EGGSHELL FOOD WRAPS: A BIODEGRADABLE PLASTIC ALTERNATIVE

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ABSTRACT

Introduction*:* As the world advances, so does the reliance on plastic due to its low cost and convenience. However, plastic waste harms the environment since it accumulates in landfills and takes a long time to decompose. This study addresses the issue by creating a biodegradable food wrap using eggshell powder, calcium acetate, and natural binders. **Methodology:** This study used quantitative experimental research, which involved forming a bioplastic mixture from these materials, shaping into food wraps, and testing for tensile strength, water absorption, and heat & bacterial resistance. The tests assessed the wrap's feasibility as an alternative to plastic. **Results:** The wraps' tensile strength varies from 3.53 to 5.1 MPa and has a water absorption rate of 131.25% to 133.33%. They resisted heat up to 250°C and showed no bacterial growth. **Discussions:** The findings suggest that eggshell-based wraps combine durability, safety, and biodegradability, making them a promising substitute for commercial plastic wraps in small-scale use. Though not ideal for heavy-duty applications, they offer eco-friendly food storage solutions. **Conclusion:** This study proved that biodegradable wraps can be made from waste materials like eggshells without compromising function. **Recommendations:** Further research may explore mass and speedy production, lessening costs, testing shelf-life, and using other waste materials.

Keywords: biodegradable plastic, eggshell food wrap, plastic waste reduction, calcium acetate, sustainable packaging

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Above all, the researchers extend their utmost gratitude to the **Almighty God** for granting them strength, wisdom, and perseverance throughout their journey.

DEDICATION

The researchers would like to dedicate this study to their teachers, families, classmates, friends, and everyone who helped them throughout the research process. They are genuinely thankful for the never-ending support that motivated them to push through and finish the paper.

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CHAPTER 1

THE PROBLEM AND ITS SETTING

Introduction

Plastic pollution is a global problem. Plastic use has quadrupled over the past three decades, producing approximately 400 million tons of plastic globally yearly (Mcdermott, 2024). With the surging amount produced, 19 to 23 million tons of plastic waste leaks into aquatic ecosystems, polluting lakes, rivers, and seas annually (United Nations Environmental Programme, 2025). Out of this amount, single-use plastics account for approximately 50% of the total produced (World Economic Forum, 2021). Their widespread use causes significant pollution as they are often not recyclable and take 20 to 500 years to decompose. Even then, plastic never fully disappears; it just gets smaller and smaller (United Nations, 2021).

The accumulation of waste poses severe environmental and health risks, particularly in Qatar. Studies by Castillo et al. (2016) revealed that polypropylene microplastics are the most prevalent type in the country's marine waters. These microplastics significantly impact Qatar's marine health and ecosystems, with various species ingesting the waste. They also harm human health as microplastics may be consumed by people as they enter the food chain. Although Qatar has taken initiatives to solve this problem, it still has not completely solved plastic pollution.

Consequently, this research aimed to create a biodegradable plastic alternative from eggshells. This material would be beneficial for food packaging and retail industries. This approach not only lessens plastic use but also utilizes overlooked everyday materials and may help the Qatar initiatives in resolving the plastic pollution found in the country.

Despite this, several gaps remain. First, the durability and flexibility of commercial plastic has not been compared with the bioplastic created by the researchers. Further, the invention of plastic alternatives have not been shown to decrease plastic pollution and utilization. Identifying locally abundant materials in Qatar is essential for sustainability efforts, yet this aspect is often overlooked. Moreover, the real-world applications and long-term performance of these food wraps require further investigation. Lastly, the time it takes to transform large quantities of eggshells into plastic is yet to be observed to note the time and resources needed for specific amounts of bioplastic created.

The food bags were tested through tensile, water absorption, heat resistance, and bacteria tests. The tensile test showcased the model's durability and stretchability relating to the amount of material that can be contained inside without tear; while the water absorption test showcased durability and longevity of the product. Further, the heat resistance test determined its burning and melting points. Most importantly, the bacteria tests showcased possible bacteria growth in the bioplastics as it is an organic material.

While single-use plastics offer convenience, their impact on the environment, human, and animal life is detrimental. By finding eco-friendly alternatives, plastic pollution could be addressed which causes a reduction in the plastic waste found in landfills or oceans and contributes to future studies that cover the creation of more sustainable materials.

Background of the Study

Despite single-use plastic being cheap, easy, and quick, it also serves as the primary contributor to waste in the world. According to Plastic Oceans (2021), 50% of plastics are produced for single-use purposes, used for a few moments but last in the environment for several years. These various wastes not only take away from humans by contaminating food supply but also take away land for housing.

Thus, the researchers made eggshell wraps to alleviate these issues. Several studies have investigated that eggshell particles used with starch-based bioplastics improved their strength and biodegradability.

For instance, research published by Sharif et al. (2023) used yam starch (*Dorceasea*) to develop bioplastic films and reinforced them with different concentrations of eggshell. The results showed an increased tensile strength and water resistance, making them more efficient as storage.

Similarly, a study by Steiger et al. (2024) introduced a bioplastic material composed of chitosan, eggshells, and wheat straw. This product functioned as an absorbent, with a doubled water absorption capacity, and could serve as a fertilizer when it decomposes.

Another study by Khalid et. al. (2024) reviewed the development of biodegradable packaging films derived from various egg components like eggshells. The review highlighted the product's biodegradability, sustainability, and suitable mechanical, barrier, thermal, optical, antioxidant, and antimicrobial properties as substitutes for traditional synthetic polymers. Using various egg components in the packaging industry was a safe, non-toxic, cost-effective, and economical approach.

Commented [1]: States: "The utilization of various egg components in the packaging industry served as a safe, non- toxic, cost- effective, and economical approach."

Finally, a study by Kasmuri and Zait (2018) concluded that eggshells as fillers performed much better than chitosan in potato starch-based bio-plastic. It also concluded that adding fillers in starch-based bioplastics can improve the bioplastic performance.

In conclusion, these studies collectively show that using eggshells improves the performance of plastic alternatives. Thus, this paper is valuable in reducing the harmful effects of plastic waste by creating an alternative that uses a promising and abundant material.

Statement of the Problem

The objective of this study is to create food wraps using eggshells. Specifically, it answered the following questions:

1. What are the physical characteristics of bioplastics with 150 mL and 180 mL of calcium acetate in terms of:

   1.1. tensile strength;

   1.2. water absorption; and

1.3. heat resistance?

2. What bacteria are detected on the bioplastic, and how might this impact its safety for food use?

Hypothesis

H1: Creating a biodegradable plastic alternative out of eggshells is feasible.

Scope and Limitations

This study aimed to create food bags using eggshells to develop alternatives to using plastic as the primary material to improve the earth's ecosystem further and reduce pollution. This study was conducted in the school of the researchers in Doha, Qatar. To measure the eggshell food wraps' durability, the researchers measured the characteristics of the bags before and after the tests. The study does not only test the bags' durability but also seeks its performance in relation to water and heat and the possibility of bacteria formation.

This study held limitations such as the durability and flexibility of commercial plastic has not been compared with the bioplastic created by the researchers. Further, the variability of the material, as different types of eggshells vary in their physical property, may cause slight inconsistencies in the results. Furthermore, the exact burning and melting points were not measured as they did not melt or burn until the maximum temperature the microwave could hold which was 250° Celsius. Lastly, the researchers did not test the behavior of the bioplastic with cold foods, as one-time-use plastic food bags are often used primarily for storing hot foods.

Commented [2]: Removed statement involving allergies regarding eggshells

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Significance of the Study

The researchers aim to use this study to help the following people:

School Community

This study can provide teachers and students of various institutions with more eco-friendly alternatives for food bags instead of the usual nonbiodegradable plastic. Most notably, this study can be useful for Food Technology students and staff in the canteen.

Philippines and Qatar

This study can benefit the Philippines and Qatar as they aim to achieve a safer and greener ecosystem. With that knowledge, they can encourage the people to start using sustainable alternatives to reduce carbon footprints and pollution in the country and may collaborate with the researchers to further extend the reduction of plastic waste.

Future Researchers

This study can benefit future researchers who want to create alternatives for nonbiodegradable materials from egg components. This study can guide or help innovate a better bioplastic using biodegradable materials. This may motivate them to conduct similar researches as it has been proven to be doable.

CHAPTER 2

REVIEW OF RELATED LITERATURE AND STUDIES

Review of Related Literature and Studies

This section presents the related literature and studies reviewed by the researchers that are significantly related to the present study.

Benefits of Using Alternatives in Food Packaging

Different alternatives to plastic in food packaging include glass, cardboard, and cellulose. These materials contribute to a healthier ecosystem and can be recyclable and reusable. However, challenges include low durability, short shelf life for food stored, and higher costs. These drawbacks show why innovating alternatives to plastic is important (SP Group, 2022).

Adding onto that, a study from Pengfu and Pengfu (2023) stated that using recycled materials is important in making eco-friendly and sustainable plastics for benefits like reduction of plastic pollution, carbon footprints, and reliance on fossil fuels. These materials are biodegradable or compostable, making them less environmentally harmful. Food businesses are encouraged to adopt such materials for a more sustainable approach.

Lastly, there are different benefits for each material to be used and other environmental implications, so it is vital to choose the right one. Some problems these materials also alleviate are greenwashing and microplastic pollution (Holley, 2021).

Eggshells for Biodegradable Plastic Development

There is potential in using agricultural waste, including eggshells, to create biodegradable plastics. Research by Mostafa et. al. (2018) provided a detailed review of various biopolymers and their synthesis, highlighting how waste materials such as shells can replace conventional plastic in multiple applications. 33 This aligns with using eggshells as a sustainable alternative to traditional plastic food packaging.

A review by Teo et al. (2024) on calcium oxide waste-based catalysts discusses how waste materials like eggshells, mud clam shells, spent coffee grounds, and others can be repurposed for different purposes. The review shows how to prepare these materials and their performance. By converting waste materials into valuable substances, waste management and cost-effective solutions for environmental conservation are achieved.

The development of biodegradable plastics using natural polymers, including eggshell-derived calcium carbonate, is shown in Lavric et. al. (2018)'s paper. The paper discusses the eggshell's potential for replacing synthetic plastic materials in various sectors. It evaluates the performance and environmental benefits of such alternatives, aligning with the concept of eggshell-based food packaging.

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Researchers found that the degradation rate of the bioplastic out of cornstarch and eggshells was 36%. Compared to a sample without eggshell, it was only about 25%, reaching 0% for commercial plastic. This meant that the application of eggshells and cornstarch in the production of bioplastics had the highest degradation rate due to the microorganisms Bacillus sp. and Aspergillus sp. (Mohamad et. al., 2019).

Further, when eggshells, labeled as "eco-shells," are used as a filler in bioplastics, it reduces 25-50% of plastic content, depending on the type it is used with. The carbon reduction is more significant if an eco-shell is used with recycled or ocean-bound plastic. It is 100% recyclable, and even if incinerated, it does not release carbon, only harmless residue (Jenns, 2023).

Examples of Alternatives to Plastic for Packaging

Biodegradable materials such as cassava starch, seaweed, eggshells, and onion skins offer innovative packaging solutions.

- Titanium Oxide: The article investigates the development of bioplastics out of corn starch, vinegar, and glycerol, enhanced with titanium dioxide (TiO_2) nanoparticles. The study found that adding TiO_2 improved the tensile strength from 3.55 to 3.95 MPa. while reducing their flexibility and slightly slowing down their biodegradability. Overall, the research suggests that TiO_2-reinforced starch bioplastics are promising for environmentally friendly packaging applications (Amin et. al., 2019).
- Onion Skin: According to Ramanujam in the New Food Magazine (2024), onion skins have antimicrobial properties of natural materials, extending the shelf-life of food prone to easy spoilage. The research also states that when chemicals of the plastic stick onto food, though they do not possess provide any nutritional value, unlike onions.
- Cassava starches: Joshi et al. (2022) stated cassava starches can make suitable bioplastics if done and stored right, with many studies conducted on its ability to be a plastic alternative. This material has ultra-lightweight structural scaffolds/aerogels and is shown to have high biodegradability,

biocompatibility, and compressive strength. Wahyuningtiyas and Suryanto (2017) observed that bioplastic degradation is affected by water content, moisture, and oxygen levels. Glycerol is a natural sugar alcohol used as a solvent, sweetening agent, and in medicine. They concluded that the more glycerol is added to the cassava starch bioplastic, the faster its degradation process, the longer its shelf-life, and the higher the moisture absorption would be. This proves that it is feasible to create food packaging out of environmentally friendly materials, but it also has a lot of benefits.

Eggshells in Creating Packaging and Products

Some studies developed biodegradable films from alginate, glycerol, and eggshell powder to combat plastic pollution. These films are strong, water-resistant, dissolve easily in water, and decompose via vermicomposting in 14–21 days. With a rough texture and evenly distributed eggshell particles, they are ideal for eco-friendly food packaging and repurposing eggshell waste (Villanueva et. al.., 2023).

Commented [3]: Biodegradable films from alginate, glycerol, and eggshell powder = "They are ideal for eco-friendly food packaging."

Researchers at the University of Saskatchewan created a sustainable "bioplastic" pellet made from chitosan, eggshells, and wheat straw. The pellet absorbs excess phosphate from water and can be used as fertilizer. It breaks down naturally, helping reduce microplastic pollution and offering an eco-friendly solution to improve water quality and recycle nutrients (Steiger et. al., 2024).

This further proves that using eggshells as a material in creating different products is optimal and provides many benefits. Scientists have discovered a method for converting eggshells into environmentally friendly plastic for food packaging. Strong, sustainable packaging combines biodegradable materials with tiny particles extracted from the shells. This procedure helps reduce the pollution caused by plastics and food waste (Gyekye, 2012).

Commented [4]: "Scientists have discovered a method for converting eggshells into environmentally friendly plastic for food packaging."

Future Prospects

The use of biodegradable plastics in packaging, agriculture, and medicine is very feasible, and studies explore the production of these materials from renewable materials like cellulose and starch. While they help reduce plastic waste and emissions, challenges like cost and scalability remain. Enhancing their qualities and affordability for more widespread use is the primary goal of ACS Publications (2023)'s research.

For example, researchers at the University of Leicester are exploring eggshell-derived glycosaminoglycans for sustainable food packaging. This initiative could reduce disposal costs for food producers and offer an alternative to traditional plastics (University of Leicester, 2012).

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Conceptual Framework

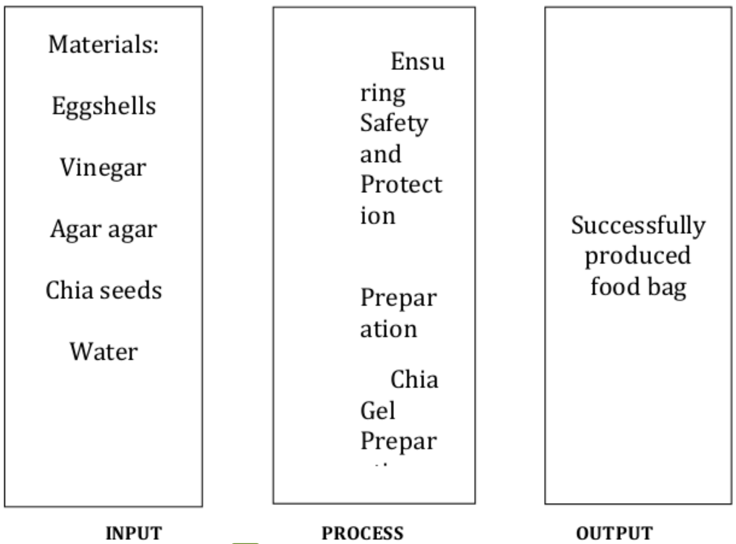

Figure 1: Conceptual Framework

Figure 1 shows the conceptual framework of the study. The Input-Process-Output was used. The first frame shows the input including the materials and equipment used to form the product. The next frame shows an outline of the research procedures to be conducted. This includes the preparation of the materials, conditioning of the eggshells, formation of the different solutions, and testing procedures. Lastly, the output frame shows the product, which is a food wrap made out of eggshells as the primary material instead of plastic.

Definition of Terms

The following are the definitions of terms used by the researchers giving the readers a better understanding of the research paper.

Bacteria - These are microscopic, single-celled organisms found in many environments. Detecting these bacteria is vital in determining the bioplastic's safety for preserving food.

Biodegradability - The ability of a material to decompose. In this study, the biodegradability of the food wraps is vital to determining the time they could safely store food without affecting its quality.

Biodegradable Plastic - A type of plastic that takes a shorter time to decompose than commercial plastics, reducing environmental harm.

Bioplastic - A plastic that utilizes natural and environmentally friendly materials instead of chemicals and oil.

Calcium Acetate - A chemical compound composed of calcium salt of acetic acid. It is used to form and harden the product's structure.

Durability - The strength of a certain material. This study aims to determine the bioplastic's durability to see if the wraps' strength is comparable to those of commercial plastics.

Eggshells - The hard exterior covering of an egg, primarily composed of calcium carbonate. In this context, eggshells are utilized as the main material in creating the alternative food bag due to their natural composition and abundance.

Food Wrap - A wrap designed to store and protect food during outdoor activities like backpacking and camping. This is the product the study aims to achieve.

Heat Resistance - The ability of a material to resist the impacts of heat energy by maintaining its mechanical properties such as strength, toughness, or elasticity. This characteristic of the bioplastic will be tested to ensure that it holds heated foods.

Microwave Susceptor - The test measures heat resistance by subjecting test materials to extreme heat until their burning and melting point.

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Plastic - A synthetic material made from a wide range of organic polymers such as polyethylene, PVC, nylon, etc., that can be molded into shape while soft and then set into a rigid or slightly elastic form. This material is the main factor in pollution and the material this study aims to find an alternative for.

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Tensile Strength - The maximum stress a material can bear before breaking when stretched or pulled. This characteristic of the bioplastic will be tested to ensure that it holds food for a reasonable amount of time without breakage.

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Water Absorption - The ability of a material to absorb water when immersed and 8 is defined as the ratio of the weight of water absorbed by a material in a saturated state over the weight of the dry material.

CHAPTER 3

RESEARCH METHODOLOGY

Research Design

This study followed the Quanti-Experimental design wherein several tests were done and the results were precisely measured and treated to be further analyzed in creating a conclusion.

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According to Sirisilla (2023), the experimental design offered a systematic framework for exploring two-variable scientific studies. In this case, the volume of calcium acetate placed in the bioplastic served as the independent variable. Consequently, the performance of the resulting eggshell food bags was the dependent variable.

Furthermore, an accurate examination of the food wraps' performance under different stress conditions was needed for the deliberate selection of variables. This led to the researchers using a quantitative methodology to uphold precision, consistency, and accuracy. Overall, adopting the quanti-experimental design ensured precise measurement and analysis of the bioplastic's performance such as tensile strength, water absorption, heat resistance, and bacterial growth, which was critical in assessing the product.

Research Locale

The study was conducted in the school of the researchers in Qatar. The researchers selected locations that provided the facilities, equipment, and materials needed for the study's completion.

Materials and Equipment

Table 1

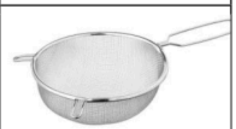
Materials

Material	Quantity	Price	Picture
Eggshells	15 grams	QAR 4.75	
Vinegar	250 milliliters	QAR 4	
Agar agar	12 grams	QAR 5	
Chia seeds	40 grams	QAR 22.75	
Water	875 milliliters	QAR 1	
Glycerin	15 milliters	QAR 11.25	

Cornstarch	20 grams	QAR 3	
TOTAL		QAR 51.75	

Table 2

Equipment

Equipment	**Purpose**	**Picture**
Electric grinder	These tools are used to grind different materials.	
Strainer	A tool used to separate liquids from fine solids.	

Stove	An appliance used to heat various food and substances.	
Non-stick pan	A container where materials to be heated are placed.	

Research Procedure

The procedure shows the step-by-step process that demonstrates how to make biodegradable food bags out of eggshells.

Ensuring Safety and Protection:

1. Wear protective equipment such as safety goggles, safety gloves, and a laboratory gown to prevent injuries from any accidents.

Preparation:

1. Check if all the materials and equipment are ready for use.

Chia Gel Preparation:

1. The electric grinder forms fine chia powder out of 40 grams of chia seeds.
2. Add the chia powder to 500 milliliters of water in a mixing bowl.
3. Mix the ingredients and let the mixture sit for 10-15 minutes.

4. Stir every 5 minutes to ensure the chia powder does not clump until it forms a thick gel.

Forming Calcium Acetate:

1. Clean and dry the eggshells, ensuring that all membranes are removed.
2. Crush 6 eggshells (10-15 grams) into a fine powder using an electric grinder.
3. Place 250 milliliters of vinegar in a heat-resistant container.
4. Gradually add the eggshell powder while stirring the mixture gently.
5. Wait for the carbon dioxide bubbles to subside completely.
6. Filter the solution through a strainer 4-5 times to remove undissolved eggshells.
7. Heat the solution at a low temperature until the volume is reduced by half.
8. Set the mixture aside and allow it to cool.

Forming the Agar Solution:

1. Hydrate 30 grams of agar agar in 375 milliliters of water in a non-stick pan for 15 minutes.
2. Heat the mixture over medium temperature and continuously stir.
3. Cook until the agar agar particles are dissolved and a smooth gel is made.
4. Add 33 grams of glycerin for flexibility and continue heating and stirring.
5. Dissolve 30 grams of cornstarch in 45 milliliters of cold water.
6. After dissolving, add the substance to the agar agar mixture until it thickens.

Combining Everything:

1. Reduce the heat to a low temperature, then gradually add the chia gel to the agar agar solution and stir.
2. While constantly stirring, slowly pour the calcium acetate solution with varied amounts per batch to the following:
   - Batch 1: 150 milliliters
   - Batch 2: 180 milliliters
3. Continue heating over low temperature and stir until the mixture becomes thick and uniform.

Drying and Final Product:

1. Spread the mixture onto a flat parchment paper and even it out using a spatula.
2. Allow it to air-dry for 1-2 days.
3. Once dried, detach the plastic from the mold.

Testing Procedures:

The following procedures will be used to test the efficiency of the food bags out of eggshells.

Tensile Strength Test

1. Cut the bioplastic into films with a thickness of 0.5 mm and a length of 1 cm. Measure the cross-sectional area using the formula:

   Cross-sectional area [m^2] = Thickness [m] x Width [m]
2. Secure one side of the bioplastic film around the hook of the digital weighing scale using metal clamps.

3. Pull on the other side of the test material until it breaks. Record the maximum weight measured before the test material breaks. The product must tear or rip apart and not simply slide off its attachment.
4. Convert the measurements into the needed units and calculate for the tensile strength:

   Tensile strength [MPa] = $\frac{\text{[illegible] [illegible] [[illegible]]}}{\text{[illegible]–[illegible] [illegible] [[illegible]}^2]} \text{[illegible]} 10^6$

Water Absorption Test

1. Weigh a 13 cm by 6.5 cm bioplastic film.
2. Submerge it in 8 oz of water for 24 hours.
3. Record the final weight of the bioplastic film.
4. Using the measurements, find the water absorption rate of the material using the formula:

   Percentage of Water Absorption = $\frac{\text{[illegible] [illegible]–[illegible] [illegible]}}{\text{[illegible] [illegible]}} \times 100$

Microwave Susceptor Test

1. Microwave 6 cm × 6 cm bioplastic samples.
2. Continue heating until the sample starts to lose its solid structure.
3. Use an infrared thermometer to measure the surface temperature at which melting begins.
4. Increase microwave power to 70%-100% (high power) for burning point evaluation.
5. Observe changes like charring, smoke, or ignition.
6. Measure the temperature at which burning, blackening, or ignition occurs.

Schematic Diagram

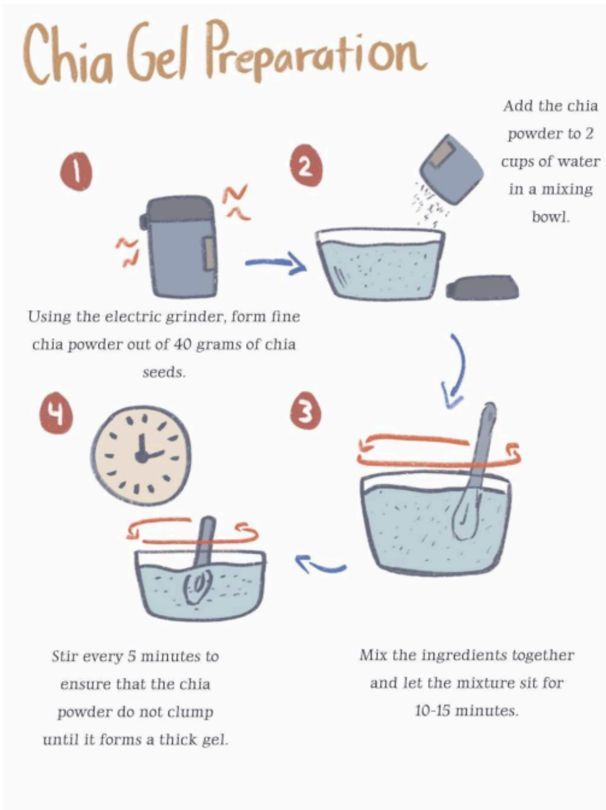


Figure 3: Chia Gel Preparation

Figure 3 illustrates the process in preparing the chia gel solution which acts as a binder for the bioplastic, helping clump and stick the different materials.

Figure 4: Forming Calcium Acetate

Figure 4 illustrates the process in creating the calcium acetate, a mixture of eggshells and vinegar, the material used to enhance the durability of the bioplastic.

Figure 5: Forming the Agar Solution

Figure 5 illustrates the process in creating the agar solution which serves as the base of the bioplastic and a material that helps enhance the bioplastic's durability.

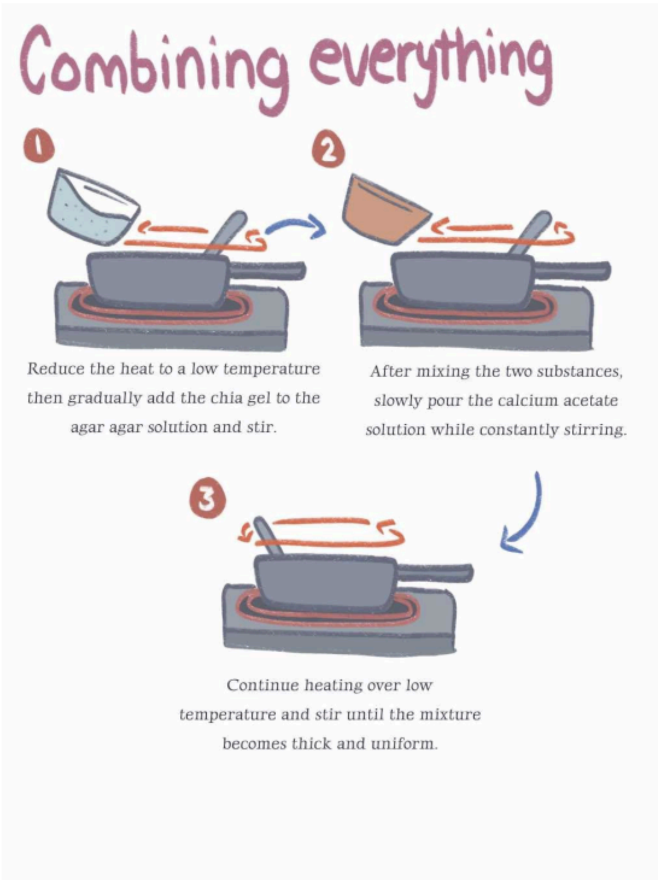


Figure 6: Combining Everything

Figure 6 illustrates the combining of all the mixtures to create the bioplastic. This process is vital in forming the final output.

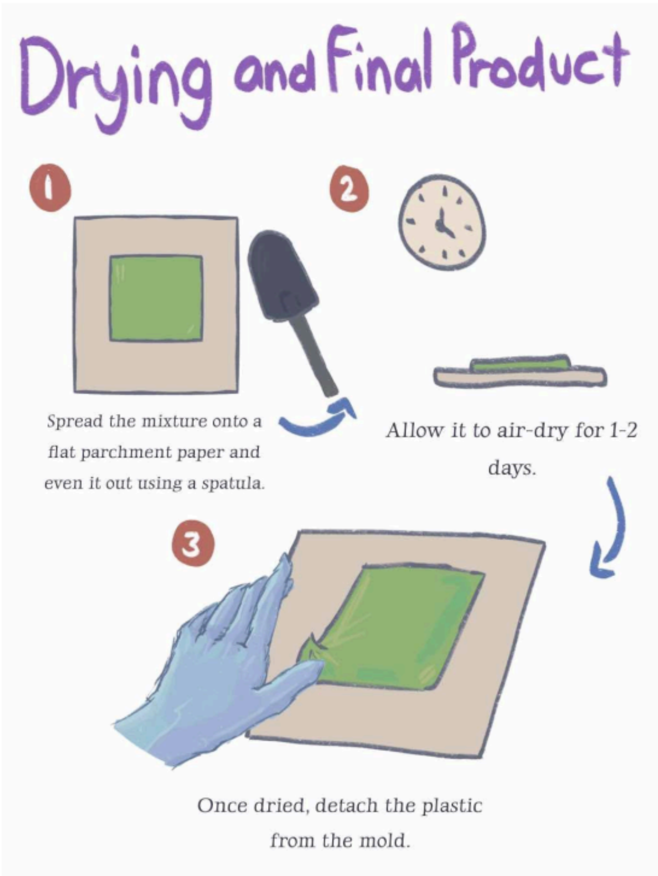


Figure 7: Drying and Final Product

Figure 7 illustrates the drying of the bioplastic and the final processes to achieve the product.

CHAPTER 4

PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

This chapter brings about the results and interpretation of data collected from the creation and testing of the eggshell food bags. The tensile strength, water absorption, heat resistance, and bacterial growth rates of the bioplastics are discussed which are vital in determining the bioplastic's strength and safety.

1.1 Physical characteristics of bioplastics with 150 mL and 180 mL of calcium acetate in terms of tensile strength

Table 3

Physical Characteristic of the Bioplastic: Tensile Strength

Calcium Acetate	Trial	Cross-Sectional Area	Maximum Force (N)	Tensile Strength (MPa)
150 mL	Trial 1	0.000005 $\square^2$	22.0649625 N 	4.4129925 MPa
	Trial 2		25.49729 N 	5.099458 MPa
	Trial 3		23.53596 N 	4.707192 MPa

	Average tensile strength			4.739880833 MPa
180 mL	Trial 1	0.000005 ▯^{2}	19.6133 N 	3.92266 MPa
	Trial 2		17.65197 N 	3.530394 MPa
	Trial 3		23.53596 N 	4.707192 MPa
	Average tensile strength			4.053387733 MPa

Table 3 shows that the bioplastics, with a constant cross-sectional area of 0.000005 ▯^{2}, have varying amounts of calcium acetate. Trials 1, 2, and 3 containing 150 mL of calcium acetate received a maximum force of 22.0649625 N, 25.49729 N, and 23.53596 N, respectively. As a result, the first trial had a tensile strength of 4.4129925 MPa while the second had a tensile strength of 5.099458 MPa. The third trial received a tensile strength of 4.707192 MPa. This led to the average tensile strength of the bioplastic containing 150 mL of calcium acetate being 4.739880833 MPa. On the other hand, trials 1, 2, and 3 containing 180 mL of calcium acetate received a maximum force of 19.6133 N, 17.65197 N, and 23.53596 N, respectively. As a result, the first trial had a tensile strength of 3.92266 MPa while the second had a tensile strength of 3.530394 MPa. The third trial received a tensile strength of 4.707192 MPa. This led to the average tensile strength of the bioplastic containing 180 mL of calcium acetate being 4.053387733 MPa.

The second trial containing 150 mL of calcium acetate had the highest tensile strength at 5.099458 MPa, making it greater than all other trials. The third trials of both bioplastics containing 150 and 180 mL of calcium acetate follow with 4.707192 MPa. It was followed by the first trial containing 150 mL of calcium acetate's tensile strength of 4.4129925 MPa, which left the first and second trials containing 180 mL of calcium acetate having the lowest tensile strength at 3.92266 MPa and 3.530394 MPa, respectively.

The data suggested that a lower concentration of calcium acetate enhances the tensile properties of the bioplastic. Additionally, the Japanese Industrial Standards established the minimum tensile strength for bioplastics to be 0.39 MPa to ensure that various bioplastics meet basic mechanical property requirements for real-life applications (Budiman et. al., 2022). The data showed that the eggshell food wraps have exceeded the requirements set by at least 3.140394 MPa, indicating that it is suitable and durable for daily life. Finally, the eggshell bioplastics exceed the tensile strength of titanium dioxide-reinforced starch bioplastics which have a tensile strength of 3.55 MPa to 3.95 MPa (Amin et. al., 2019).

1.2 Physical characteristics of bioplastics with 150 mL and 180 mL of calcium acetate in terms of water absorption

Table 4

Water Absorption of the Eggshell Bioplastics

Calcium Acetate Content	Initial Weight	Final Weight	Absorption (%)
150 mL	1.8 grams	4.2 grams	133.33%
180 mL	3.2 grams	7.4 grams	131.25%

Table 4 presented data on bioplastics with a uniform size of 13 cm by 6.5 cm. The bioplastic containing 150 mL of calcium acetate exhibited initial weights of 1.8 grams and final weights of 4.2 grams, resulting in an absorption rate of 133.33%. Similarly, the bioplastic with 180 mL of calcium acetate had initial weights of 3.2 grams and final weights of 7.4 grams, corresponding to an absorption rate of 131.25%.

The bioplastic containing 150 mL of calcium acetate exhibited the highest absorption rate at 133.33%, making it greater than the absorption rate of the bioplastic with 180 mL of calcium acetate, which measured 131.25%.

Both samples exhibited absorption rates exceeding 100%, indicating the bioplastics' capacity to absorb water and moisture which was vital in determining their efficiency in holding foods with liquids. The table showed that addition of more calcium acetate led to less water absorption which is attributed to longevity and maintaining the bioplastic's mechanical properties compared to a study of Judawisastra (2017) where increasing the PVA content to 29 wt% was found to decrease water absorption but have lower stiffness and higher elongation. Therefore, the lower absorption rate of the 180 mL calcium acetate-infused bioplastic showed more potential to store foods containing moisture and liquids with less possible impact on its mechanical strength.

1.3 Physical characteristics of bioplastics with 150 mL and 180 mL of calcium acetate in terms of heat resistance

Table 5

Heat Resistance of the Eggshell Bioplastics

Calcium Acetate Content	Time microwaved	Maximum Temperature	Melting Point	Burning Point
150ml	30 minutes	250°C	did not melt	did not burn

180ml			did not melt	did not burn

Table 5 indicates the heat resistance of the bioplastics containing 150 mL and 180 mL of calcium acetate. There were no signs of burning nor melting when exposed to extreme temperatures as high as 250° Celsius.

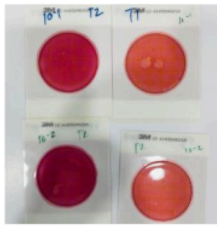
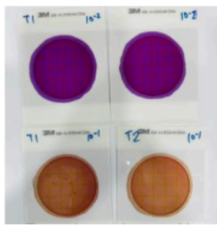
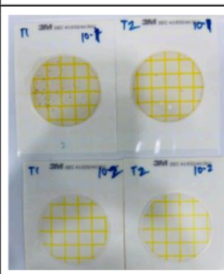
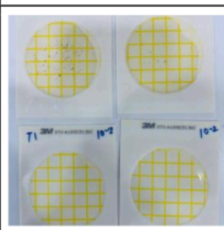
This suggests that the wraps possessed good thermal stability, which is essential for food packaging materials to withstand breakage when storing heated foods, cooking, or storage conditions without degradation. The thermal stability of biopolymer-based food packaging materials has also been researched by Perera et. al. (2023). Performance Plastics (2023) also stated that many polymers are designed to withstand and perform under harsh conditions. This means that they can be exposed to high heat without compromising their mechanical properties.

2. What bacteria are detected on the bioplastic

Table 6

Bacteria Detected in the Eggshell Food Wraps

Bacteria Type	**Documentation**	**Detection**

Total coliform		Not detected
Enterobacteriacea		Not detected
Escherichia coli		Not detected
Staphylococcus aureus		Not detected

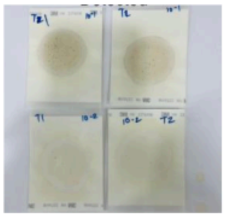
Yeasts and Molds		Not detected

Table 6 shows the possible bacteria that could be detected in biodegradable materials. The table shows no coliform bacteria was found in the eggshell food wraps. Further, there were no signs of Enterobacteriaceae and Escherichia coli in the bioplastic. Lastly, no staphylococcus aureus, yeasts, or molds were detected in the food wrap.

Table 6 indicates that the product can have food placed in it without contamination as no bacteria formation occurs. This suggests that the wraps possess inherent antimicrobial properties, effectively preventing the growth of these pathogens.

Calcium acetate, a calcium salt of acetic acid, is recognized for its antimicrobial effects. It has been utilized in food packaging to inhibit bacterial growth, enhancing food safety and extending shelf life (U.S. Food and Drug Administration [FDA], 2023). In summary, the data suggests that the food wraps, using calcium acetate, effectively prevent the growth of harmful microorganisms, thereby contributing to food safety and preservation.

Hypothesis

The alternative hypothesis that it is feasible to create a biodegradable plastic alternative out of eggshells is accepted. The study’s outcome showed that the researchers successfully created wraps that have tensile strengths up to 5.099458

MPa, have a water absorption rate up to 133.33%, and have a burning or melting point of at least 250°C, and prevent bacterial growth while staying environmentally friendly as they are biodegradable.

CHAPTER 5

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents the summary, conclusions, and recommendations based on the data gathered, analyzed, and interpreted.

Summary

The negligence of people in recycling has become a major problem in the environment, especially in food packaging which is often made to be single-use products only. This often results in excess waste piling up in landfills or ecosystems. Furthermore, the plastics used have a harder time decomposing which can cause serious global warming and pollution to the environment. This research study's goal was to create a biodegradable food bag and tested its effectiveness under certain conditions: tensile strength, water resistance, heat capacity, and bacterial contamination. The product used eggshells as its main component, specifically calcium acetate. The researchers aimed to encourage the people and different food personnel to start recycling and use more sustainable and eco-friendly materials.

3

Summary of Findings

The following is the summary of results for each Statement of the Problem in this study.

1. **Testing for tensile strength**

The test conducted showed the food wraps' ability to hold weight through using a digital weighing scale and consistent amount of pulling force applied until the food wraps' breakage when it reached its maximum capacity showing its tensile strength. The tests showed that the wraps could carry weights heavy enough for food but may not be suitable as continuous heavy-duty packaging.

2. **Testing for water resistance**

The researchers tested the food wraps' water resistance by measuring its weight before and after submerging under 235 mL of water for 24 hours which were used to calculate its water absorption percentage. The results of the test for both bioplastics showed an absorption percentage of at least 100% indicating its ability to hold food that contain liquids and moisture.

3. Testing for heat capacity

The researchers tested the food wraps' heat capacity using a microwave. The wraps placed inside were heated as the temperature was gradually increased to as high as 250° celsius and observed if the product showed any reactions to heat. The results showed no changes indicating that the mechanical properties of the food wraps were unaffected by exposure to heat.

4. Testing for bacteria development

The researchers requested assistance from a Microbiologist to perform several tests searching for the development of: Total Coliform, E. Coli, Enterobacteriaceae, Staphylococcus aureus, yeasts, and molds. These are the most common bacteria that can contaminate food. The results indicated that no bacteria formed during the testing of the bioplastics.

Conclusions

The following conclusions are drawn from the findings based on the analysis of collected data.

1. The tensile strength of the bioplastics showed greater tensile strength, when less amounts of calcium acetate was added. This makes it more durable, and viable to use for carrying food.
2. The bioplastics with an increased concentration of calcium acetate have lower water absorption which is related to less degradation. Less

degradation improves the tensile strength and stiffness of the bioplastic, which lengthens the shelf-life of the bioplastics. By adding a higher amount of calcium acetate to the solution, it lessens the water absorption and degradation which is good for storing food at increased periods of time.

3. The bioplastics are not affected by long exposure to heat under 250°C, and did not show signs of melting or burning. This makes it feasible to use warm or hot food that comes into contact with it.

4. Bacteria do not thrive in the eggshell bioplastics. This makes it safe to consume food that comes into contact with the bioplastics, as it does not collect and accumulate bacteria.

Recommendations

Based on our observations and experimental findings from the study, the following recommendations are made:

1. The **Philippine School Doha (PSD) Community** is encouraged to use biodegradable eggshell packaging for school programs, events, and daily activities where food packaging is needed. However, it is recommended that they limit the amount of liquid added to the bioplastic as excessive weight may cause the packaging to soften and tear. Using eco-friendly packaging enhances student and staff awareness about sustainable alternatives to plastic while contributing to the school's waste reduction efforts.

2. The **Qatar and Philippine Communities** should explore utilizing these environmentally friendly materials. Businesses and local manufacturers can benefit from converting to biodegradable packaging to decrease plastic waste. At the same time, government measures can

encourage widespread utilization of such alternatives that align with environmental sustainability goals.

3. **Future researchers** should focus on creating more durable yet equally environmentally friendly eggshell bioplastics. Additionally, they can investigate ways to speed up the manufacturing process, lessen material costs, such as finding an alternative to chia seeds, and test its shelf life and feasibility in large-scale applications. Researchers could also experiment with different natural waste materials to produce more sustainable bioplastics and examine their environmental advantages.

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LETTER OF VALIDATION

October 20, 2024

Shiela Mae C. Bello, MAEd
Science Teacher
Philippine School Doha

Dear Ma'am Shiela,

Greetings of joy and good health!

We, the researchers of Group 1 from Grade 10- Edison would like to ask for your time and expertise in reviewing and validating our self-made Statement of the Problem. Our foregoing study is Eggshell Food Wraps: A Biodegradable Plastic Alternative.

The Statement of the Problem is attached for your reference.

Your favourable response to this matter is highly appreciated.

Thank you.

Respectfully yours,

Unica Raija A. De Vera
Zoe Carleigh F. Arucan *Mykeila Marie S. Biglete*
Hanna Margaret A. Docoy *Daivid H. Gardince*
Rodrigo Joaquin B. Puno *Maja Jamila R. Santiago*

Noted by:

PRECIOSO L. TANO, PhD
Research Teacher

CARIDAD A. CAÑETE, EdD
Vice Principal, Junior High School Department

Approved by:
Shiela Mae C. Bello, MAEd
Science Teacher

October 20, 2024

Mary Grace A. Docoy, MAIE
Science Teacher
Philippine School Doha

Dear Ma'am Grace,

Greetings of joy and good health!

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Maja Jamila E. Santiago

Noted by:
PRECIOSO I. TANO, PhD
Research Teacher

CARIDAD A. CAÑETE, EdD
Vice Principal, Junior High School Department

Approved by:
Mary Grace A. Docoy, MAIE
Science Teacher

October 20, 2024

Ricardo S. Paig, EdD

Mathematics Teacher

Philippine School Doha

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Noted by:

PRECIOSO L. TANO, PhD

Research Teacher

CARIDAD A. CAÑETE, EdD

Vice Principal, Junior High School Department

Approved by:

Ricardo S. Paig, EdD

Mathematics Teacher

APPENDICES

Figure 8: Final Presentation of the Bioplastics

Figure 9: Image of the Materials Used

Figure 10: First Creation of Bioplastic

Figure 11: Appearance of Bioplastic After 7 Days

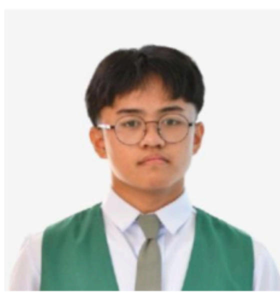
CURRICULUM VITAE

This researcher is **Zoe Carleigh F. Arucan.** She is from Caloocan, Manila. She was born on June 13, 2009. Some of her achievements include getting 2nd place in the Library Book Week digital art contest, achieving grade 7 level in the English Learning Area's Reading Program, best in Arabic for the 1st quarter of S.Y. 2024-2025, and nominated for Artist of the Year for Grade 10 JHS Prom Minor Awards. A myriad of hope with the chorale of faith, a dream that I can see is a dream that I can reach.

This researcher is **Mykeila Marie S. Biglete**. She is from Nagcarlan, Laguna, and was born on May 23, 2010. She is a Junior High School student in the Philippine School Doha, allocated to the section: 10-Edison. She has been enrolled in PSD for the past 2 years and has constantly received awards for integrity from the Prefect of Discipline. She was also a consecutive high achiever and frequent participant in significant occasions at her previous school, Alashbal International School. Her recent accomplishments include modeling for renowned photographer, Porto Maniax, and being nominated for 'Ms. Campus Crush' in the minor awards for the Junior-Senior Promenade. The old saying by Steve Jobs, "Your time is limited, so don't waste it living someone else's life" is a quote she lives by and truly believes in.

This researcher is **Unica Raija A. De Vera**. She is from Santa Barbara, Pangasinan, born on December 01, 2008. She has been a consistent Honor Student and achiever since entering the Philippine School Doha in 2013. She has participated and claimed titles in the following events for the School Year 2024-2025: Georgetown Model United Nations Fall Conference Participant, PICE Math Quiz Bee Finalist, Miss Intramurals 2024, Book Week Photography Contest Champion, ShowcACE AraLink 1st Runner-Up and Best Storyteller, Battle of the Bands Finalist, International Education Day Female Champion, Junior-Senior Promenade Female Total Performer and Star of the Night, Second Tournament of the Qatar Secondary Debate League, INDAK Dance Battle Category 2 Champion, Physics Carnival 2nd Runner-Up, AWSAJ Model United Nations Outstanding Delegate, and FameLab Speech Competition 2nd Place. She is a member of the following clubs: News Writer and Broadcaster of the Link, Auditor of the Debaters' Society, Vice President of the Junior-Senior Dance Club, and a member of the Dunong Academic Guild. She was a Gold Awardee in the S.Y. 2021-2022 and S.Y. 2022-2023, and Silver Awardee in the S.Y. 2023-2024. Through everything, she believes in Philippians 4:13; "I can do all this through him who gives me strength."

This researcher is **Hanna Margaret A. Docoy**. She is from Surigao City and was born on October 25, 2009. Currently, she is a C.A.T. Officer for the S.Y. 2024-2025. Some of her accomplishments include being actively part of the Preschool Young Performers Club in S.Y. 2013-2014, Primary Dance Club from the year 2015 to2017, Intermediate Dance Club in the years 2018 to 2020, and Junior-Senior Dance Club from the year 2022 to 2024. In Intramurals Basketball Girls 3x3, she placed Champion for the S.Y. 2023-2024, and 1st Runner-Up for the S.Y. 2024-2025. She believes in "Treat others the way you want to be treated."



This researcher is **Daivid H. Garduce**. He is from Rosario, Batangas, and was born in Doha, Qatar on November 16, 2008. His achievements include being a Bronze Awardee through S.Y. 2018-2019, 2022-2023, and 2023-2024. Another of his achievements also include being a Silver Awardee in PIMSO Science National, Bronze Awardee in PIMSO Science International, Academic Olympiad Spelling Bee champion S.Y. 2018-2019. He was also a C.A.T. Officer S.Y. 2024-2025. He believes in the saying "The most effective way to do it, is to do it. - Amelia Earheart."

This researcher is **Rodrigo Joaquin B. Puno.** He is from Lapu-Lapu City, Cebu. He was born on August 26, 2008. Some of his achievements include getting top 1 overall twice during his younger years at a different school, being a Bronze Awardee through S.Y. 2020-2021, 2021-2022, 2022-2023, 2023-2024, Intramurals Champion for the Volleyball Boys Category during S.Y. 2023-2024 and 3rd Place during S.Y. 2024-2025, More of his achievements include participating in the Qatar Preparatory School Debate League (QPSDL) representing Philippine School Doha (PSD). Currently, he is part of the PSD Mighty Falcons Senior Varsity Team. He goes by the quote; "try and fail but never fail to try".

This researcher is **Maja Jamilla R. Santiago**. She is from Cainta, Rizal, and was born on December 20, 2009. At her former school, Alashbal International School, She obtained several achievements such as winning first place in a book reading competition. Additionally, she performed in PSD's 2019 Summer Voice and Piano Recital. Outside of academics, she actively participates in church activities through singing and dancing. She was a former member of St. Francis Children's Choir and is currently a part of Youth For Christ Qatar. She also enrolled in various summer workshops at IAID Academy for Arts, Dance & Music. Through all this, she believes in Jeremiah 29:11, "For I know the plans I have for you," declares the LORD, "plans to prosper you and not to harm you, plans to give you hope and a future."

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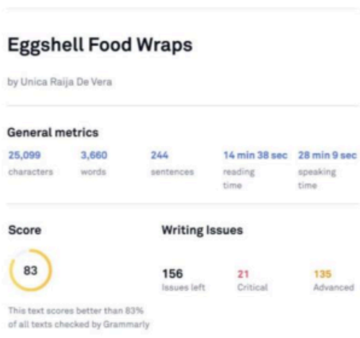

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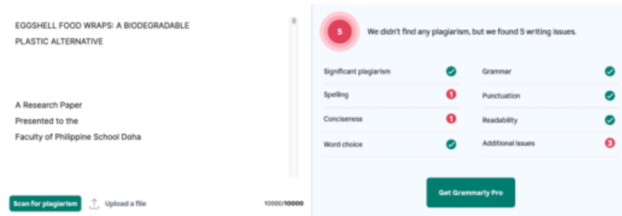
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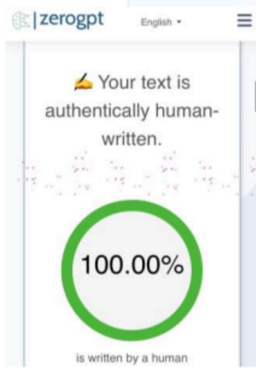
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