Place the blended pulp in a tub filled with water.
    - Add 15 grams of calcium carbonate to the pulp mixture.
    - Sieve or drain the pulp mixture using a deckle to achieve the desired consistency and thickness.
5. **Drying:**
    - Press the drained pulp onto a dry fabric.
    - Use a sponge to absorb excess water from the pulp.
    - Utilize a compressor to press out any remaining water, making the pulp compact and thin.
    - Hang or lay the pressed pulp flat to dry completely under direct sunlight for a full day.
6. **Final Touches (Optional):**
    - Once dry, you can add fragrances, patterns, or designs to the paper.

Exhibit 2.0 Papermaking Process Flow Chart



Under is the provided table for the specific quantities used in each step. Through the formulation listed, the researchers were able to make 8-12 papers with sizes 12x13 inches depending upon the thickness of the pulped paper.

Table 6.0 Formulation of the Paper (per batch)

Materials	Quantity
Kapok Fibers	100 g
Paper Wastes	400 g
Sugarcane Leaves	300 g
Calcium Carbonate	15 g
Sodium Carbonate	10 - 15 g (in every boiling and soaking)

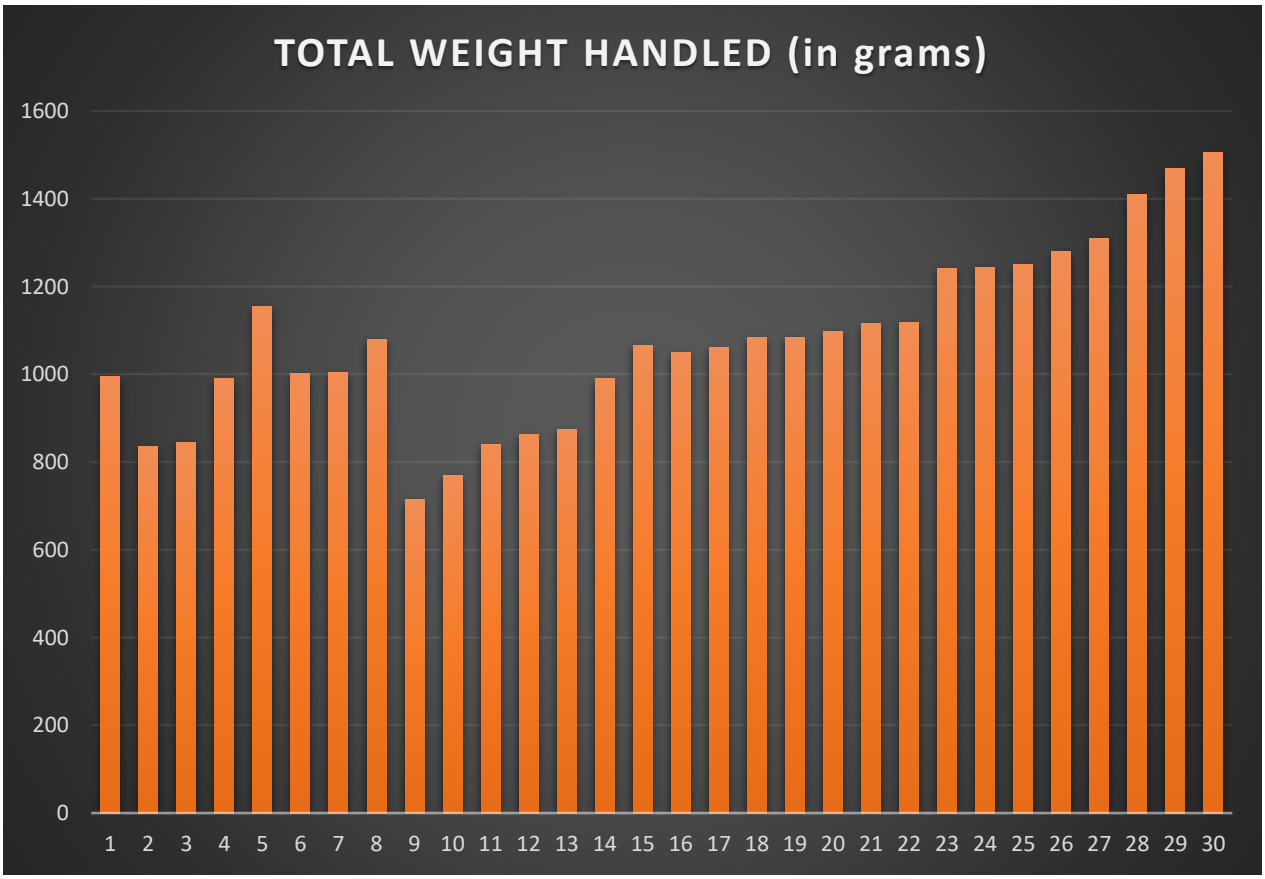
Testing

In this part, the quality of the paper will be determined. In testing the quality, the researchers use the following testing methods:

1. SIMPLE LOAD/STRENGTH TEST.

To test the paper bags' capability to handle the weight without breaking and to determine the overall weight it can carry, the researchers will use the sandbag method on it in different sizes and weights and measure the total kilograms by a "hanging" scale. This will determine the optimal weight limit that the formulated 6x9 inches of paper bag can carry.

Exhibit 3.0 Load/Strength Test



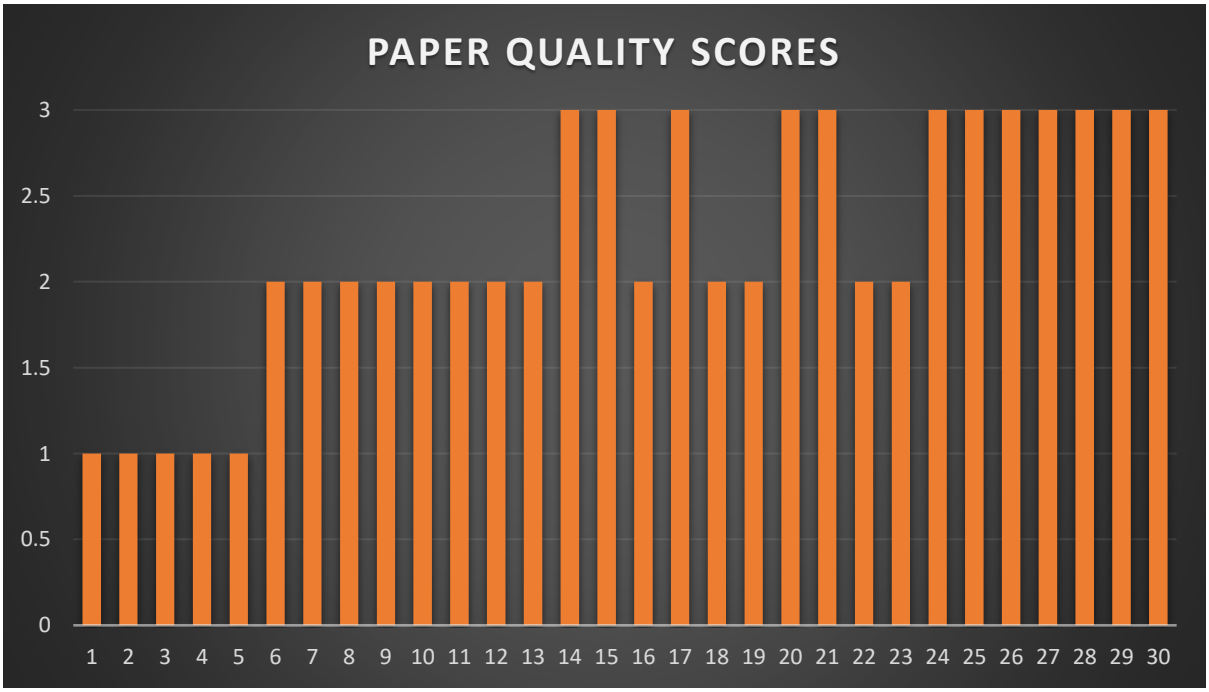
This analysis examines the load strength of paper samples tested in 30 paper samples and their capacity to handle weight. The data reveals variations in the weight each sample could withstand before breaking. Trial 30 stands out with the highest load strength, handling a maximum weight of 1505 grams. Conversely, Trials 9 exhibit the least weight handles of 715 grams.

2. SIMPLE VISUAL TEST

Assessing the factors that compose the visual appearance is crucial in determining the quality and effectiveness of the paper bag. The appearance of a paper bag and its parts will be assessed through two tests which are the paper quality test and the glue application test.

- Paper Quality depends on its thickness and appearance

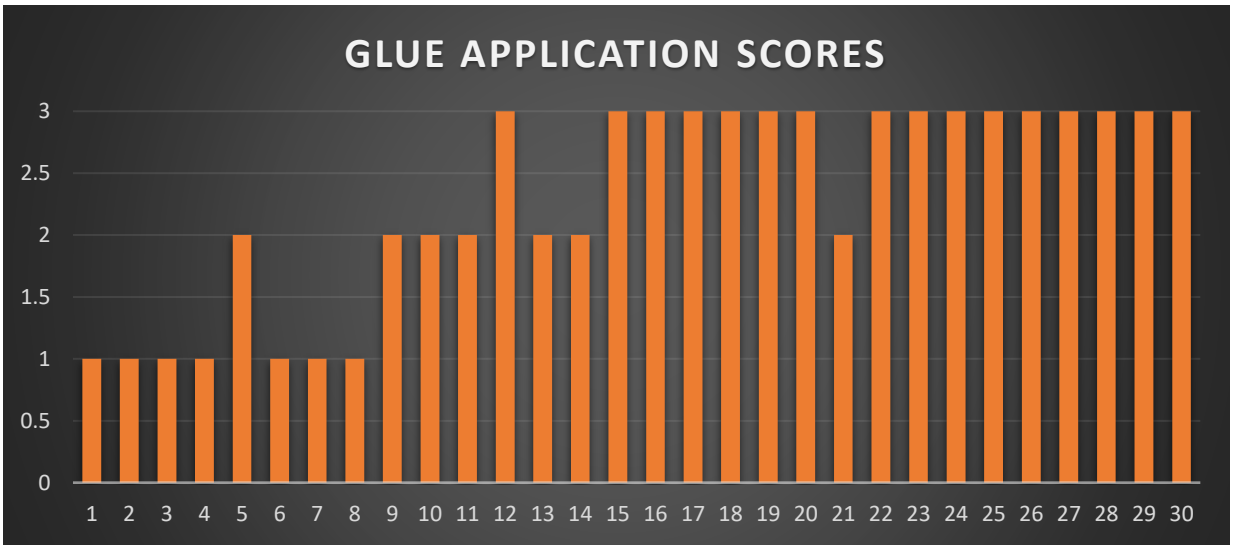
Exhibit 4.0 Paper Quality Test



Among the 30 papers, the data shows that 5 samples received a score of 1 (thin and flimsy), 13 samples scored 2 (moderate), and 12 samples scored 3 (thick and sturdy). This distribution indicates that a significant portion of the paper samples (12 out of 30) had a quality considered thick and sturdy, while fewer samples fell into the thin and flimsy category (5 out of 30).

- Glue Application depends on the integrity of the glued paper

Exhibit 5.0 Glue Application Test



This analysis examines the quality of glue application in 30 samples. Over half of the samples (16 out of 30) received a score of 3, indicating good application quality. However, a significant number (7 samples) received a score of 1 and another 7 papers received a score of 2.

Overall, the 6x9 inches paper bag can carry a mean weight of 1078 grams with the highest weight carried of 1505 grams, which indicates their potential to carry moderate to heavy loads. The mean score of the paper quality is 2.23 which falls around the moderate score of 2 which means that the paper has above moderate thickness and has minimal bumps. The standard deviation

of 0.727932 indicates a moderate level of dispersion in the quality ratings. This implies that some samples received scores closer to either end of the scale (1 or 3) compared to the average value. Meanwhile, the glue application mean score of 2.30 also falls in the score of 2 which means that the glue applied to the samples has uniform applications with minimal imperfections. The standard deviation of 0.83666 indicates a moderate level of dispersion in the quality ratings. This implies that some samples received scores closer to either end of the spectrum (1 or 3) compared to the average value.

The analysis of three key tests – load/strength, paper quality, and glue application – reveals a concerning trend of moderate data variation across all samples. Notably, the low weight handled in the first half of the load/strength test suggests a significant portion of samples might not withstand intended weight loads. Furthermore, a strong correlation emerges between low paper quality scores (particularly thickness) and reduced load-bearing capacity in these samples. This indicates that paper thickness plays a crucial role in determining the strength of the final product. Similarly, the observation that samples with optimal glue application (score of 3) performed well in handling weight underscores the importance of proper adhesion for overall bag strength. Inconsistent glue application could lead to tearing or bag failure under stress.

Meanwhile, the root causes of the variations of data can be traced in the pulping process, sieving technique, and other factors. The pulping process, specifically the degree of fiber refining, is a potential culprit. Under-refined fibers might create a weaker paper structure, impacting both thickness and strength. Additionally, differences in the sieving technique using the deckle can affect fiber distribution and paper quality. Uneven distribution could lead to inconsistencies in

thickness and ultimately, variations in strength. Beyond these factors, grammage (paperweight), moisture content, and the presence of additives may also contribute to the observed variations.

Revisions/Improvements

Hereunder were the revisions or improvements made to enhance the quality of the paper bag. The revisions made are the following:

1. Soak the leaves and fibers overnight with sodium carbonate and cook it the next day with the same amount of sodium carbonate to form a good texture of pulp.
2. Boil the raw materials for a minimum of 2 hours and a maximum of 6 hours.
3. Blend and beat the kapok with the sugarcane leaves to incorporate it together since it is difficult to blend it alone.
4. Beat the raw materials after cooking and before blending.

CHAPTER III

SUMMARY OF FINDINGS, CONCLUSION, AND RECOMMENDATIONS

Summary of Findings

The following were the summary of findings of the study:

1. A sustainable paper bag is made of sugarcane leaves, the fibers from kapok trees, and even paper wastes are all given a new life. The researchers have meticulously formulated a handmade process that minimizes the use of chemicals with renewable materials and compostable products. This eco-friendly approach not only reduces waste but also transforms it into a sustainable packaging solution.
2. This investigation explored the use of agricultural waste products, such as sugarcane leaves and kapok fibers, alongside recycled paper waste, as sustainable raw materials for paper production. Incorporating together the raw materials used in making the paper, sugarcane leaves, kapok fibers, and paper wastes, are effective raw materials in paper making. The calcium carbonate acts as an internal sizing during the sifting process of the pulp. However, the attempt to employ soy wax as a water-resistant coating proved unsuccessful due to its strong odor, which could potentially permeate stored items, and its detrimental impact on the paper's aesthetics.
3. The raw materials undergo 6 steps in papermaking process which are; preparation, pulping, refining, mixing and raining, and drying. Each step has corresponding actions which are important in making the paper.

4. Paper is produced in batches with a specific formulation for each batch. The formulation uses 100 grams of kapok fibers, 400 grams of paper waste, and 300 grams of sugarcane leaves. Additionally, 15 grams of calcium carbonate is added, and 10 to 15 grams of sodium carbonate is used during each soaking and cooking step for the raw materials**.** The formulation mentioned above is the quantity of rough pulp before the main pulping process and it can make up to 8 to 12, each measuring 12 inches by 13 inches. The final number of sheets depends on the thickness of the wet paper after sieving.
5. Kapok fibers are naturally water-resistant and have long fibers. This makes them difficult to blend on their own. They require mixing with sugarcane leaves for easier pulping. Additionally, kapok fibers need longer cooking times to break down their fibers effectively.
6. The longer the cooking process, the better for the raw materials to be pulped. Cooking sugarcane leaves takes 2 or more hours to break its fibers. The hard lignin in its middle is also removed since it is too hard to break and beating it manually is difficult and time-consuming. Nevertheless, sugarcane leaves form a good-quality pulp when pulped properly.
7. Tools used in papermaking are deckle, large basin, blender/food processor, fabric, scissors, compressor, and water sponge.
8. The total cost for producing the paper is Php697.00. Since every batch can make 8 to 12 papers and the paper bag made used two 12x13 inches papers, the total papers made for this research are 60 pieces. The cost of a 6x9 inch paper bag made from this process is estimated to be between Php11.62 and Php12.00, based on the total cost. The mentioned total cost excludes labor costs and readily available tools like blenders, compressors, basins, and scissors. The raw materials used were also donated resources from the researchers' area and not purchased specifically for this research.

9. Tests revealed promising results for the 6x9-inch paper bags. These bags achieved an average weight capacity of 1078 grams, with the strongest bag holding up to 1505 grams and the lowest at 715 grams. This suggests they are capable of carrying moderate to even heavy loads. Further analysis of the paper quality indicated a moderate thickness (score of 2.23) with minimal surface imperfections (bumps). Additionally, the glue application received a score of 2.30, signifying a generally uniform application with minimal flaws.
10. Number of improvements are made I order to achieve the best process in making the paper and these are; soak the leaves and fibers overnight with sodium carbonate and cook it the next day with the same amount of sodium carbonate to form a good texture of pulp, boil the raw materials for a minimum of 2 hours and a maximum of 6 hours, blend and beat the kapok with the sugarcane leaves to incorporate it together since it is difficult to blend it alone, beat the raw materials after cooking and before blending.

Conclusion

In conclusion, kapok fibers, paper wastes, and sugarcane leaves can be potential materials for pulping and can be incorporated together to make paper. In this study, the papers are made through different sessions or batches specifically with formulations composed of 15% kapok fibers, 40% paper wastes, 30% sugarcane leaves, and 15% calcium carbonate. Thus, the paper wastes are of larger amount since it is used as a binding agent for the other raw materials. This formulation may also vary on the availability of resources and tools and can also be altered or doubled with the same percentage amount.

This project offers a two-fold environmental solution. Firstly, it reduces plastic use, a major contributor to pollution. Secondly, it utilizes readily available local resources that would otherwise go to waste: sugarcane leaves (often considered useless), underutilized kapok fibers, and leftover paper scraps. By transforming these materials into new, sustainable paper products, this innovation promotes environmental protection and introduces a locally sourced alternative for packaging and storage needs. This approach not only benefits the environment but also stimulates the local economy by utilizing readily available resources within the municipality.

Overall, this research demonstrates the promise of utilizing agricultural waste and recycled paper to create sustainable paper bags. Further development and optimization hold the potential to create a cost-effective and environmentally friendly alternative to traditional paper bags.

Recommendations

Based on the findings and conclusion of the present study, the following recommendations are hereby proposed.

1. For larger production of paper, the researchers recommend using machines that are suitable for papermaking that can be used during the pulping process. Beating and blending equipment are necessities of papermaking for efficiency and effectiveness.
2. Variations of sizes bigger than 6x9 inches paper bags can also be produced and tested.
3. Enhance the formulation of the raw materials during the papermaking process for bigger production of paper or paper bags.
4. Assess the water resistant of the paper.

5. For a more appealing appearance of the paper, it is recommended to use dye to color it.
6. The paper formulated in this study, especially the texture quality, can still be enhanced by further research.

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DOCUMENTATION

This picture is taken during our first meeting and planning of what product we need to innovate. We also start working on our chapter 1 and assigning of different tasks.

In this picture we are preparing our raw materials and this involves cleaning it and washing.

This is the rough pulp of kapok fibers, cut and shredded to small pieces.

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This is the pulped sugarcane leaves with kapok fibers. They are mixed together to be incorporated effectively.

This is the blending process of the raw materials after they are cooked and pounded.

This is the sieving process of the pulped raw materials.

This part is transferring the sieved wet paper to a cloth for pressing and drying.

This part is the drying of the papers under the sun.

The papers are already dry and now ready to be folded, glued, and handles ready to be put. Photo on the left is the finished product.

This is the picture of the researchers after the research defense together with the course adviser, Dr. Carlito A. Acabal and the panelists, Mrs. Glady Mae A. Erida and Mr. Cocon B. Rusiana Jr.

CURRICULUM VITAE

PERSONAL INFORMATION

Full name : Karl E. Awit

Nick name : "Karl"

Address : Lumbangan Mabinay Negros Oriental

Date of Birth : May 18, 2003

Place of Birth : Mabinay Medicare Community Hospital, Mabinay Negros Oriental

Father : Judy Cruz R. Awit

Mother : Ma. Melionie E. Awit

Name of Siblings : 1

Religion : Roman Catholic

Sex : Male

EDUCATIONAL ATTAINMENT:

Elementary : Lumbangan Central School

Secondary : Bais City National High School

Tertiary : Bachelor of Science in Business Administration at NORSU Mabinay Campus

WORK EXPERIENCE:

PERSONAL INFORMATION

Full name : Melchizedek Cadano

Nick name : "Milky"

Address : Lumbangan, Mabinay Negros Oriental

Date of Birth : April 26, 2002

Place of Birth : Tayawan, Bayawan City Negros Oriental

Father :

Mother : Nelia K. Cadano

Name of Siblings : 2

Religion : INC

Sex : Female

EDUCATIONAL ATTAINMENT:

Elementary : Mabinay Central School (2013-2015)

Secondary : Mabinay National High School (2015-2021)

Tertiary : Bachelor of Science in Business Administration at NORSU Mabinay Campus

PERSONAL INFORMATION

Full name : Jenny Rose Liniojan Martinez

Nick name : "Jenny"

Address : Purok 3, Lumbangan, Mabinay, Negros Oriental

Date of Birth : October 26, 2003

Place of Birth : Dumaguete City, Negros Oriental

Father **:** Jonathan E. Martinez (deceased)

Mother **:** Roche L. Martinez

Name of Siblings **:** Jeiane L. Martinez

Jea L. Martinez

Religion **:** Roman Catholic

Sex **:** Female

EDUCATIONAL ATTAINMENT:

Elementary : Lumbangan Central School

Secondary : Santo Nino High School

Tertiary **:** Bachelor of Science in Business Administration at

NORSU Mabinay Campus

EXPERIENCES:

Sales Person – Princess Mae Eatery, 2020-2021

Associate Editor – The Norsunian Mabinay 2022 - Recent

Freelance Artist – 2019 - recent

PERSONAL INFORMATION

Full name : Shecaynarose A. Romano

Nick name : "khai''

Address : Bato, Mabinay Negros Oriental

Date of Birth : March 26, 2002

Place of Birth : Bato, Mabinay Negros Oriental

Father : Celito D. Romano

Mother : Roselyn A. Romano

Religion : Roman Catholic

Sex : Female

EDUCATIONAL ATTAINMENT:

Elementary : Bato Elementary School

Secondary : Mabinay National High School

Tertiary : Bachelor of Science in Business Administration at NORSU Mabinay Campus

PERSONAL INFORMATION

Full name : Mary Claire B. Serveza

Nick name : "Claire''

Address : Barras, Mabinay Negros Oriental

Date of Birth : December 31, 2002

Place of Birth : Arebasore, Mabinay Negros Oriental

Father : Ronnie E. Serveza

Mother : Jenica B. Serveza

Religion : Roman Catholic

Sex : Female

EDUCATIONAL ATTAINMENT:

Elementary : Barras Elementary School

Secondary : Mabinay Nationa High School

Tertiary : Bachelor of Science in Business Administration at NORSU Mabinay Campus

EXPERIENCE:

Pharmacies Assistant – Taring's Pharmacy (2019-2020)