Utilizing Cucurbita moschata Duch. (Winter Squash) Fruit Peels as a Viable Component of Paper

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Abstract: Cucurbita moschata Duch., more commonly known as winter squash, is economically and globally important. However, given that one-third of the food made for human consumption is wasted and never consumed, this fruit is not being utilized to its full potential. As the main component of fruit-based papers such as bananas, coconuts, and corn, winter squash is rich in soluble and insoluble fiber. To resolve the 12th United Nations Sustainable Development Goal: Responsible Consumption and Production, the effectiveness, durability, tensile strength, and biodegradability of winter squash peels as the main component of homemade paper production were investigated. The produced paper underwent 20 trials of tensile strength test, scratch test, and soil burial test using an experimental research design. It was only able to pass the tensile strength test. In contrast, it failed in terms of durability and biodegradability, possibly due to the limited testing procedures and allotted time for testing. Therefore, the utilization of winter squash in paper production was ineffective in terms of the criteria mentioned above and needs further research to be classified as a practical alternative paper component.

Key Words: Cucurbita moschata Duch.; paper; tensile strength; durability; biodegradability

1. INTRODUCTION

1.1 Background of the Study

Ever since the invention of paper, it has been used for various purposes throughout history. Paper has developed into different forms. For instance, according to Aithal (2016), it began as clay tablets for record-keeping in Mesopotamia, which evolved to papyrus—a smooth, flexible aquatic plant that can sustain ink—found in the Nile River, Egypt. The Chinese also had their alternative for papyrus, namely bamboo books, which were just as convenient. Since paper is a multipurpose material, it is commonly and frequently used by almost everyone. The World Counts (2020) states that two to three kilograms of trees are needed for one kilogram of paper. Therefore, the increase in paper production subsequently causes an increase in deforestation. As an alternative to using trees, different waste products can be used to manufacture paper that can alleviate the effects of 1.3 billion tons of food waste and 60% yearly fruit and vegetable waste, as David et al. (2019) stated. Furthermore, the Philippines is the 16th producer of winter squash globally and can produce over 247,759 metric tons each year (Tepper, 2013).

1.2 Statement of the Problem

How can squash peels be utilized to create an effective alternative for paper?

A. What is the tensile strength of the homemade paper made from squash peels?
B. What is the durability or stability of the homemade paper made from squash peels?
C. What is the biodegradability and decomposition of squash peel paper?

1.3 Hypothesis

H01: Squash peels are not effective ingredients of durable paper.
Ha1: Squash peels are effective ingredients of durable paper.
H02: The homemade paper will have a tensile strength of less than 3.6 Pa.
Ha2: The homemade paper will have a tensile strength of 3.6 Pa or more.
H03: The homemade paper will be able to endure less than forty-six (46) trials of being written.
Ha3: The homemade paper will be able to endure forty-six (46) or more trials of being written.
H04: The homemade paper will not show signs of decomposition after ten days buried in the soil.
Ha4: The homemade paper will show decomposition ten days after it is buried in the soil.

1. 4 Conceptual Framework

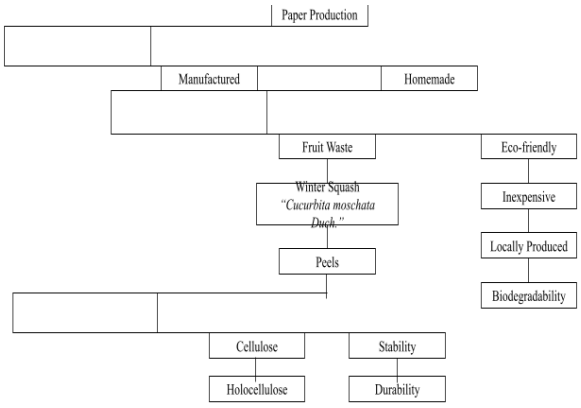

Figure 1.1 *Conceptual Framework for the Paper Production*

As shown in Figure 1.1, this research focuses on observing the paper production process in finding a suitable alternative to the ones sold on the market. The researchers decided to show the two main processes available, namely manufactured and homemade. With the homemade process being the focal point, fruit waste from winter squash, scientifically called Cucurbita moschata Duch., was used to create the alternative paper. The fruit peels of the winter squash were chosen as the paper's main component as it is biodegradable and locally produced, inexpensive, and accessible. Furthermore, winter squash peels contain cellulose and holocellulose, which are rich in fiber.

1. 5 Significance of the Study

The independent variable, winter squash fruit peels, was referred to as the essential fruit component the researchers utilized to create homemade paper. The dependent variable, viable and stable paper, was referred to as the goal end product of the whole procedure. Intervening variables, such as the paper production process, were controlled following previous studies to ensure the reliability of the research.

1. 6 Scope and Limitations

The study focused on the Cucurbita moschata Duch. (winter squash) that is locally available in the Philippines. To provide solutions to the Sustainable Development Goal number 12, Responsible Consumption and Production, as stated by the United Nations (2015), the researchers limited the scope to the winter squash peels. In highlighting the utilization of winter squash peels to create a paper alternative, the main argument that food waste has different and better purposes was shown.

2. METHODOLOGY

2. 1 Prototype Construction

The research utilized the following items: measuring cups, winter squash, assorted shredded recycled paper, blender, paper mold (silkscreen), and a large basin.

The first step was to blend two grams of winter squash and ½ cup of water for one-two minutes or until the winter squash was completely dissolved. Second, the mixture was poured into a bowl. Next, one cup of paper and one cup of water were blended until the form dissolved. Then, another cup of paper and ½ cup of water was incorporated until the paper broke down. After that, the winter squash mix was added and blended with everything for one to two minutes. The final mixture was poured into a large basin and, using a silkscreen, submerged into the mix. Last, it was taken out to dry.

3. DATA ANALYSIS

3.1 The Tensile Strength of Squash Peel Paper

Table 3.A *Amount of Weight the Paper Can Withstand Without Breaking Apart*

Trial Paper	Distance of the Paper (inches)	Number of Folds	Amount of Weight it can Handle (g)	Tensile Strength
1	6.5	2	64	10.81 Pa
2	6.5	3	13	2.07 Pa
3	6.5	2	26	4.14 Pa
4	6.5	2	20	3.18 Pa
5	6.5	0	32	5.09 Pa
				Mean: 5.06 Pa

The tensile strength of paper is the maximum amount of force it can withstand without tearing apart. To test the tensile strength of the paper, the assigned researcher placed the paper on top of two identical containers with a constant 6.5-inch distance in between. Through repeated experimentation, the researchers were able to gather the data shown in Table 3.A. Since the experiment was done only at home, the researchers cannot guarantee the accuracy of the data.

Figure 3.1 *The Testing of Tensile Strength*

The tensile strength of the paper was measured as the force divided by its area. The area of the paper is a constant of 8.5 inches by 11 inches, which in SI units is 0.26 meters by 0.28 meters since that was the size of the silkscreen where the paper was made. The force was measured by multiplying the mass it can handle by the acceleration due to gravity. Below were the computations.

$$s_1 = \frac{(64\ g)(9.8\ \frac{m}{s^2})}{(0.22\ m)(0.28\ m)} \qquad s_2 = \frac{(13\ g)(9.8\ \frac{m}{s^2})}{(0.22\ m)(0.28\ m)} \qquad s_3 = \frac{(26\ g)(9.8\ \frac{m}{s^2})}{(0.22\ m)(0.28\ m)}$$

$$s_1 = 10\ 181\ \text{mPa} \qquad s_2 = 2\ 068\ \text{mPa} \qquad s_3 = 4\ 136\ \text{mPa}$$

$$s_1 = 10.18\ \text{Pa} \qquad s_2 = 2.07\ \text{Pa} \qquad s_3 = 4.14\ \text{Pa}$$

$$s_4 = \frac{(20\ g)(9.8\ \frac{m}{s^2})}{(0.22\ m)(0.28\ m)} \qquad s_5 = \frac{(32\ g)(9.8\ \frac{m}{s^2})}{(0.22\ m)(0.28\ m)}$$

$$s_4 = 3\ 181\ \text{mPa} \qquad s_5 = 5\ 090\ \text{mPa}$$

$$s_4 = 3.18\ \text{Pa} \qquad s_5 = 5.09\ \text{Pa}$$

3. 2 The Durability of Squash Peel Paper

Table 3.B *The Number of Trials the Paper Withstood*

Trial Paper	Number of Trials being Written	Number of Times before it Tore
1	3	2
2	8	8
3	11	10
4	9	8
5	9	8
		Mean: 7.2

The durability of the paper is the ability to withstand pressure or damage. Using a pencil and eraser to create multiple erasures on each paper, the researchers found out how durable the papers were with how many times each paper could endure being erased in the same spot numerous times. After a repeated number of trials, the researchers gathered data written in Table 3.b from the experiment. Due to the limited number of papers used, the accuracy of the data collected is not guaranteed.

Figure 3.2 *The Scratch Test of the Paper*

3. 3 The Biodegradability of Squash Peel Paper

Table 3.C *Comparison of Paper Mass After Soil Burial*

Trial Paper	Mass Before (g)	Mass Afer 10 Days (g)
1	0.0045	0.0043
2	0.0036	0.0032
3	0.0051	0.0050
4	0.0073	0.0071
5	0.0039	0.0039
TOTAL: 5	Mean: 0.00488	Mean: 0.0047

According to Goswami & O'Haire (2016), biodegradability is the ability of a substance to degrade after interaction with biological substances. In this experiment, the researchers weighed the squash peel paper before and after being buried in the soil for over ten days. Due to the short amount of time

it was buried, the researchers did not see any substantial difference in the weight of the paper to conclude any biodegradation.

3. 4 Squash Peels as an Effective Component of Paper

Winter squash or Cucurbita moschata Duch. was used in the experiment to assess the effectiveness of the peels as a substitute ingredient for paper.

The pulp had a thick consistency and, mixed with the recycled paper, made a very effective pulp mixture. After the pulp was left to dry with the silkscreen in the sun, it became very sturdy and rigid. The results above showed that the prototype paper could not endure the amount of force. The paper did not pass the durability test. Also, evidence from a ten-day biodegradability test showed no change and insufficient evidence. Thus, the prototype passed the tensile strength test but did not pass the durability or biodegradability tests.

4. CONCLUSIONS

4.1. Conclusions

After conducting different testing procedures, particularly regarding the paper's effectiveness, tensile strength, durability, and biodegradability, the initial hypothesis of the research is not entirely accurate. The mixture obtained from the chosen ingredients was thick enough to be molded into the paper. However, it was not a practical alternative based on all three standards. With the testing of the paper's approximate ability to handle a certain amount of force and withstand tear, the paper was able to pass the test for tensile strength. Nevertheless, the paper's inability to resist progressive damages determined its durability to be below expected standards. Lack of adequate time was the main reason the research's biodegradability test had no substantial result. Therefore, the data gathered may not be reliable.

4.2 Summary

Through rigorous research and investigation of the initial research inquiries, the hypothesis that Cucurbita moschata Duch. (winter squash) fruit peels could be utilized as a viable component of paper was found to be inaccurate and false. In gathering data through the different testing procedures, the produced paper's tensile strength, durability, and biodegradability were not adequate to be used similarly to standard paper. Thus, this proved the whole research process to be unsuccessful.

4.3 Limitations

Due to the pandemic, the research was limited to being conducted within the homes of each researcher. Since the testing procedures were done in different research environments, the data from each experiment may not be as reliable as having the same research environment throughout. Moreover, the lack of proper laboratory equipment and measuring devices hindered the researchers from obtaining more accurate data. Therefore, the researchers had to utilize simple testing procedures to be quickly done within their homes.

4.4 Recommendations

It is recommended that the testing procedures be done within the same environment to rule out miscellaneous variables that may affect the experiment results. Furthermore, it is advised to utilize proper laboratory equipment and measuring devices to ensure the reliability of the data collected from the procedures. The usage of other abundant crops with more fiber and cellulose content could also be considered for its strengthening properties. If the researchers cannot follow the recommendations above, getting additional guidance and insight from professionals with expertise in the chosen field of research are recommended.

4.5 Implications

The overall result of the research can benefit future research conducted within the same field. The testing procedures and data collection process can be modified to create a variety of paper utilizing locally available fruit peels, waste, and other fibrous alternatives to wood fiber. In creating this end-paper, the researchers were able to recycle previously used paper and household waste products to emphasize the importance of the trees in the environment and aid in the minimization of waste. This concept subsequently contributes to the well-being of the whole community and improves the state of waste management.

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