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Jute *(Corchorus capsularis)* Mucilage and Cassava *(Manihot esculenta)* Peel Starch as an Organic Glue

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Abstract: The study focused on the preparation and evaluation of the effectiveness of the organic glue from jute mucilage and cassava peel starch as an adhesive for different types of paper such as bond paper, art paper and glossy paper. Descriptive-comparative and experimental methods of research were used, with data analyzed using Weighted mean, One-Way ANOVA and Scheffe Test. Findings showed that Jute leaves extract contained cellulose, hemi-cellulose, lignin and fat and wax, while cassava peel extract contained Starch, carbohydrates, protein and fats. The organic glue was formulated in three variations: Formulation 1 (10 ml jute leaves and 30 ml cassava starch), Formulation 2 (20 ml jute leaves and 20 ml cassava starch), and Formulation 3 (30 ml jute leaves, 10 ml cassava starch). The preparation involved decoction, straining, packaging, and labeling. The formulation with a greater percentage of cassava peel starch was more effective than the formulation with higher percentage of jute mucilage; thus, Formulation 1 is considered as the most effective organic glue to the three types of paper such as bond paper, art paper and glossy paper. The study concluded that Jute mucilage and Cassava peel starch as an organic glue is effective and beneficial for educational use. Moreover, it provides an opportunity for everyone to opt in using natural products instead of synthetic ones; offers a healthier, cost effective and readily available adhesive especially for educational use; and can also serve as a potential source of income for the household.

Keywords: *Jute mucilage, Cassava Peel Starch, Organic glue*

I. INTRODUCTION

Agriculture is one of the primary sources of income in the Philippines and a sector that contributes to the country's high level of biodiversity. Different kinds of crops, fruits, and vegetables are planted by farmers in rural areas to supply food to urban markets, and in exchange, they earn profit necessary for their daily living. Creating and transforming natural resources into useful products is very important and beneficial for those who want to be thrifty by avoiding the purchase of commercial or synthetic products in order to save money.

In connection with this, solid waste management remains a major challenge in the Philippines, especially in urban areas. Improper waste disposal, inefficient waste collection, and lack of disposal facilities are among the dominant concerns in the country's solid waste management. Unless these are addressed, the waste generated from various sources will continually lead to health hazards and serious environmental impacts such as ground and surface water contamination, flooding, air pollution, and the spread of diseases.

Similarly, urban solid waste management is considered one of the most immediate and serious environmental problems in many developing countries. Environmental degradation is worsened by the escalating accumulation of solid waste improperly disposed of in various areas. Solid waste pertains to all unnecessary materials coming from households, institutions, farms, and industries. It has become a persistent problem in rapidly urbanizing communities due to improper practices in segregation, collection and transport, disposal, and recycling. Dumping of solid waste has exacerbated the effects of rains, typhoons, and storms, resulting in obstructed water flows and flash floods.

The SDG 12 Action 43699 of the United Nations Department of Economic and Social Affairs (2015), which promotes zero waste, defines it as a waste management philosophy involving the prevention of waste generation, efficient use of resources, examination of the causes of waste formation, and the collection and recovery of waste at the source. Formulating organic glue from jute mucilage and cassava peel starch aligns with SDG 12, as it not only provides an eco-friendly alternative to conventional adhesives but also contributes to reducing agricultural waste, encourages the recycling and reuse of local resources, and promotes sustainable practices within the community.

Moreover, cassava peels are considered solid waste. Cassava is often seen as a low-quality raw material but can be processed to produce dried cassava chips, starch, ethanol, liquid sugar, sorbitol, monosodium glutamate, and modified cassava flour, as it contains low amounts of proteins, minerals, and vitamins. However, among various types of starches, cassava peel starch is advantageous because of its paste clarity, low gelatinization temperature, good gel stability, and excellent film-forming properties. Films produced from cassava peel starch are more flexible than those formed by other starches (Xu et al., 2016).

Thus, cassava peel starch extract was utilized in this study as one of the main ingredients in preparing the organic glue. Extracting cassava peel through the process of decoction is one of the most effective ways of recycling and responds to Republic Act No. 9003 Article I, Section 2 (b), also known as the "Ecological Solid Waste Management Act of 2000," which states that:

"Set guidelines and targets for solid waste avoidance and volume reduction and waste minimization measures, including composting, recycling, re-use, recovery, green charcoal process, and others, before collection, treatment and disposal in appropriate and environmentally sound solid waste management facilities in accordance with ecologically sustainable development principles"

Also, Republic Act No. 9512, Section 2, also known as the National Environmental Awareness and Education Act of 2008, aims "to promote national awareness on the role of natural resources in economic growth and the importance of environmental conservation in the context of sustainable development." The act also encourages schools and academic institutions to become more actively involved in environmental issues at both practical and local levels (GOVPH). Thus, developing an organic glue that is naturally made, health-beneficial, sustainable, and eco-friendly is an active response to this call.

Cassava is a vital food security crop because it is reliable, producing life-sustaining yields even under unfavorable climatic conditions that cause cereal and crop failures. It is an important staple food in the tropics, providing a cheap source of dietary carbohydrate energy. Cassava is not only used for human consumption, it can also serve as animal feed, traditionally in the form of peels.

On the other hand, cassava starch, which is readily available, has been used to produce non-structural adhesives and may serve as a cost-effective and accessible alternative, thus saving industries from spending foreign exchange on imported adhesives. Cassava starch possesses enormous potential as a versatile and eco-friendly material that extends beyond its primary use in the food industry. Despite its widespread applications in the textile, pharmaceutical, and cosmetics sectors, the wood and lignocellulose industries have yet to realize cassava starch's full potential.

Another material that can be used in formulating adhesive glue is jute. Many people believe that jute is commonly used only for cooking and medicinal purposes, not knowing its essential benefits in making organic glue. Jute mucilage, as a natural plant extract, can be a key ingredient in developing organic adhesives because of its sticky characteristics. Jute is an edible leafy vegetable belonging to the genus Corchorus. It is widely found in tropical and subtropical areas in Asia, such as the Philippines. It is a nutritious plant that can grow easily and requires low maintenance.

Furthermore, jute leaves contain mucilage. According to Songmin Oh (2022), mucilage is a water-soluble biopolymer with high water-holding capacity. Structurally, it is a highly branched polysaccharide composed of various sugars and uronic acid molecules. The utilization of mucilage is highly dependent on its unique functional properties and bioactive roles of mucilage are notable. The emulsifying and rheological properties, as well as its strong suspending ability, are due to its capacity to form colloidal liquid systems and hydrogels. The viscosity of the gel can affect the texture of the product. Therefore, mucilage can be used as a food additive such as a thickener, binder, emulsifier, emulsion stabilizer, film-forming agent, and gelling agent.

Even though most adhesives are not entirely unsafe to use, there are still associated risks and potential health hazards. This remains one of the biggest limitations of today's adhesives, which have undergone constant innovation and synthesis over the years. This research may pave the way for creating a chemical-free, organic, and natural substance that can replace commercial glues.

This study, which focuses on creating and transforming jute mucilage and cassava peel starch extract into organic glue, aims to demonstrate that nature offers alternative resources for producing natural adhesives. This can be valuable for those who lack access to basic school supplies and require materials for academic activities. In addition, the product developed is environmentally friendly, being non-toxic and biodegradable. The purpose of the study was to create a natural glue and to offer solutions to the issues of expensive commercial adhesives, health hazards, and pollution. Likewise, the study also aims to provide knowledge and potential additional income to the residents of Barangay Busing, San Pascual, Masbate, by utilizing raw materials such as jute leaves and cassava peel starch, both of which are abundantly available in the locality. These materials can serve as an alternative adhesive for educational purposes, ultimately benefiting learners in the community.

II. MATERIALS AND METHODS

Raw Materials: Jute leaves and cassava peels were used and were collected from Barangay Busing, San Pascual, Masbate.

The study utilized descriptive-comparative and experimental methods of research. The descriptive method was used to determine the phytochemical properties of jute mucilage and cassava peel starch, the stages in preparing the organic glue, the different formulations, its effectiveness as an adhesive on various types of paper such as bond paper, art paper, and glossy paper and its educational implications. The comparative method was used to determine the differences among the three formulations. The experimental method was employed to develop the organic glue using jute mucilage and cassava peel starch with varying formulations in order to identify the most effective and highest quality organic glue. The study was conducted at Busing Integrated School in Busing, San Pascual, Masbate, during School Year 2023–2024. It involved thirty (30) individuals from the school, including elementary students and both elementary and secondary teachers, who served as evaluators to determine the glue's effectiveness. Evaluation sheets were distributed to assess the level of effectiveness of the organic glue and the data were statistically analyzed using weighted mean, one-way ANOVA, and Scheffe test.

III. RESULTS AND DISCUSSION

The continuous rise in the production and use of commercial synthetic glue products along with their side effects and high cost has led to increased interest in exploring traditional plants as sources for eco-friendly organic adhesives. The quantitative phytochemical composition of jute leaves is presented in Table 1, and that of cassava peels is shown in Table 2.

Table 1
Phytochemical Properties of Jute Leaf Extract

Phytochemical Properties	Percentage
Cellulose	65.2
Hemi-cellulose	22.2
Lignin	10.8
Fats and Wax	0.3

(Source: International Journal of Research and Analytical Reviews, June 2019)

Table 2
Phytochemical Properties of Cassava Peel Extract

Phytochemical Properties	Percentage
Starch	121.45
Sugar	5.13
Protein	1.12
Fats	0.41

(Source: The International Journal of Integrated Engineering, May 2020)

Stages in the Preparation of the Organic Glue

The process of making organic glue from jute mucilage and cassava peel starch, along with sample preparation, is summarized below. It includes the gathering of raw materials, preparation of tools and equipment, extraction through decoction, straining of jute leaves, incorporation of other ingredients, and finally, packaging.

Gathering of the Raw Materials. Both young and mature jute leaves and cassava peels were collected. They were washed thoroughly in salt water to remove dirt and unwanted particles. Glycerin was also prepared to be used as an emulsifier.

Preparation of the Tools and Measurement of Ingredients. All materials, tools, and equipment were prepared, including measuring cups and spoons for precise measurements, a digital weighing scale for accuracy, a blender to crush and grind the peels, a mesh strainer, a pot for boiling, a stove for heat, and bottles for storage. The preparation for extraction included weighing the exact amount of jute leaves and cassava peels needed for each formulation. The cassava peels were ground using a blender and set aside for decoction.

Extraction Method through Decoction. The extraction process began with blending the cassava peels to obtain the starch extract. The jute leaves were then placed in a pot with heated water and simmered for 20 minutes over medium heat to extract the mucilage. This process ensures the thorough extraction of the chemical properties of the jute leaves and cassava peel starch.

Straining the Jute Leaves. After decoction, the jute leaves were strained using a mesh to obtain the mucilage. Straining is crucial to remove plant residues and produce a pure solution.

Incorporating Other Ingredients. After straining, other ingredients such as cassava peel starch, leftover rice, and glycerin were added. Leftover rice served as an additional starch source to improve the texture of the organic glue, while glycerin acted as an emulsifier. The proportions of jute mucilage and cassava peel starch were adjusted to achieve the desired consistency of the organic glue.

Packaging. Once all ingredients were incorporated and the desired consistency was achieved, the mixture was poured into small containers and set aside to cool and solidify. Labels were also provided and attached to the small bottles for identification of the different formulations of the organic glue. Lastly, improvements in the packaging and presentation of the sample product were implemented.

Based on the results, it can be deduced that the steps involved in the preparation of organic glue from jute mucilage and cassava peel starch, as well as the accurate measurement of ingredients, must be strictly followed to achieve optimal results. Since the organic glue was designed to have the proper texture derived from the mucilage and starch, the process of determining the ideal proportions was conducted repeatedly to produce a consistent and effective final product.

These findings are consistent with the study of McKeag (2017), who emphasized that toxicity, hazardous incompatibility, equipment safety, and even flammability are primary considerations for manufacturing companies in the production of adhesives or glues. These factors affect not only human health but also nearby communities. Thus, this study was conducted to produce a natural, organic glue from waste cassava peel starch and jute mucilage. Furthermore, according to Gebremedhin (2017), the preparation of adhesives from natural products is essential and efficient in our daily activities and plays a particularly important role in school-related applications.

The development of jute mucilage and cassava peel starch as an organic glue aligns with the Production Theory of Dr. Shehzad Inayat, as cited by Dorfman (2015), which states that economic processes occur through the conversion of inputs into outputs, using resources to create goods or services for local and international exchange. The transformation of natural materials like jute mucilage and cassava peel starch into organic glue exemplifies a productive activity consistent with this theory.

Different Formulations of the Organic Glue

Three different formulations were developed and tested in this study. Several trial formulations were carried out to achieve the most effective version of the organic glue. Table 3 presents the percentage composition of each formulation:

Table 3
Different Formulations of the Organic Glue

Ingredients	Formulations		
	1 (25/75)	2 (50/50)	3 (75/25)
Jute Mucilage	10 ml	20 ml	30 ml
Cassava Peel Starch	30 ml	20 ml	10 ml
Glycerin	5 ml	5 ml	5 ml
Left over rice	2 g	2 g	2 g

Level of Effectiveness of the Organic Glue

Formulation 1, when applied to bond paper, art paper, and glossy paper, obtained mean scores of 3.76, 3.60, and 3.43, respectively resulting in an overall mean of 3.60. These scores were interpreted as "very highly effective" and ranked first. Similarly, Formulation 2 was also found to be very highly effective as an adhesive for bond paper (3.63), art paper (3.40), and glossy paper (3.33), with an overall mean of 3.45, placing it in rank 2. However, Formulation 3 received mean scores of 3.13 for bond paper, 2.83 for art paper, and 2.80 for glossy paper, with an overall mean of 2.92. This was interpreted as "highly effective" and ranked third.

Based on the results, it can be implied that the most potent adhesive effect was achieved by Formulation 1 (25/75 ratio), which contains 10 ml of jute mucilage, 30 ml of cassava peel starch, 2 g of leftover rice, and 5 ml of glycerin. Formulation 2 (50/50 ratio), consisting of 20 ml of jute mucilage and 20 ml of cassava peel starch (with the same amount of rice and glycerin), came in second. Formulation 3 (75/25 ratio), containing 30 ml of jute mucilage and 10 ml of cassava peel starch, ranked last despite having the same amounts of leftover rice and glycerin.

It can be further inferred that higher cassava peel starch content contributes significantly to the adhesive strength, as shown in Formulation 1. Conversely, Formulation 2 with equal parts jute mucilage and cassava peel starch also showed promising results and may still be a viable formulation for use as an adhesive on different types of paper. Formulation 3, which contains a higher amount of jute mucilage, can still be used as an adhesive, but it is less effective compared to Formulations 1 and 2, particularly when used on art paper and glossy paper. Thus, based on the data presented, the overall effectiveness of the organic glue depends on the synergistic balance of jute mucilage, cassava peel starch, leftover rice, and glycerin. The proportion of each component directly influences the adhesive strength and consistency of the formulation. Jute leaves and cassava peel extract contain phytochemical properties that demonstrate adhesive capabilities when applied to different types of paper, such as bond paper, art paper, and glossy paper.

Table 4
Level of Effectiveness of the Organic Glue

Kinds of Paper	Formulations		
	1 (25/75)	2 (50/50)	3 (75/25)
Bond Paper	3.76 (VHE)	3.63 (VHE)	3.13 (HE)
Art Paper	3.60 (VHE)	3.40 (VHE)	2.83 (HE)
Glossy Paper	3.43 (VHE)	3.33 (VHE)	2.80 (HE)
Overall Mean	3.60 (VHE)	3.45 (VHE)	2.92 (HE)
Rank	1	2	3

Legend:

RANGE	*Scale*	*Verbal Interpretation*	*Rubrics*
3.26-4.00	*4*	*Very Highly Effective (VHE)*	*The paper was glued within second*
2.51-3.25	*3*	*Highly Effective (HE)*	*The paper was glued within a minute.*
1.76-2.50	*2*	*Moderately Effective (ME)*	*The paper was slightly glued.*
1.00-1.75	*1*	*Fairly Effective (FE)*	*The paper was not glued at all.*

CONCLUSIONS

Jute leaves and cassava peel extract contain phytochemical properties that demonstrate adhesive capabilities when applied to different types of paper, such as bond paper, art paper, and glossy paper. Three stages were followed in the preparation of the organic glue, and all formulations proved capable of producing a good-quality adhesive using jute mucilage and cassava peel starch. Among the three formulations, the one with a greater percentage of cassava peel starch demonstrated higher effectiveness than those with a higher proportion of jute mucilage. Thus, Formulation 1 is considered the most effective for use on all three types of paper. Overall, organic glue made from jute mucilage and cassava peel starch was found to be both effective and beneficial, particularly for educational purposes.

RECOMMENDATIONS

The study recommends exploring additional ingredient combinations and refining preparation techniques to further improve the odor, color, and viscosity of the organic glue. It is also advised to store the product in a cool, low-temperature environment, and consider the use of organic preservatives to extend its shelf life.

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