Hong Kong Student Science Project Competition 2022

Template of Extended Abstract (Investigation)

(Word Limit: 1,000 words, Pages: 2 pages only)

Team Number: SBBC244

Project Title: nonpaper 似紙非紙

Project Type: Investigation

To our best knowledge and after thorough literature research, as at 14/05/22 , there are similar works. If there are, the reference links are as below:

Wolfgang 1973

Glasser, W. G., Slupski, R. H., & Clark, J. P. (n.d.). Pulp-and paper-making potential of peanut hull waste in blends with softwood pulp. Wood and Fibre Science. Retrieved February 3, 2022, from https://wfs.swst.org/index.php/wfs/article/view/2094

P. Musekiwa 2020

Optimization of pulp production from Groundnut ... - cell. (n.d.). Retrieved February 3, 2022, from https://www.cell.com/heliyon/pdf/S2405-8440(20)31028-8.pdf

IJSER 2016

A study on production of pulp from groundnut shells - IJSER. (n.d.). Retrieved February 3, 2022, from https://www.ijser.org/researchpaper/A-Study-on-Production-of-Pulp-from-Ground-Nut-Shells.pdf

The enhancement our project has made for the existing related products or research is summarised as below:

Similarity:

- Exploring the use of peanut hulls for making paper.

Differences/Enhancement:

- Not using the process of Kraft and Soda Pulping (Wolfgang 1973, P. Musekiwa 2020, IJSER 2016)
- Such studies focused on the production of pulp using solely peanut hulls and did not include the addition of paper or wood pulp. We will explore the viability of the blending of wood materials and groundnut materials together to make the best quality recycled paper.
- Various groundnut shell species used: Walnut Shell, Sunflower Seed Shell, Pistachio Shell (rather than the Peanut Shell used in studies)
- Mechanical pulping was used instead.

I. Background

Problem:

- According to TheWorldCounts, "The pulp and paper industry is a big contributor to the problem of deforestation and is partly to blame for the endangerment of some species that live in the forests."[1]
- Paper produced nowadays can be recycled 6 to 7 times, yet 26% of the total waste in landfill is paper waste.
- Nut shell material is a viable substitute material to be used in the production of paper, yet every year, many nut shell materials are wasted and used.

Highlights of the literature review:

- Kraft and Soda Pulping (Wolfgang 1973[2], P. Musekiwa 2020[3], IJSER 2016[4]) was used to make paper out of peanut shells.
- Paper made from pure fibres from groundnut shells resulted in paper of inferior strength and quality.
- It has been suggested that the blending of wood materials and groundnut materials to make paper can be explored instead — according to Wolfgang 1973, "when peanut hull pulp is added to the wood pulp in proportions up to approximately 20% by weight, the strength of the paper product produced" "increased over that of paper made with pure softwood pulp."

The Research Gap:

- How wasted nut material can be used in the production of recycled paper products.
- How the process of mechanical pulping can be used to create waste nut shell pulp
- Exploring the potential of 4 species of groundnut shells: Peanut Shell, Sunflower Seed Shell, Walnut Shell, Pistachio Shell, in the production of recycled paper.

II. Objectives

(Aim) Part A: Investigate ways to incorporate waste nut shell products into the composition of recycled paper products through the means of mechanical pulping and the use of a deckle and mould.

(Aim) Part B: Investigate which blend of waste nut shell pulp and paper pulp ratio will produce the best quality recycled paper based on the following the properties:

(1) Paper surface (appearance) (2) Grain (3) Grammage and thickness

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[1] The World Counts, https://www.theworldcounts.com/stories/Environmental_Impact_of_Paper_Production.

[2] Glasser, W. G., Slupski, R. H., & Clark, J. P. (n.d.). Pulp-and paper-making potential of peanut hull waste in blends with softwood pulp. Wood and Fibre Science. Retrieved February 3, 2022, from https://wfs.swst.org/index.php/wfs/article/view/2094

[3] Optimization of pulp production from Groundnut ... - cell. (n.d.). Retrieved February 3, 2022, from https://www.cell.com/heliyon/pdf/S2405-8440(20)31028-8.pdf

[4] A study on production of pulp from groundnut shells - IJSER. (n.d.). Retrieved February 3, 2022, from https://www.ijser.org/researchpaper/A-Study-on-Production-of-Pulp-from-Ground-Nut-Shells.pdf

III. Hypothesis

It is expected that the "softer" groundnut shells will respond better to mechanical pulping, creating a better quality recycled paper.

IV. Methodology

Materials + Equipment Used:

Weighing Scale, Blender, Bucket

For producing recycled paper pulp: 50g of Shredded Paper, 2000cm^3 of Water

For producing groundnut shell pulp: 50g of Peanut Shell/Pistachio Shell/Walnut Shell/Sunflower Seed Shell, 2000cm^3 of Water

For producing final recycled paper product: Bucket/Container for combining pulp, Large Storage Container (≈ 50x36x16cm, for water bath), Room Temperature Water (for water bath), Large Deckle and Mould (2050cm^3 Handmold), Towels, Sponge, Clothing Iron

Test (1): Flashlight

Test (3): Balance, Ruler, Bowl

Experiment:

- Two, separate pulps were created: The Paper Pulp (created by blending 50g shredded paper and 2000cm^3 water) and The Nut Pulp (created by blending 50g nut shells and 2000cm^3 water).
- Then, to find the nut shell and paper pulp ratio that will produce the best quality recycled paper, we created hand-made paper using a Deckle and Mould with various ratios of Paper Pulp and Nut Pulp.

Control experiment:

- This was set up to showcase a paper product with no composition of any waste nut shells.
- We produced a sample of paper created with solely paper pulp.

Analysis:

- The main reasoning behind our mixture of paper and nut shell pulp was that the addition of a 'Nut Shell Pulp' may guarantee a higher success rate, due to the already proven successfulness of the 'Paper Pulp' method (currently the most popular and common method to produce recycled paper).
- Ideally, the cellulose present in these shells can replace a large proportion of recycled paper used, reducing the use of wood materials. Furthermore, increasing the quality of papers by benefitting from the shells' high tensile strength.
- It is expected that the addition of soft groundnut shells may result in a finer and more consistent pulp, allowing more emulsification of the groundnut pulp and paper pulp, creating a smoother version of the ordinary recycled paper.

V. Results

- The four paper products had different physical properties, and therefore could be used for different purposes.
- The highest nut pulp:paper pulp ratio paper was brittle and there was a distinct separation of paper and pulp for all four experiments. Therefore, the upper limit for paper-making using the mechanical method is the ratio of 90:10.

- The peanut shell paper was relatively ductile at lower percentages, such as at the 50% and 70% ratio. The surface was smooth at 50% and 70%.
- The sunflower seed paper fully formed pieces of paper at 50% and 70%. The surface was more rugged, suggesting the purpose of the paper would not be suited for standard use in conventional uses such as writing and printing.
- The walnut shell paper and pistachio paper both encountered problems with shell emulsification and neither managed to form paper at 70%, with pistachio failing at 50%. This could be because of the 'harder' nature of these shells.
- Overall, the softer shells were able to form smoother paper physically and were able to create smoother particle distribution, especially at lower percentages.

- The recycled paper products produced are not useful for purposes requiring bending and folding.

- Through the Grammage and thickness results, it can be shown that overall the grammage for each piece decreases with the ratio of nuts used. However, the trend for all paper is that it has a high grammage of above 400, thus the best use of this recycled paper would be for posters and cards rather than printing or writing paper.

- This experiment showed that although there were some limitations with the various nuts tested, and the paper made in this way often differed from our control from colour to texture, some of the nuts tested were able to make usable paper, particularly with the softer shells, even up to the percentage of 70%.
- This, if implemented over a widespread area, could significantly impact the paper production industry through reducing the volume of paper pulp needed and using the remains of nut shells effectively, reducing waste.
- Our experiments had limitations due to our lack of industry paper-making equipment, and further experimentation could yield higher quality paper, opening up the potential for widespread implementation.

VI. Conclusion

This proposed project meets both the Part A and Part B objectives. This can be shown with many successful pieces of paper produced using the method listed above with the incorporation of nut shell pulp with recycled paper products, showing the prospective potential that waste nut shells hold in revolutionising the production of recycled paper.

Through the paper surface results, a successful peanut shell product can be produced if the peanut shell ratio was to be between 50% - 70%, successful sunflower seed shell product will be produced if the sunflower seed was in concentration of 50% - 70%, successful walnut shell product will be produced if the walnut shell is lower than 50% percent and successful pistachio shell product can not be produced.

The unsustainable practice of deforestation may be minimised as previously wasted nut materials are cultivated and given greater promises of sustainable growth in the future as an alternative solution, as well as environmental awareness for the succeeding generation. All of which is a vital step taken toward a greener planet, UN's sustainable goal number 13, and more importantly, has revitalised our environmental ambitions.