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RESEARCH ARTICLE OPEN ACCESS

DEVELOPMENT OF AN ORGANIC DE-LIMER AND POLISHER USING THE ACID FROM AVERRHOA BILIMBI (KAMIAS FRUIT): A SUSTAINABLE SOLUTION FOR INDUSTRIAL CLEANING

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ABSTRACT

The central aim of this research was to explore the feasibility of utilizing an organic cleaning solution as an alternative to chemical agents for eliminating watermark stains on stainless steel kitchen countertops, windows, and equipment. The primary objective was to mitigate the adverse environmental impacts associated with descaling agents. The research employed an experimental design to test formulations of Kamias delimer solutions for their total acidity and the reduction of pathogens such as salmonella, E. coli, and staphylococcus. Maintenance employees and culinary students familiar with standard cleaning processes were surveyed to gauge their opinions on the product's use. Averrhoa bilimbi, with its high citric acid content, presented as an effective solution for removing tarnish, stains, and oxidation from metals, leaving a remarkable shine. The Kamias Delimer, with a total acidity of 5.69 pH, proved effective in reducing pathogens by up to 99.99% within a 10-minute contact period. Survey respondents positively endorsed the use of the kamiasdelimer solution. The findings from this research initiative will provide valuable insights in Barangay San Ildefonso, Alaminos Laguna, contributing to the development of eco-friendly and sustainable cleaning solutions suitable for the local community. This investigation adds to the expanding knowledge about sustainable cleaning methods, aiming to optimize the utilization of Kamias fruit.

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INTRODUCTION

The researchers' concerns about environmental damage and the need for sustainable ways have increased the emphasis on developing eco-friendly solutions in various businesses. The creation of cleaning goods and Delimer formulations is one sector that is undergoing tremendous change. Many typical cleaning solutions include harsh chemicals that can harm the environment, from manufacturing through disposal. As a result, there is a growing effort to develop greener alternatives that employ natural materials and can degrade without causing harm. Kamias Fruit offers an ecologically friendly alternative to typical cleaning procedures. In contrast to chemical-laden cleaning solutions, Kamias fruit, with its natural acidic qualities, provides an efficient and biodegradable cleaning choice. Using Kamias as a cleaning agent can help reduce traditional cleaning practices' environmental concerns. This shift is taking place because consumers are becoming more aware of the negative impacts of traditional methods and desire healthier items for the environment. Developing an organic Delimer harnessed from a naturally occurring source offers a promising solution to mitigate these concerns. Kamias fruit (Averrhoa bilimbi) is a fruit-bearing tree of the genus Averrhoa, family Oxalid Acid; it lives for many years, particularly when well cared for. The mature Kamias tree can reach between 5 and 10 meters in height; its trunk is relatively short and can quickly divide into several branches. The trunk and branches must be exposed to sunlight for fruits to form. In addition, the Kamias tree blooms in February and continues to blossom and produce fruits until December (Yap, 2018). This constant and protracted fruiting cycle demonstrates the Kamiastree's sustainability, demonstrating its capacity to supply fruits consistently throughout the year. This attribute emphasizes the tree's remarkable environmental resilience. Furthermore, according to Seebaluck-Sandoram et al. (2019), the extracts from Kamias fruit can stop the growth of certain types of bacteria, including Escherichia coli, Salmonella spp., and Staphylococcus aureus. In addition, Kamias contains active compounds such as saponins, glucosides, tannins, flavonoids, citric acid, formic acid, pectin compounds, flavonoids, vitamin C, minerals, calcium oxalate, and potassium (Julianti and Sinaga., 2021). According to the British Stainless-Steel Association (2023), Citric acid can be used for cleaning and passivating stainless steel as an alternative to nitric acid. Solution strengths of 5–10% citric acid are used for passivation treatments. This study suggested an opportunity for locally sourced, ecologically friendly, sustainable solutions. Developing an all-natural product emerged as one possible solution for eliminating limescale and polishing surfaces. From the researcher's perspective, it was evident that Barangay San Ildefonso

in Alaminos, Laguna, faced a challenge in fully capitalizing on the potential of Kamias. While some residents incorporated Kamias into their culinary creations, others harvested the fruit and sun-dried it. Unfortunately, a portion of the fruit went to waste as it fell from the tree and rotted. The researchers perceived this scenario as a promising opportunity to optimize Kamias usage, not only as a culinary element but also as a valuable Cleaning Agent. Through this study, the Barangay could have effectively reduced the unnecessary waste of Kamias, yielding tangible benefits.

METHODOLOGY

The research aimed to assess the effectiveness of Kamias acid in removing limescale and polishing metal surfaces. It used experimental methods with two different acidic formulations to study their impact on removing stains from various surfaces. The chosen design compared the acidity levels in these formulations for cleaning stainless steel surfaces. Respondents, including maintenance employees, culinary custodians, and cafeteria staff, were selected based on their product experience and responsibilities for cleanliness.

A group of 30 participants from the Lyceum of the Philippines University Laguna provided insights through a survey questionnaire, using a 4-Likert scale for data collection. The research intended to determine the acid's efficiency for cleaning purposes based on the feedback from these participants. According to Bartkowski (2022), formulation development holds a pivotal role in product creation, impacting patent eligibility, lifespan, and the overall triumph of the product. Organizations incorporate formulation development processes and staff into their product development phases through various approaches, aiming to bring forth their unique offerings. Researchers took safety precautions by wearing safety goggles, gloves, and protective clothing to prevent exposure to potential hazards such as chemicals and physical contact. The precautions aimed to protect against eye injuries, chemical absorption, and burns. For the study, respondents were selected based on their experience with the product. Maintenance employees, culinary custodians, and cafeteria staff participated in a survey to gather insights using a 4-Likert scale, focusing on food preferences. Thirty participants from Lyceum of the Philippines University Laguna provided their input for the researchers' Survey Questionnaire.

Table 1. Materials and Equipment

Materials	Source	Quantity
Kamias	Kamias tree (Brgy. San Ildefonso, Alaminos, Laguna)	500grams
Distilled Water	Supermarket	500grams
Rubber Spatula	Supermarket	1 unit
Clear Spray Bottle (2 oz)	Supermarket	2 Bottles
Sauce pot (4.3” x 7”)	Appliances Shop	1 unit
Butane Stove	Appliances Shop	1 unit
Strainer (0.032, 324 holes/Sq. In., 28% open area)	Appliances Shop	1 unit
Ceramic Dish Bowl (H2.1” x D6.8”)	Appliances Shop	2 Bowl
Wooden mortar and pestle (10.3cm x 8cm)	Appliances Shop	1 unit
Stainless Chef Knife (8inch)	Appliances	1 piece
Vinyl Gloves	Online Shop	1 Box of 100

Table 2. Kamias Delimer Product A

Qty per Bottle:	60 ml	Yield:	5 Bottles
Method:	Boiling	Category:	Product A Delimer
Ingredients	Specifications	Quantity	Unit
Kamias	Washed	500	grams
Water	Distilled Water	242	grams

Mise en Place & Method of Work:
1. Prepare 500g Kamias by washing and rinsing under cold running water.
2. Weigh 242g of water, then transfer it to a clean ceramic dish bowl.
3. Using a Knife and Chopping board, chop the kamias into small pieces and transfer in other dish bowl.

Extracting Acid:
1. Using the mortar and pestle, pound the chopped Kamias until all the solution have been extracted.
2. Strain all the extracted solution and make sure no traces of flesh from Kamias.
3. After extracting the solution, transfer it into a clean sauce pot.
4. Boil the juice for 10–15 minutes at 212°F or until watery paste can be seen.
5. Once observed, let it cool down for at least 5 minutes or until room temperature.
6. Fill the bottle with the solution, the acid to the bottle 30%=21.1 grams of Acid and 70% = 48.4 grams of water.

Table 3. Kamias Delimer Product B

Qty per Bottle:	60 ml	Yield:	5 Bottles
Method:	Boiling	Category:	Product B Delimer
Ingredients	Specifications	Quantity	unit
Kamias	Washed	500	grams
Water	Distilled Water	250	grams

Mise en Place & Method of Work:
1. Prepare 500g Kamias by washing and rinsing under cold running water.
2. Weigh 250g of water, then transfer it to a clean ceramic dish bowl.
3. Using a Knife and Chopping board, chop the kamias into small pieces and transfer in other dish bowl.

Extracting Acid:
1. Using the mortar and pestle, pound the chopped Kamias until all the solutions have been extracted.
2. Strain all the extracted solution and make sure no traces of flesh from Kamias.
3. After extracting the solution, transfer it into a clean sauce pot.
4. Boil the juice for 10–15 minutes at 212°F or until watery paste can be seen.
5. Once observed, let it cool down for at least 5 minutes or until room temperature.
6. Fill the bottle with the solution, the acid to the bottle 18%=10.7 grams of Acid

And 82% = 50grams of water.

The survey test parameters assessed various characteristics of a new cleaning product derived from Kamias acid. Firstly, it examined the product's effectiveness in eliminating dirt, bacteria, and impurities, particularly its ability to remove watermarks, a crucial factor impacting consumer decisions. Secondly, the evaluation focused on the product's odor, considering the importance of a pleasant scent in the perception of cleanliness. The researchers' product boasted a subtle Kamias citrus fragrance that dissipated after use. Thirdly, the texture after using the product was scrutinized, revealing that unlike traditional De-limers, this new product left no oily residue, ensuring a smooth, texture-free surface. Safety was another crucial aspect; the product was found to be safe, not causing skin irritation upon contact. However, despite these positive findings, the researchers recommended precautionary instructions for safe handling, emphasizing factors such as proper storage, keeping it away from children, and avoiding eye contact. Finally, the evaluation considered the product's physical appearance, noting that due to its organic nature, it might not appeal to all users, and the visible powder from the acid in the bottle could impact its visual appeal. Overall, the evaluation showcased the product's cleaning efficiency, a pleasing but non-persistent odor, absence of residue, safety for skin contact, while also highlighting concerns about its appearance and the need for careful handling to prevent accidents. Researchers conducted a laboratory test at Lipa Quality Control Inc. to evaluate a homemade organic Delimer made from Kamias acid. The aim was to determine its acidity level and marketability for consumers, involving a group of 30 participants for the evaluation. Data from this test will be used to create a comprehensive report that includes methods, analysis, and suggestions for future research. Credible sources were emphasized for accuracy. The Kamias extract was used to create a pH indicator for subsequent product tests. Understanding Kamias' acidity and components aids in determining its potential uses. Ethical considerations include informed participant consent, safeguarding identities, and using data solely for research purposes.

Table 4. Formulations of Kamias Delimer

	Product A		Product B	
Acid	30%	21.1 g	18%	10.7 g
Water	70%	48.4 g	82%	50 g

RESULTS AND DISCUSSIONS

Table 5. The Acidity of Kamias Delimer

Test Parameter	Results	Replicates	Test Method
Total Acidity %	5.68	2.04x: 5.84: 5.63	Titrimetric Method

The pH (Libretexts, 2023) of the solution experiences a gradual rise. Close to the equivalence point, which marks the juncture where the moles of added acid match the moles of initial acid in the solution, the pH ascends more steeply. This is due to the depletion of the majority of the originally present H+ ions. When titrating a monoprotic strong acid (HCI) with a monobasic strong base (NaOH), it can be computed to the volume of base required to achieve the equivalence point using the following correlation: *Averrhoa bilimbi* is a supplement thick, dull natural product that fundamentally develops in the storage compartment of tall plants. It contains a great deal of nutrients, (Vazhacharickal, 2017c). The first will be 15% acidity with 85% measure of water and the subsequent one is 10% sharpness and 90% of water.

Table 6. Kamias Delimer against Salmonella spp

	Contact time	5mins	8mins	10mins
Salmonella spp	% Reduction	0.00%	0.00%	0.00%

In the laboratory study focusing on Kamias' acid, researchers found that it only resulted in a 0.00% reduction in salmonella spp. The natural acidity of Kamias is graded at 5.68; however, the eradication of salmonella requires additional chemicals so that it can successfully eliminate the microorganism. Despite efforts to prevent salmonella spp infections, it remains a prominent cause of acute diarrheal illnesses, as noted by Gabr Popaet al. (2021). Julie Garden-Robinson's work in 2020 emphasizes that Kamias' inherent acidity is insufficient to effectively eliminate salmonella spp., unlike commercial De-limers which demonstrate this capability. According to Huang Gua Shu's (2017) research suggests that Kamias extract, like other natural substances, possesses potential antimicrobial properties due to its acidic composition and various acids present. According to Abraham (2017), although Kamias' acidity within the pH range of 0 to 14 might hinder the growth of certain bacteria, it falls short in completely eradicating the bacteria itself. This proves that the kamiasdelimer has enough acidity to kill the E.coli bacteria. The kamiasdelimer at 5.68 pH acidity has been enough to eradicate 99.99% of the E. coli bacteria after 5 minutes of exposure.According to Carol DerSarkissian (2017), Escherichia coli is present not only within the human intestine but also in contaminated food and beverages. Kamias are known for being naturally rich sources of phytochemicals used for both consumption and natural antimicrobial agents that are usually used for cleaning because it has multi-purpose(Pascale Mosoni, 2022). In addition, phytochemicals are known as plant protection agents from microbial infections or pest infestations and serve as a plant defense mechanism (Pant et al. 2017). Kamias contain phytochemicals like amino acids that contain a pH level from 5.0 to 6.5; amino acid surprisingly can kill E. coli (Yan, 2019).

Table 7. Kamias Delimer against Escherichia Coli

	Contact time	5mins	8mins	10mins
Escherichia Coli	% Reduction	99.9%	99.9%	99.9%

This proves that the kamiasdelimer has enough acidity to kill the E.coli bacteria. The kamiasdelimer at 5.68 pH acidity has been enough to eradicate 99.99% of the E. coli bacteria after 5 minutes of exposure.According to Carol DerSarkissian (2017), Escherichia coli is present not only within the human intestine but also in contaminated food and beverages. Kamias are known for being naturally rich sources of phytochemicals used for both consumption and natural antimicrobial agents that are usually used for cleaning because it has multi-purpose (Pascale Mosoni, 2022). In addition, phytochemicals are known as plant protection agents from microbial infections or pest infestations and serve as a plant defense mechanism (Pant et al. 2017). Kamias contain phytochemicals like amino acids that contain a pH level from 5.0 to 6.5; amino acid surprisingly can kill E. coli (Yan, 2019).

Table 8. Kamias Delimer Against Staphylococcus aureus

	Contact time	**5mins**	**8mins**	**10mins**
Staphylococcus aureus	% Reduction	82.56%	93.27%	97.89%

It shows the percent reduction of staphylococcus aureus with varying contact times with the kamiasdelimer. In just 5 minutes, the solution effectively reduced the bacteria by 82.56%. After 8 minutes, 93.27% success rate of removing Staphylococcus aureus bacteria. Ten minutes or more is the recommended contact time of the kamiasdelimer as a high reduction rate has been achieved after such duration. Staphylococcus aureus is a type of bacteria that can not be easily eliminated by heat treatment and sanitizing chemicals; it is also antibiotic-resistant. Therefore, researchers carried out a study that demonstrates the acid from Kamias fruit may effectively decrease the spreading of the bacteria Staphylococcus aureus from metal and glass surfaces. The organic Delimer removes 97.89% of S. aureus and works best when applied in 10 minutes. The summary encompasses insights from data depicting employee age disclosure rates, showing higher responses from older workers experienced in cleaning agents. It also indicates a predominant male representation in the cleaning industry, reflecting gender-based preferences and traditional perceptions regarding task performance.

Table 9. Demographic Profile of the Respondents

Age	Frequency	Percent
Lessthan30	8	21.6
31to39	6	16.2
40to49	10	27
50ormore	9	24.3
Notidentified	4	10.8
Total	37	100
Sex	Frequency	Percent
Male	19	51.4
Female	18	48.6
Total	37	100
Job	Frequency	Percent
Maintenance	14	37.8
Custodian/ Front desk	6	16.2
Others/Not identified	17	45.9
Total	37	100

Table 10. Summary of Survey Results

Indicator	Product A Mean	Product B Mean	Verbal Interpretation
1 The product produces a effective result after using it.	3.19	3.24	Agree
2. Odor of the product.	3.30	3.22	Agree
3. The product is safe to use.	3.27	3.30	Agree
4. No oily feel.	3.24	3.32	Agree
5. The product's external appearance is marketable.	3.16	3.24	Agree

Conversely, female representation is relatively lower and often attributed to distinct job-specific qualities.A distribution analysis among respondents highlights a diverse range of employment roles, notably showing a significant presence in the "Others/Not Identified" category. The representation emphasizes the need for a comprehensive assessment and potential reclassification to adapt to evolving job roles.Custodians and front desk employees, chosen as respondents due to their frequent use of the Delimer in cleaning, offer valuable expertise for improving the product's performance. The comparison between Products A and B in Table 12 provides an overview of participants' opinions on various crucial product qualities. This assessment covers the effectiveness after use, odor, safety, absence of an oily sensation post-use, and the marketable external appearance of the products. Safety received the highest mean scores for both items, with Product B slightly outperforming Product A, indicating a positive perception of safety for both products and highlighting an essential aspect of customer satisfaction. However, the lowest mean score was attributed to the marketability of the products' external appearance, suggesting potential room for improvement in the visual appeal of Product A. Feedback from a group of ten culinary students positively reviewed the researchers' product, acknowledging its efficiency in eliminating glass watermarks, its effectiveness as a de-limer, and its conformity to safety standards. This feedback signifies widespread agreement on the product's effectiveness and safety, emphasizing its favorable reception among users.

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