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RESEARCH ARTICLE **OPEN ACCESS**

UTILIZATION OF EGGSHELLS: A PILOT STUDY TESTING OF TOOTHPASTE TABLET PRODUCTION

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ABSTRACT

Eggshells are one of the main contributors to waste, especially in the food industry as it is being generated in large quantities, causing numerous problems in the environment. In addition, toothpaste tubes in landfills take up to 500 years to biodegrade. The researchers found a way to lessen this environmental problem in the Philippines wherein is to provide a sustainable solution to these issues with the means of creating toothpaste tablets. A quantitative research design was used for this experimental study to assess the acceptability of the toothpaste tablets. The research was concluded through a microbial test at the Lipa Quality Control Center, consisting of various test parameters. The formulations consisted of a combination of 50% eggshells and 50% toothpaste solution, as well as 75% eggshells with 25% toothpaste solution. Unfortunately, due to the results of microbiological testing, the processed ingredients cannot be deemed suitable. Most of the outcomes exceeded the average values, which is an undesirable outcome. Consequently, the researchers managed to create a final product that, regrettably, was determined to be unsafe based on microbial test results. Nevertheless, the idea of developing toothpaste tablets using food waste holds promise as a sustainable practice and a potential research avenue to explore.

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INTRODUCTION

Eggshells, specifically when pulverized or crushed, have a variety of valuable applications, such as a natural calcium supplement, a coffee sweetener, a therapy for mild skin irritations, a nontoxic abrasive cleanser, compost for gardens, and insect control, to name a few (Aguirre, 2019). In culinary and cooking, eggs are used in various ways, making them a versatile, valuable ingredient in any food preparation. Correspondingly, as eggs are used in large quantities in making products relating to the food industry and manufacturing, the amount of waste incurred and its high disposal cost have gone unnoticed (Patil, 2021). One of the most discarded food wastes is eggshell (Baláž *et al*., 2021), and it is detrimental to our environment as it adds to pollution due to odor production and microbial growth. If the amount of eggshell waste is calculated in the Philippines, Beruño *et al*. (2022) asserted that around 4.24 million tons of eggshell waste are produced by one of the Philippines' agricultural businesses, equating to 4,020 metric tons of daily waste. The researchers devised this experimental study and opted for a product that people could use regularly. This study highlights the importance of repurposing organic waste by creating a product that employs eggshells as a primary component rather than discarding them.

According to Waheed *et al*., eggs are a good source of nutrients and contain many nutritional and non-nutritional elements in their shell. As they are a rich source of minerals like calcium, it is also a good component for toothpaste tablets. Inaddition, sesame seeds are among the additional components that will be included. Natural remedies are often used for medical purposes, and sesame seeds are also highly regarded for their nutritious properties (Tanevitch *et al*., 2020). The more advanced and contemporary form of toothpaste's traditional uses is toothpaste tablets, in which the toothpaste formula is compressed into a tablet form that should be chewed before brushing. It is a good alternative due to its portability, convenience, less packaging waste, and ease of use (Mohite & Mirani, 2023). It is easy to use as the tablet shall be chewed for at least 5 seconds before using a wet toothbrush to brush the teeth. It also promotes less packaging waste, as toothpaste tubes are detrimental to our environment. These tubes are difficult to disassemble and recycle due to their materials and remnant toothpaste inside (Malea *et al*., 2020). Polymers and metal layers are used to create toothpaste tubes, and these materials cannot be recycled as it is tough to remove. It can also take 500 years for toothpaste tubes to biodegrade fully, and as toothpaste is essential to our daily lives, the tubes only end up in landfills (Surawase, 2022). The final product shall be in tablet form, as this is an immense alternative to toothpaste tubes.

This solution and alternative are beneficial since they encourage people to reduce food waste and become sustainable in the long run. Moreover, toothpaste tablets aim to promote a plastic-free concept and a sustainable oral care solution while having the same benefits as our usual toothpaste (Suppipat *et al*., 2022). Because of the world's rapid population growth, people should be aware of the importance of sustainability, and even a simple, environmentally sustainable solution for wastedisposal is a good practice (Khan & Banerjee, 2020). It is even timely to this generation, whereas it is easier to foster the benefits of an eggshell toothpaste tablet and to stress the value of repurposing and using organic waste.

METHODOLOGY

The researchers used experimental research to determine the effectiveness and acceptability rate of the two experimental treatments, which are 50% eggshells with 50% toothpaste solution and 75% eggshells with 25% toothpaste solution. The design was chosen to assess the differences between the experimental treatments regarding their acceptability and microbial count. In this experimental study, microbial testing was employed to evaluate the product's acceptability. The microbial test results were based on established guidelines, including the US Food & Drug Administration Bacteriological Analytical Manual, the 3M Petrifilm E. coli Coliform Count Plate Interpretation Guide, and BIOTECH-UPLB standards. These standards served as the framework for assessing several key test parameters, namely the Total Plate Count (CFU/g), E. Coli Count (CFU/g), Salmonella Detection, Yeast Count (CFU/g), and Mold Count (CFU/g). The Bacteriological Analytical Manual is an approved laboratory method by the FDA for detecting pathogens, including bacteria, viruses, parasites, yeast, and mold, in food and cosmetic products. It offers two approaches for determining aerobic plate counts: the Conventional Plate Count Method and the Spiral Plate Method, aligning with standards set by the Association of Official Analytical Chemists (AOAC) and the American Public Health Association (APHA). The 3M Petrifilm Coliform Count Plate is a sample-ready culture medium system designed to simplify colony counting through the use of modified Violet Red Bile nutrients, a cold-water-soluble gelling agent, and a tetrazolium indicator. Additionally, the BIOTECH-UPLB standard was employed for Salmonella Detection, using DASTM kits from BIOTECH in a PCR-based method to identify foodborne pathogens. The researcher employed microbiological analysis, which involves biological, biochemical, and chemical methods for microorganism identification and quantification, using laboratory test results to gather information. This approach is commonly used for assessing pathogenic and spoilage bacteria. The researcher monitored and documented microorganism counts, with results typically available within three to five days, reporting on Total Plate Count, Salmonella, E. Coli, Yeast, and Mold cases. Furthermore, the researcher sought recommendations for additional tests to be conducted on the finished product.

This experimental study relied solely on the information from the microbiological test results since the laboratory results can only be obtained through formal tests completed by the selected testing center. To avoid bias and manipulation, the researchers will ensure their findings are reliable and consistent. The researchers obtained eggshells during the process of obtaining the specific materials in an ethical manner while requesting authorization for the mentioned ingredient. One of the goals of the study was to adopt sustainability practices, so eggshells were obtained from the respective houses and the college every after-kitchen laboratory. Moreover, the study extensively examined the efficacy and safety of toothpaste through thorough microbiological analysis. The primary objective was to comprehensively assess the toothpaste's performance in terms of both effectiveness and safety, with microbiological analysis serving as the core of the study's objectives. The investigation delved into various aspects of toothpaste's impact on oral health, including changes in oral bacterial count, the specific microbial strains influenced by toothpaste, and alterations in the oral microbiome resulting from long-term use. These examinations aimed to provide crucial insights into toothpaste's influence on oral health, including its ability to reduce bacterial populations and its effects on different microbial strains. Additionally, the study aimed to offer a more holistic understanding of the long-term impact of toothpaste on the oral microbial community.

RESULTS AND DISCUSSIONS

The study's outcomes hold significance for both psychological theory and clinical dental treatment by underscoring the potential benefits of incorporating eggshells and sesame seeds into toothpaste formulations, aligning with the idea that natural ingredients can have positive effects. These ingredients, known for their remineralization and antimicrobial properties, contribute to promoting dental health and catering to environmentally conscious consumers by adjusting pH, reducing abrasiveness, and combating mouth infections for enhanced cleanliness. The study also recommends further research to enhance fluoride content and focus on bacterial growth removal through microbial testing, emphasizing the importance of investigating relationships, impacts, and perceptions to gain comprehensive insights. In conclusion, this study lays the foundation for a comprehensive natural approach to oral healthcare. Regarding the microbiological results, two samples (752 and 505) both utilizing eggshells as a key ingredient tested negative for E. coli and salmonella, suggesting a level of safety. However, sample 505 exhibited a lower Total Plate Count (7.2 x 10^3 CFU/g) compared to sample 752 (2.5 x 10^4 CFU/g), indicating a lower bacterial colony presence. While Total Plate Count alone does not determine the presence of hazardous bacteria, it should typically range between 25 and 250 for APC.

Table 1. Materials

Material	Source	Specification
Sodium Bicarbonate (Baking Soda)	Supermarket (Waltermart Sta.Rosa)	250grams
SesameSeeds	Waltermart	100grams, roasted and powderized
Xylitol	Shopee	100grams, powdered
Eggs hells	Food waste from LPU Laguna–Laboratories and from the house holds	1kg boiled and dried eggshells, turned into a fine powder
Coconut Oil	Shopee	500 ml
Flavoring (Peppermint)	Supermarket (Waltermart Sta.Rosa)	20ml
Oven	Home equipment	1pc
PillPressMachine	Shopee	1pc,12mm
MixingBowls	Home equipment	300g,10pcs
Grinder/Blender	Home equipment	1pc
Sifter	Home equipment	1pc
Microscale	Shopee	1pc
Spoons	Home Equipment	5pcs
Pot	Home equipment	Large,1pc
Hammer	Home equipment	1pc

In terms of yeast and mold counts, sample 505's mold count exceeded the allowable range of 10 or fewer colonies per gram, according to the Food and Drug Administration. The researchers conducted these tests as their product contained food components, which made Total Plate Count a suitable parameter for assessing bacterial population. However, APC cannot distinguish harmful pathogens and toxins. The difference in Total Plate Count between the samples may be attributed to various factors such as temperature, moisture, and oxygen, though further analysis is needed to confirm the cause. The decision to include E. coli testing was made because untreated food can harbor this bacterium, and the researchers used heat to somewhat sterilize their product.

Table 2. Standardized Recipe for CODE 505 Experimental Solution

Code 505	Experimental solution		
Yield	150.4g		
Ingredients	Specification	Quantity	Unit
Eggshells	Boiled, dehydrated	76.4	Grams
Sesame seeds	Powdered	74	Grams

Table 3. Standardized Recipe for CODE 505 Toothpaste Solution

Code 505	Toothpaste solution		
Yield	150.6g		
Ingredients	Specification	Quantity	Unit
Baking soda		54	Grams
Xylitol	Powdered/granulated	61.1	Grams
Coconut oil		20.4	Grams
Mint oil		15.1	Grams

Table 4. Standardized Recipe for CODE 752 Experimental Solution

Code 752	Experimental solution		
Yield	224.4g		
Ingredients	Specification	Quantity	Unit
Eggshells	Boiled, dehydrated	76.4	Grams
Sesame seeds	Powderized	74	Grams

Table 5. Standardized Recipe for 752 Toothpaste Solution

Code752	Toothpastesolution		
Yield	76.8g		
Ingredients	Specification	Quantity	Unit
Bakingsoda		20.40	Grams
Xylitol	Powdered/granulated	26.00	Grams
Coconutoil		15.30	Grams
Mintoil		15.10	Grams

Table 6. Code 505 Toothpaste Formulation

Code505	Amount(g/ml)	Percentage
Baking Soda	13	17%
Xylitol	15	20%
Coconut Oil	5	7%
Flavoring	4	5%
Sesame Seeds	18	50%
Eggshell	19	

Table 7. Code 752 Toothpaste Formulation

Code752	Amount(g/ml)	Percentage
BakingSoda	5	9%
Xylitol	6	10%
CoconutOil	4	3%
Flavoring	4	3%
SesameSeeds	24	
Eggshell	32	75%

Both samples had E. coli counts of less than ten colonies, indicating a relatively low presence of this bacterium. As for salmonella, the researchers included this test as a precaution, given their use of eggshells as a key component, even though they took measures to clean and sterilize the shells. Both samples tested negative for salmonella. The yeast and mold count detects fungal growth and yeast colonies and is typically considered safe at levels of less than 10 per gram for food products. In this case, the researchers followed this regulation, but the results revealed a significant presence of yeast andmold colonies above the allowable limit, which they attribute to the sample's formulation and moisture content as the primary cause of mold growth. After examining the results of the various microbial tests, the researchers concluded most of which revolve around the safety of the product. Upon inspection the samples were very far in terms of safety such that both samples contain many bacterial colonies which could be hazardous to humans, Moreover, the abnormal amount of yeast, which is present in sample 752 makes it even more hazardous. Taking into consideration the process of how and where the two samplers were made, the most plausible factor that made the difference was the ratio of experimental to toothpaste formula. In conclusion, the data shows that both samples are microbially unsafe and potentially hazardous, except for sample 505 showing slightly better results, though still unsafe, sample 505 contained fewer bacterial colonies and a large discrepancy of yeast colonies compared to sample 752.

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