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Development, Evaluation and Heavy Metal Analysis of Tailor's Chalk Using Eggshell and Green Apple Snail Shell in Three Formulations

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ABSTRACT

This study focused on developing, evaluating, and analyzing the safety of tailor's chalk made from eggshells and green apple snail shells in three different formulations. Eggshells and green apple snail shells, both rich in calcium carbonate were used as main materials for tailor's chalk production. These substances were collected, washed, and ground to fine powders to prepare the product base. Using descriptive and developmental research, the quality of the chalk was assessed by (60) sixty respondents who are garment faculty members, students dressmakers and tailors in a 4-point Likert-scale. The assessment included several features like, appearance, texture, marking ability, erasability, durability and water solubility. Formulation 2 was the best rated of the three formulations as a "Moderately Acceptable" preparation. Statistical analysis (ANOVA) revealed that there were significant differences between respondent groups and Formulation 2 consistently performed better. In addition, heavy metal testing conducted by the Philippine Institute of Pure and Applied Chemistry (PIPAC) showed that the formulation is safe in terms of mercury, lead, cadmium, arsenic and chromium content making it non-toxic and user-safe. In conclusion, the result suggested that waste sources, such as eggshell and green apple snail shell, can be successfully utilized for sustainable and eco-friendly alternative substitute of commercial tailor's chalk. The study highlighted the importance of sustainable feedstock in enhancing innovation and recycling waste; as well as texture improvement to encourage scalability for local industries.

Keywords: *Eggshell, Green Apple Snail Shell, Tailor's Chalk, Arsenic,*

INTRODUCTION

Eggs often were commonly used in food trade (bakeries, restaurants). They generated a lot of eggshells as a consequence. Most of these eggshells are being thrown away. Despite their apparent insignificance, these eggshells could lead to a significant amount of waste. When people consider all of these eggshells that had been thrown away, they realized that this everyday waste might have been more than just trash. Eggshells from eateries, bakeries, and other food businesses that used eggs as an ingredient were, therefore, frequently considered waste, indicating a substantial stream of discarded material that merited more thought for possible recycling or other uses.

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Large amounts of eggshells were inevitably produced due to the widespread usage of eggs in a variety of food enterprises, such as bakeries, restaurants, and other food processing industries. They stated that more than half of the world's waste stream was made up of these eggshells, which were primarily thrown away as waste. Despite their seemingly small size, they can have significant environmental significance if not properly managed eggshell waste (Waheed, Adewale & Abdulrahman, 2022). The researchers highlighted that there was a strong connection between increased egg consumption and the increasing accumulation of eggshell waste worldwide. Indeed in 2020 egg consumption globally surpassed 8,400 million dozen and nearly 50 thousand tons calcium waste in the form of eggshell was produced per annum.

McGregor (2016) in her Hobby Farms article "18 Everyday Uses for Eggshells," shared some real-world uses of egg shells citing that there is more to do with the egg shell than throw it out – you can actually use it for good purposes. Trinidad (2019) also explained that chicken eggshells contain 97% of calcium carbonate, magnesium carbonate, and calcium phosphate including organic materials which can be a potential source for chalk production.

Moreover, the Philippines was known for its wide farmlands where green apple snails produced and reproduced. Due to their population, they could impact the palay plants and others, becoming pests for farmers because they were destructive. The snails reproduced in the warm, wet conditions common to agricultural areas of the Philippines. With their rapidly increasing numbers, they ate vast quantities of vegetation, particularly young shoots of rice plants.

The state's major agricultural regions, especially its large rice fields, suffered severe damages from the highly invasive Green Apple Snail (Pomacea canaliculata) according to Centre for Agriculture and Bioscience International (CABI, 2018). This species is a continuing and significant threat to the country's food security and impoverishment of farmers in the Philippines. The rice-eating nature of these snails was most visible in rice production, the absolutely dominant Philippine crop. The green apple snail ravaged small rice seedlings and tender young tillers by cutting at the base, resulting in high plant mortality. Indeed, Pomacea snails were able to eliminate as much as 100% of newly planted rice in one day causing significant yield reduction. The control of these populations of snails became increasingly necessary to safeguard the livelihoods of farmers and promote year- round food availability (CABI, 2018).

In the garments and clothing production industry, even the small tools can have a significant impact. One such essential tool is the tailor's chalk- a simple yet vital instrument used for marking patterns and constructing garments. With the expansion of fashion and textile industries, the need for tailor's chalk and like materials increased as well, with the great majority being made commercially and chemically treated. A good tailor's chalk is an essential piece of fashion design student supplies that instructs students on how to cut a pattern and how to draw/pattern mark fabric. Tailor's chalks can be triangular chalks, water-soluble chalks or marker pens (TailorChalks Editorial Team, 2025). The team believed that learning how to use tailor's chalk is the building blocks of student's development regarding technical fluidity and creativity, thus also becoming an essential tool for future fashion designers. Furthermore, the researchers also aimed to develop tailor's chalk from natural waste materials like eggshells and green apple snail shells, in a novel, environment-friendly response to the worldwide push for sustainability. From the abundance of natural resources as well as an increased environmental consciousness, the need for organic options has become obvious. Eggshell and green apple snail shell wasted have a unique characteristic in the term of high calcium carbonate content, fine texture, but usually this is thrown away. In this research we have set out to tackle waste in the fashion sector, and embrace circular design practices by repurposing these biodegradable materials for a purpose such as chalk, reducing dependency on synthetic and non-degradable products.

Like a pioneer of the future research on sustainable alternatives for common tools, making tailor's chalk from eggshells and green apple snail shells was part of the shift to greener production.

The study contributed to several Sustainable Development Goals (SDGs). It supported SDG 9: Industry, Innovation, and Infrastructure by using waste materials to create a new and environmentally

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sustainable tailor's chalk. By addressing a pest problem (apple snail shells) and re-purposing waste (eggshells), it encouraged sustainable industry. It also aligned with SDG 12: Responsible Consumption and Production.

Perhaps the most closely related SDG was this one. Because the study directly addressed the problem of discarded eggshells from food enterprises and apple snails, it demonstrated the principles of responsible consumption and production by reducing waste generation of shells as agricultural waste. It promoted recycling and reuse because it actively worked to keep these waste materials out of landfills by turning them into a valuable product (tailor's chalk). Additionally, it encouraged sustainable resource management by making use of plentiful natural waste and reduced dependency on virgin or chemically treated materials for the manufacturing of chalk.In terms of SDG 15: Life on Land, by finding a use for their shells, the study implicitly supported efforts to manage or reduce the impact of this invasive species, even if not directly eradicating them. Utilizing their shells added an economic incentive for their collection, which could aid in population control.

Lastly, the research aligned with SDG 8: Decent Work and Economic Growth by converting a waste stream into a novel product. Local production plants, raw material collectors, and distribution networks could be setup. These plans helped to stimulate economic growth and create jobs, especially for township communities. By optimizing existing resources, it promoted sustainable economic development.

Accordingly, in the present study, a safe and sustainable tailor's chalks using eggshells and green apple snail shells was developed, which attempted to develop a safer environmental product for consumers' health; while also, filling the gap on its acceptability and use performance tests whether it passed on toxicity heavy metal analysis. It was a move toward less wasteful production methods that were beneficial to the local economy and good for the fashion industry and also, well, for the environment.

Objectives of the Study

The aim of this study is to develop, evaluate and perform heavy metal content analysis on tailor’s chalk produced from eggshell and green apple snail shell based with three different formulation. That is, a safe and green chalk was developed by accomplishing the following objectives: to develop safe and eco-friendly chalks using natural materials with regard to sensory factors (appearance, texture, and odor) based on marking ability, erasability, durability, and water solubility. The study also sought whether the respondents' evaluation differed in relevance between the three formulations. It also tried to determine the heavy metals component of developed chalk, especially mercury and arsenic, through analysis conducted by the Philippine Institute of Pure and Applied Chemistry (PIPAC). Finally, it sought to estimate the cost of production and gather feedback and suggestions from survey participants in order to improve the final product.

METHODS

This study utilized descriptive and developmental research methods to develop and evaluate tailor’s chalk made from eggshells and green apple snail shells. A total of sixty (60) respondents, consisting of 15 Garments Faculty Members, 15 second- and third-year Garments Students from Mindoro State University (Calapan City), 15 Dressmakers, and 15 Tailors from Calapan City, Naujan, and Baco, Oriental Mindoro, were selected using purposive sampling. An evaluation questionnaire developed and validated by the researchers was used to collect data on the chalk’s performance and acceptability in terms of marking ability, erasability, durability, and water solubility. Respondents tested the chalk on fabric and provided written feedback. The product was also subjected to heavy metal testing by the Philippine Institute of Pure and Applied Chemistry (PIPAC) at Ateneo de Manila University to ensure safety.The collected data were recorded, tallied, tabulated, and statistically analyzed to determine the effectiveness of the developed tailor’s chalk and identify areas for improvement.

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Materials and Procedures

Development of Tailor's Chalk using Eggshell (Gallus gallus domesticus, L) and Green Apple Snail Shell (Pomacea canaliculata)

Planning and Preparation

The development of tailor's chalk was planned by identifying the materials and formulation using eggshell (Gallus gallus domesticus) and green apple snail shell (Pomacea canaliculata).

Gathering of Materials

- Eggshell
- Green apple snail shell
- Magnesium silicate
- Acetic acid
- Water-soluble coloring agent
- Natural pure soy Wax
- Measuring cups
- Grinder/processor
- Mortar and pestle
- Electric pot
- Triangle silicone molder
- Mask and gloves
- Hairnet
- Silicone scraper

Processing and Development

1. Preparation of Eggshell and Green Apple Snail Shell Powder
   - Collecting eggshells and green apple snail shells.
   - Cleaning and washing the shells thoroughly under running water to remove dirt, organic matter, and odor.
   - Sun-drying the cleaned shells for two (2) days.
   - Grinding the dried shells using a processor; if not finely ground, using a mortar and pestle to achieve finer texture.
2. Preparation of Chalk Mixture
   - Preparing the binder by combining ordinary chalk, magnesium silicate, kaolin clay, and acetic acid.
   - Adding a water-soluble coloring agent to the mixture.
   - Heating an electric pot and melting the wax.
   - Adding the prepared shell powder and binder into the melted wax.
   - Mixing the ingredients continuously and thoroughly until fully dissolved and well blended.
3. Molding and Drying
   - Pouring the mixture into a triangle silicone molder.
   - Air-drying the molded chalk for one (1) day until hardened.
4. Evaluation of the Developed Tailor's Chalk
   - Testing the developed tailor's chalk in terms of marking ability, erasability, durability, and water solubility.
   - Collecting feedback from respondents to assess the product's performance and acceptability.
   - Conducting safety testing (heavy metal content) to ensure the quality of the developed tailor's chalk.

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Figure 1. *Development and Evaluation of Tailor's Chalk Using Eggshell and Green Apple Snail Shell (Process Flow)*

RESULTS AND DISCUSSION

Summary of Respondents' Evaluation on Tailor's Chalk Made from Eggshell in three formulations

The evaluation results showed that all three eggshell-based tailor's chalk formulations were rated "Moderately Acceptable," with overall mean scores ranging from 3.45 to 3.49. Among them, Formulation 2 obtained the highest mean (3.484), indicating better overall balance in performance and user satisfaction compared to Formulations 1 and 3. In terms of sensory qualities, the chalk was generally acceptable in appearance, texture, and odor, which can be attributed to the calcium carbonate content of eggshells and proper processing methods such as cleaning, drying, and grinding. For performance attributes, odor and durability received the highest ratings, followed by marking ability, showing that the chalk was effective, firm, and produced clear fabric markings. Meanwhile, texture, water solubility, and especially erasability received slightly lower ratings, suggesting areas for improvement, particularly in smoothness and ease of removing markings.

Overall, the findings demonstrate that eggshell-based tailor's chalk is a functional, durable, and eco-friendly alternative to commercial products, supporting the claim of the United Nations Environment Programme (2023) that recycled materials can achieve both functionality and sustainability. Among the formulations, Formulation 2 is the most recommended due to its balanced performance and higher acceptability.

Table 1. *Summary of Respondents' Evaluation on Tailor's Chalk Made from Eggshell in three formulations*

	F1		F2		F3	
VARIABLES	M E A N	VI	M E A N	VI	M E A N	V I
A P P E A R A N C E	3.51	HA	3.55	HA	3.52	H A
TEXTURE	3.36	M A	3.35	M A	3.33	M A
ODOR	3.78	HA	3.66	HA	3.57	H A
MARKING ABILITY	3.64	HA	3.64	HA	3.64	H A
ERASABILITY	3.08	M A	3.21	M A	3.28	M A
DURABILITY	3.67	HA	3.71	HA	3.61	H A
WATER SOLUBILITY	3.12	M A	3.28	M A	3.38	M A
OVERALL MEAN	3.451	M A	3.484	M A	3.478	M A

Legend: *HA = Highly Acceptable
*MA = Moderately Acceptable

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*VI = Verbal Interpretation

Summary of Kruskal–Wallis Test Results on the Differences in Respondents' Evaluation

The Kruskal–Wallis test showed that most attributes appearance, texture, odor, erasability, and durability had no significant differences among the formulations ($p > 0.05$), indicating consistent quality and user perception. This supports Sinha et al. (2020) on the stability of calcium carbonate-based materials. However, marking ability and water solubility showed significant differences ($p < 0.05$), suggesting variations in performance due to formulation factors like particle size and binder content, as noted by Thakker et al. (2021). Overall, the chalk demonstrated uniform acceptability, with improvements needed in marking clarity and moisture resistance, aligning with United Nations Environment Programme (2023) on optimizing eco-friendly products.

Table 2. *Summary of Kruskal–Wallis Test Results on the Differences in Respondents' Evaluation*

Variable	X^2 (chi-square)	Df	P-value	Result
Appearance	7.29	3	0.055	Not significant
Texture	4.85	3	0.183	Not significant
Odor	4.70	3	0.195	Not significant
Marking ability	8.66	3	0.034	Significant
Erasability	4.49	3	0.214	Not significant
Durability	2.86	3	0.414	Not significant
Water Solubility	11.74	3	0.008	Significant

Summary of Respondents' Evaluation on Tailor's Chalk Made from Green Apple Snail Shell in three formulations

All green apple snail shell–based tailor's chalk formulations were rated "Moderately Acceptable" (3.44–3.48), indicating general acceptability in terms of performance and sensory qualities. Among them, Formulation 2 obtained the highest mean, suggesting a better balance of composition, consistent with Wang et al. (2019) on the importance of proper particle size and binder ratio. In individual attributes, appearance and durability received the highest ratings, showing good visual quality and strength, while odor was also acceptable due to proper processing. However, texture, erasability, and water solubility had lower ratings, indicating the need for improvement, which supports Callister and Rethwisch (2020) on the variability of natural materials. Overall, the findings confirm that green apple snail shells are a functional and eco-friendly alternative for tailor's chalk. Formulation 2 is the most recommended due to its balanced performance, aligning with the sustainability goals of the United Nations Environment Programme (2023).

Table 3. *Summary of Respondents' Evaluation on Tailor's Chalk Made from Green Apple Snail Shell in three formulations*

VARIABLES	F1		F2		F3	
	MEAN	VI	MEAN	VI	MEAN	VI
APPEARANCE	3.60	HA	3.60	HA	3.63	HA
TEXTURE	3.36	MA	3.34	MA	3.34	MA
ODOR	3.78	HA	3.55	HA	3.55	HA
MARKING ABILITY	3.68	HA	3.68	HA	3.48	MA
ERASABILITY	3.03	MA	3.22	MA	3.20	MA
DURABILITY	3.80	HA	3.76	HA	3.72	HA
WATER SOLUBILITY	3.03	MA	3.30	MA	3.17	MA
OVERALL MEAN	3.47	MA	3.48	MA	3.44	MA

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Summary of Kruskal–Wallis Test Results on the Differences in Respondents' Evaluation

The Kruskal–Wallis test showed that appearance, texture, odor, marking ability, and erasability had significant differences among the three formulations ($p < 0.05$), indicating that respondents could clearly distinguish variations in sensory and performance qualities. Among these, marking ability had the most significant difference ($p = 0.003$), highlighting the strong influence of formulation factors such as particle size and binder content, as supported by Pradhan and Rout (2020). In contrast, durability and water solubility showed no significant differences ($p > 0.05$), suggesting consistent strength and moisture response across all formulations. This stability aligns with findings of Pliya and Cree (2020) and Azarian et al. (2022), who noted that calcium carbonate-based materials exhibit uniform mechanical and moisture properties. Overall, the results indicate that while sensory and usability attributes vary and require optimization, the chalk maintains consistent structural quality. This supports the potential of green apple snail shells as a reliable and sustainable material, in line with the United Nations Environment Programme (2023).

Table 4. *Summary of Kruskal–Wallis Test Results on the Differences in Respondents' Evaluation*

Variable	X^2 (chi-square)	D f	P-value	Result
Appearance	8.02	3	0.046	Significant
Texture	10.02	3	0.018	Significant
Odor	10.44	3	0.015	Significant
Marking ability	13.61	3	0.003	Significant
Erasability	8.68	3	0.034	Significant
Durability	2.12	3	0.548	Not significant
Water Solubility	7.38	3	0.061	Not Significant

Summary of the Heavy Metal Analysis Results of Eggshell Evaluated by the Philippine Institute of Pure and Applied Chemistry (PIPAC)

The heavy metal analysis conducted by PIPAC showed that the eggshell samples used for tailor's chalk production contained arsenic (<0.3 ppm) and mercury (<0.1 ppm), both of which are below toxic reportable limits. This indicates that the materials are safe for handling and suitable for educational and craft applications. The results were obtained using standard analytical methods such as ash–acid digestion and hydride vapor generation for arsenic, and cold atomic absorption spectrophotometry for mercury, ensuring accurate detection of trace metals. These findings comply with FAO/WHO (2017) safety standards, which recommend very low heavy metal levels for materials used in human-contact applications, particularly in educational settings. Overall, the results confirm that the eggshell-based material is non-toxic, environmentally safe, and appropriate for sustainable tailor's chalk production.

Table 4. *Summary of the Heavy Metal Analysis Results of Eggshell Evaluated by the Philippine Institute of Pure and Applied Chemistry (PIPAC)*

Analyte(s)	Result(s)	Analytical Method(s)
Arsenic,ppm	Less than 0.3	Ashing-acid Digestion/Hydride Vapor Generation Atomic Absorption Spectrophotometry
Mercury,ppm	Less than 0.1	Acid digestion/cold vapor atomic absorption Spectrophotometry

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Summary of the Heavy Metal Analysis Results of Green Apple Snail Shell Evaluated by the Philippine Institute of Pure and Applied Chemistry (PIPAC)

The heavy metal analysis conducted by PIPAC revealed that the green apple snail shell powder contained arsenic (<0.3 ppm) and mercury (<0.1 ppm), both well below hazardous and internationally accepted safety limits. This confirms that the material is chemically safe for use in tailor's chalk production and other human-contact applications. The analysis used validated methods such as acid digestion, hydride vapor generation, and cold vapor atomic absorption spectrophotometry, ensuring accurate detection of trace metals. The low heavy metal content suggests that the shells likely came from a clean freshwater environment, with minimal exposure to pollutants. This is supported by Yousif et al. (2021), who reported that freshwater snail shells from uncontaminated habitats typically contain very low levels of arsenic and mercury. Additionally, Adeyeye and Ayejuyo (2020) noted that mollusk shells, due to their high calcium carbonate content, tend to limit heavy metal accumulation. Overall, the findings confirm that green apple snail shells are safe, non-toxic, and environmentally suitable, supporting their use as a renewable raw material for eco-friendly tailor's chalk production.

Table 5. *Summary of the Heavy Metal Analysis Results of Green Apple Snail Shell Evaluated by the Philippine Institute of Pure and Applied Chemistry (PIPAC)*

Analyte(s)	Result(s)	Analytical Method(s)
Arsenic,ppm	Less than 0.3	Ashing-acid Digestion/Hydride Vapor Generation Atomic Absorption Spectrophotometry
Mercury,ppm	Less than 0.1	Acid digestion/cold vapor atomic absorption Spectrophotometry

Table 6. *Computed cost of Production and Evaluation of Tailor's Chalk using Eggshell and Green Apple Snail Shell*

MATERIALS/TOOLS	
Items	Estimated Amount
Eggshell	Php 140.00
Green Apple Snail Shell	Php 140.00
Acetic acid	Php 60.00
Natural pure soy wax	Php 230.00
Magnesium Silicate	Php 705.00
Colorant	Php 142.00
Mask	Php 30.00
Gloves	Php 120.00
Hairnet	Php 40.00
Mortar and pestle	Php 356.00
Silicone scraper	Php 81.00
Silicone Molder	Php 168.00
Measuring cups	Php 38.00
Liquid measuring cup	Php 66.00
EQUIPMENT	
Blender	Php 1,175.00
Test	

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Arsenic	Php 4,800.00
Mercury	Php 4.500.00
Rush fee	Php 4,650.00
LABOR	
Work labor	1000.00
Total Expenses	Php 18,441.00

CONCLUSIONS

Based on the results of the study, the main problems observed in the eggshell-based tailor's chalk were related to texture, erasability, and water solubility, as these attributes received only moderately acceptable ratings from the respondents. The chalk surface was slightly coarse, which may have affected the smoothness of marking on different types of fabrics. Additionally, some markings were difficult to erase completely, leaving faint residues, and the chalk's reaction to moisture was inconsistent, indicating that its solubility in water was not uniform across all formulations. These issues were likely caused by factors such as uneven particle size of the eggshell powder, an imbalance in the binder composition, and variations in the drying and curing processes during production. In contrast, other attributes such as appearance, odor, marking ability, and durability demonstrated high acceptability, suggesting that the eggshell-based chalk was visually appealing, free from unpleasant odors, produced clear and visible markings on fabric, and maintained sufficient durability for practical tailoring use. These positive results indicate that the chalk has potential as a functional and sustainable alternative to commercially available tailor's chalk.

Recommendations

Based on the findings of the study, some recommendations are made to help improve the quality, effectiveness and sustainability of tailor's chalk from egg shell and green apple snail shells. The first issue is the milling/grinding, this should be improved for a finer and more consistent powder which will help to achieve a better texture, finish and more professional looking tailor's chalk. The binder composition and the drying time must also be such that the chalk leaves a clear mark on fabric which is visible while erasable or washable without leaving stains. Creating a uniform production protocol is also vital to guarantee the strength, solubility and the quality. To make the product more versatile, colour pigments other than natural white shell can be tried. The addition of ecologically safe pigments or dyes, for example blue, red and yellow would increase the visibility effect on other fabric colors and types. It would also be desirable to further investigate the addition of other substances to promote slide and smear during writing on coarse woven fabric material. Moreover, testing of different seawater animal shells for alternative calcium sources might offer further durability and performance advantages. The best performer can then be selected from the tested colour version/material composition and established as production standard for an environmentally sustainable end product that reconciles performance with ecology. Furthermore, the product packaging and labeling should be improved to indicate (safety) aspects what users should know. Clear warnings should be applied to the outer packaging and the product (or its immediate container) to notify consumers of possible hazards. So in your case, the warning would be: CAUTION: NOT FOR PET OR HUMAN CONSUMPTION. It should also read; KEEP AWAY FROM CHILDREN to prevent accidental ingestion. Additionally, since the product is made from shells, a warning regarding potential allergens or the risk of inhaling fine dust during heavy use should be included to ensure the safety and well-being of the consumers.

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