

Research Article

## Acceptability of Kamias (*Averrhoa bilimbi* L.) fruit extract as an additive for dishwashing liquid

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### Abstract

Recently, there has been a growing interest in utilizing natural additives in household cleaning products to promote sustainability and reduce chemical usage. Kamias (*Averrhoa bilimbi*) fruit, known for its acidic properties and potential antimicrobial effects, presents a viable alternative for enhancing the quality and safety of dishwashing liquids. The present study was conducted to utilize Kamias (*A. bilimbi*) fruit extract as an additive in the production of dishwashing liquid. Physical and microbial tests were performed to ensure the dishwashing liquid's quality, consistency and microbial safety. These tests measured pH, specific gravity, total plate count, *Staphylococcus aureus*, and *Escherichia coli* detection. A 4-point Hedonic scale using a modified sensory evaluation tool was used to describe the acceptability of the dishwashing liquid in terms of appearance, fragrance, texture (hand-feel), longevity of suds, degreasing power, and overall quality. The study showed that the appearance ( $\bar{x} = 3.50$ ), degreasing power ( $\bar{x} = 3.57$ ), and overall quality ( $\bar{x} = 3.63$ ) of Kamias fruit extract dishwashing liquid were liked very much. The texture (hand-feel) was interpreted as liked moderately, with a mean value of 3.47. In terms of fragrance ( $\bar{x} = 3.40$ ) and longevity of suds ( $\bar{x} = 3.20$ ), the Kamias dishwashing liquid was liked moderately. Data also showed that Kamias dishwashing liquid has a pH (7.00 @ 22.2°C) in the neutral range and a specific gravity of 1.0290, which indicates its density relative to water. Furthermore, the detected microbial count demonstrated a significantly low microbial load ( $<10^{\text{Est}}$ ) as determined by the total plate count data. The absence of *S. aureus* and *E. coli* indicated a hygienic state, increasing the sample's safety quotient across various applications.

**Keywords:** Acceptability, *Averrhoa bilimbi* L., Fruit extract, Dishwashing Liquid, Hedonic scale, Microbial evaluation

### INTRODUCTION

*Averrhoa bilimbi*, popularly known as "kamias" is a perennial tree thought to have been intentionally introduced to the Philippines and in other tropical countries (Datiles, M. J., 2022). It can grow in semi-wild conditions, in backyard (Ravindran, 2017), and home gardens (Swedha, 2022). It is grown through seed propagation and became popular as a source of food and medicine. This species is one of the two species in the Oxalidaceae family that gained commercial interest due to its fruits (Datiles, M. J., 2022). Kamias fruit has been the subject of numerous research studies not just as a

food commodity but also on its components and bioactivity. Kumar *et al.* (2013), Hasanuzzaman *et al.* (2013) and Garg *et al.*, 2022 explored the pharmacological effect, phytochemical content and antimicrobial properties; Swedha (2022) established a theoretical basis for the medicinal use of kamias leaves and fruits in the treatment of various diseases; Abraham (2016) identified secondary metabolites such flavonoids, coumarins, saponins and phenols and different extracts yield presence of various phytochemical components; and Leliqia and Safitri (2021), revealed the antibacterial activities of Kamias fruits. Additionally, research by Gupta and

Gupta (2024) highlights the fruit's unique chemical profile, which contributes to its effectiveness in various therapeutic and industrial applications. These findings underscore the fruit's relevance in both nutritional science and pharmacological research, expanding its potential uses. However, the extremely acidic and sour nature of the fruit's juice (Alhassan *et al.*, 2016; Ariyasona and Wathugala, 2023) makes the fruit useful but underutilized most of the time. Swedha (2022) described Kamias as an underutilized perennial evergreen plant. Recent studies suggest that increased research and development could overcome these barriers and unlock its full potential for both nutritional and medicinal applications (Jayawardane *et al.*, 2022).

With the unselective nature of kamias on soil preference, it tends to grow easily on most types of soil. Soil that is well-drained, rich, and moist is the preferred soil type of kamias. However, it also grows and fruits well in sandy and limestone-rich soil type (Kamrul Islam Siddique, 2013). Kamias favors good sunlight exposure and does not propagate good in shady area. When very young, it is sensitive to cold temperatures (Kumar *et al.*, 2013). Studies by Afifah *et al.* (2021) demonstrate that Kamias can thrive in various soil types, including acidic, alkaline, and loamy soils, which enhances its potential for cultivation in different regions. This adaptability is attributed to the plant's robust physiological mechanisms, allowing it to efficiently utilize available soil nutrients (Chitra *et al.*, 2023). The fruit's tolerance to various soil conditions underscores its versatility and resilience, making it a valuable crop in both agricultural and ecological contexts.

Cebu, one of the islands in the Philippines, is a suitable home to kamias, with most of its land exposed to seawater (Carating *et al.*, 2014), making most of the island's geographical zone a coastal lowland area. Soils in lowland areas are made of weakly developed sandy soils which is common to alluvial plains and coastal areas (Asio *et al.*, 2009). These soil characteristics of Cebu make it a good thriving habitat for kamias. It is found in semi-wild conditions in countries like Indonesia and the Philippines (Ravindran, 2024).

Nowadays, in pursuing natural and low-cost dishwashing liquid, recent integrations have been made for the product to become cheaper and consumer-friendly for daily use. Hence, citrus fruits like calamansi, lemon, and the like are integrated to make it more natural in the eyes of the consumers. These citrus fruits were known to have an antibacterial properties (Afroja *et al.* 2017), which can enhance the cleaning potential of the dishwashing liquid. Studies conclude that *Averrhoa bilimbi* contains oxalic acid (Lao, 2015; Ferreira *et al.*, 2021) which is used as a bleaching agent for kitchen wares. They highlight that the fruit's high oxalic acid content contributes to its effectiveness in removing stains and enhancing the cleanliness of kitchen wares.

Garg *et al.* (2022) examine the oxalic acid content and antibacterial properties of *A. bilimbi*, highlighting the dual benefits of the fruit in practical applications. Their research underlines how oxalic acid contributes to its use as a bleaching agent, while the antibacterial properties enhance its effectiveness in maintaining cleanliness and hygiene. Furthermore, the fruit extract contains antibacterial properties (Abraham, 2016) and is suitable for dishwashing liquids used as additives. Similarly, Iwansyah (2021) explores the antibacterial properties of *A. bilimbi* fruit extract, confirming its efficacy against a range of bacterial strains. Their study emphasizes the extract's potential for use in natural antibacterial formulations, including its role in disinfecting and preserving kitchen environments. They concluded that the concentrations found in the fruit extract have a strong effect against *Staphylococcus* and *Bacillus* bacteria, which are common causes of diseases. According to Zulwazi *et al.* (2023), eco-friendly dishwashing liquid soap can be produced as one of the initiatives that can replace dishwashing soap containing chemicals. This is because the product is created from natural materials and is suitable for people of all ages. The present study explores the possible tendency of kamias (*A. bilimbi*) as an ingredient in dishwashing liquid. The interest in this study arises from the fact that kamias is a common fruit-bearing tree in the locality and the presence of phytochemical and antibacterial components revealed in various studies.

## MATERIALS AND METHODS

### Research design

The study used a quantitative research method following the experimental design, which involves an experimental approach using a formulation of Kamias (*A. bilimbi*) fruit extract as an additive in dishwashing liquid. This experimental research design is a structured framework of protocols and procedures created to conduct experimental research with clarity and transparency (Sirisilla, 2023). Formulations without Kamias fruit extract were not included in this study to specifically focus on evaluating the unique properties and potential benefits provided by the Kamias extract. By isolating the variable of interest, the study aims to determine the impact of Kamias on the dishwashing liquid's quality, safety, and consumer acceptability without confounding effects from other variables. This targeted approach allows for a more precise assessment of the extract's effectiveness and relevance in practical applications. The standardized 4-point Hedonic Scale method was utilized to determine the acceptability level of respondents. The Hedonic scale is widely used in sensory evaluation to measure consumer preferences and product acceptability. Recent studies affirm its efficacy in quantifying subjective sensory experiences, providing valua-

ble insights for product development and innovation across various industries (Sidel *et al.*, 2018; Heymann, 2019; Addo-Preko *et al.*, 2023). Descriptive and statistics were used to test the level of acceptability of the respondents on different samples.

### Materials, tools and equipment

The tools and equipment used in making kamias fruit extract as an additive for dishwashing soap were basins, measuring cups and spoons, wooden ladle, stainless casserole, Polyethylene terephthalate (PET) bottle, weighing scale, and cheesecloth. The raw materials such as sodium lauryl ether sulfate (SLES), sodium lauryl sulfate (SLS), sodium chloride, linear alkylbenzene sulfonic (LABS), coco diethanolamide (CDEA), glycerine, propylene glycol, colorant and scent were purchased from the Far Eastern Drug Inc., a local chemical supply.

### Preparation of kamias fruit extract as an additive for dishwashing liquid

The kamias fruit was pricked and soaked in water overnight to reduce its acidity. After soaking for almost 8 hours in the water, the kamias juice was squeezed out using a cheese-cloth. Sodium Lauryl Sulfate and Sodium Lauryl Ether Sulfate were manually mixed in hot-deionized water on a clean basin until fully dissolved. The gradual addition of iodized salt while stirred continuously was done in one direction until all the salt was dissolved. All additives such as LABS, CDEA, glycerine, propylene glycol, colorant, Kamias fruit extract, and fragrance were mixed, allowing the mixture to cool. The mixtures were stored in a covered pail for one day. This storage period allows for complete homogenization of the ingredients, ensuring consistency in the final product. It also provides sufficient time for any necessary chemical reactions to stabilize, enhancing the efficacy and safety of the dishwashing liquid. Keeping the mixture covered minimizes contamination risks, thereby maintaining its microbial integrity (Pacheappan *et al.*, 2022). The mixtures were strained after being poured into PET bottles to remove the impurities.

### Respondents

The study employed a purposive sampling approach to recruit participants based on their individual observations. The sample comprised 100 individuals representing the general consumer population, including 80 women and 20 men. The participants were drawn from the following groups: housewives, canteen dishwashers, students, faculty members and parents. This diverse sample was selected randomly to ensure a representative cross-section of the target consumer demographic. Table 1 shows the distribution of respondents.

### Data gathering procedure

The research team developed the Kamias fruit extract dishwashing liquid formulation in the laboratory facility in a state University's premises. The kamias fruit was pricked and soaked in water overnight to reduce its acidity, and after soaking for approximately eight hours, the juice was extracted using a cheesecloth. Sodium Lauryl Sulfate and Sodium Lauryl Ether Sulfate were manually dissolved in hot deionized water, with iodized salt gradually added and stirred continuously until fully dissolved. Subsequently, all additives, including LABS, CDEA, glycerine, propylene glycol, colorant, kamias fruit extract, and fragrance, were mixed and allowed to cool, followed by a one-day storage period in a covered pail. The mixtures were strained after being poured into PET bottles to remove the impurities. This controlled setting ensured the consistent and standardized preparation of the product samples used in the study. The study employed a purposive random sampling approach to recruit participants. Potential respondents were individually approached and invited to participate in the evaluation of the Kamias (*Averrhoa bilimbi*) fruit extract dishwashing liquid. Those who agreed to participate were provided with a structured questionnaire designed to assess the acceptability and perceived performance of the product. Throughout the data collection process, the research team strictly adhered to established health and safety protocols to ensure the well-being of the respondents and the researchers. Upon completion of the questionnaires, the research

**Table1.** Distribution of respondents

Respondent groups	Gender			
	Female	Male	Total	%
Housewives	30	0	30	30.00
Canteen dishwashers	10	2	12	12.00
Students	20	9	29	29.00
Faculty members	5	5	10	10.00
Parents	15	4	19	19.00
Total	80	20	100	100.00
%	80.00	20.00		

team carefully retrieved and reviewed the forms to ensure their completeness. The responses were then meticulously collated and tabulated, setting the stage for comprehensive data analysis and interpretation.

In addition to the consumer evaluation, samples of the kamias fruit extract dishwashing liquid were sent to The First Analytical Services and Technical Cooperative (FAST) Laboratories- an established laboratory testing center for physical and microbiological assessment in Cebu, Philippines. This complementary testing provided objective, scientific data to supplement the subjective consumer feedback.

The combination of consumer acceptability data and laboratory test results enabled the research team to understand the Kamias fruit extract dishwashing liquid's performance and suitability for the target market.

### Modified sensory evaluation

The finished products were subjected to sensory evaluation. A 4-point hedonic scale was used in describing acceptability wherein four (4) is interpreted as liked very much and one (1) as disliked very much. Organoleptic evaluation sheets were given to one hundred respondents to appraise the acceptability of the quality characteristics of Kamias dishwashing liquid in terms of appearance, fragrance, texture (hand-feel), longevity of suds, degreasing power, and overall quality.

### Statistical analysis

To evaluate the quality characteristics and the acceptability of Kamias dishwashing liquid in terms of appearance, fragrance, texture (hand-feel), longevity of suds, degreasing power, and overall quality, an organoleptic evaluation using a 4-point Hedonic scale was used. The gathered data were analyzed using descriptive statistical methods involving average mean and percentage using the IBM SPSS Software version 20. The sensory survey was subjected to interpretation using the following parametric scale. "Liked very much" rating was given when the respondents felt the product was excellent. A "Liked moderately" rating was given to the product, which they feel is very good. Respondents feel that the product is not good has a "Disliked moderately" rating. A "Disliked very much" rating was given to the poor product.

### Physical tests and microbiological evaluation

The physical and chemical tests were performed to ensure the quality and consistency of the dishwashing liquid, measuring pH and specific gravity. Physical tests, such as viscosity, pH, and foam stability, are crucial as they determine the product's usability and effectiveness in removing grease and residues from kitchenware (Borković *et al.*, 2021). These experiments contributed to the soap's overall performance and suitability evaluation.

**Table 2.** Four-point Hedonic Rating Scale

Scale	Range	Interpretation
4	3.50- 4.00	Liked very much
3	2.50- 3.49	Liked moderately
2	1.50- 2.49	Disliked moderately
1	1.00- 1.49	Disliked very much

Microbial analysis was performed to determine the microbial safety and quality of the dishwashing liquid. These analyses are vital for detecting potential microbial contaminants, ensuring product safety (Karanth *et al.*, 2023), and meeting regulatory standards and consumer expectations (Mørretrø *et al.*, 2021). The streak plate method identified specific microorganisms, including *Staphylococcus aureus* (*S. aureus*) and *Escherichia coli* (*E. coli*), and is essential for obtaining pure cultures for accurate research (Ogodo *et al.*, 2022). Additionally, a total plate count using the spread plate method quantified the microbial load, which is essential for microbial quality control (McGoverin *et al.*, 2021). Integrating these evaluations into the quality control process is imperative to guarantee the reliability and marketability of dishwashing liquids.

## RESULTS AND DISCUSSION

### Formulations of *Averrhoa bilimbi* fruit extract dishwashing liquid

The ingredients used for the formulation of kamias (*A. bilimbi*) fruit extract dishwashing liquid are shown in Table 3.

Data showed that the appearance and degreasing power of *Averrhoa bilimbi* dishwashing Liquid were described as liked very much, with a mean of 3.50 and 3.57, respectively. Studies by Borković *et al.* (2021) indicate that consumers prefer dishwashing liquids with a well-regarded appearance and high degreasing efficiency for their effectiveness and visual appeal. The majority described fragrance, texture (hand-feel) and suds' longevity as 'liked moderately'. According to Borković *et al.* (2021), dishwashing liquids with a well-balanced fragrance, effective suds retention and a desirable hand-feel contribute significantly to overall user satisfaction and product effectiveness in dishwashing liquids. Results also revealed that respondents 'liked very much' the overall quality of the product. Table 4 shows the level of acceptability of kamias fruit extract as an additive for dishwashing liquid.

Table 5 shows the physical and microbial evaluation of *Averrhoa bilimbi* dishwashing liquid. Dishwashing liquid soap typically exhibited a pH range between 3 and 11.5, with the most commonly used variants falling below a pH of 7, making them acidic and highly effective at cleaning. However, such formulations can potentially

**Table 3.** Material composition of *Averrhoa bilimbi* fruit extract dishwashing liquid

Ingredients	% by weight
Kamias Fruit Extract	39.1
Sodium Lauryl Sulfate	7.8
Sodium Lauryl Ether Sulfate	7.8
Hot deionized water	39.1
Iodized salt	3.9
Linear alkyl benzene sulfonic (LABS)	0.2
Coco diethanolamide (CDEA)	0.2
Glycerine	1.5
Propylene glycol	0.08
Cologrant	0.04
Fragrance	0.2

lead to skin dryness or irritation. Kamias dishwashing liquid had a neutral pH (7.00 @ 22.20C), comparable to other eco-friendly dishwashing formulations designed to be gentle on the skin and surfaces. For instance, De Moura and Da Silva (2024) found that dishwashing liquids with a pH range of 6.5 to 7.5 were effective in cleaning while minimizing skin irritation. Similarly, a study by Palaniappan *et al.*, (2021) indicated that neutral pH formulations performed well in grease removal and were safer for frequent use compared to more acidic or alkaline products. Rungyuttapakorn and Wongwatcharapaiboon (2020) suggest that dishwashing liquids with a pH between 6 and 8, closer to neutral, possess unique properties that make them gentle and particularly suitable for sensitive skin. Thus, the Kamias dishwashing liquid aligns well with these findings, offering a balanced, effective, and user-friendly solution. Additionally, its specific gravity of 1.0290 indicated its density relative to water. According to Nazdrajic *et al.* (2024), a specific gravity within this range ensures adequate viscosity, enhancing the product's ability to cling to dishes and effectively remove grease and residues. In comparison, Desi Ardilla *et al.* (2023) reported that dishwashing liquids with a specific gravity below 1.01 often suffered from poor consistency and reduced cleaning efficiency and a specific gravity above 1.05 could lead to overly thick formulations, which may be harder to rinse off and less user-friendly. Therefore, the Kamias dishwashing liquid's specific gravity of 1.0290 indicates a balanced formulation, aligning well with industry standards for optimal performance and user experience. The microbial analysis revealed a remarkably low microbial count (<10<sup>Est.</sup>), as indicated by the total plate count data, which signifies a high level of hygiene in the product. This observation was crucial as it reflect-

ed the cleanliness and safety of the product. Studies by Milton *et al.* (2020) highlight that maintaining a microbial count below 10 CFU/mL in blenderized tube feeding is essential to prevent bacterial growth and potential health risks.

Similarly, research by Harini and Muralidharan (2021) demonstrated that kitchen dishwash with low microbial counts prevented cross-contamination in kitchen environments more effectively. A study by Møretrø *et al.*, (2022) further supports that low microbial counts enhance the shelf life and stability of dishwashing products, reducing the need for preservatives. Consequently, the Kamias dishwashing liquid's low microbial count aligns with industry standards and best practices, underscoring its safety and effectiveness for household use. The absence of harmful pathogens like *S. aureus* and *E. coli* further enhanced the safety and versatility of the product for various applications. In the context of food safety, the absence of pathogens like *S. aureus* and *E. coli* is critical. These bacteria are known to cause foodborne illnesses and pose serious health risks to consumers. Studies by Dai *et al.* (2021) emphasize that formulations devoid of *S. aureus* and *E. coli* provide a safer option for household use, reducing the risk of cross-contamination and enhancing overall product safety. Demonstrating the absence of these patho-

**Table 4.** Level of acceptability of kamias fruit extract as an additive for dishwashing liquid

Characteristics	Observations for Kamias Dishwashing Liquid	
	Mean	Interpretation
Appearance	3.50	Liked very much
Fragrance	3.40	Like moderately
Texture (hand-feel)	3.47	Like moderately
Longevity of Suds	3.20	Liked moderately
Degreasing Power	3.57	Liked very much
Overall quality	3.63	Liked very much

**Table 5.** Physical and microbial evaluation of *Averrhoa bilimbi* dishwashing liquid

Characteristic	Test Method	Results
pH	Electrometric Method	7.00 @ 22.2°C
Specific gravity	By Pycnometer	1.0290
Total plate count (CFU/g)	Spread Plate	<10 <sup>Est.</sup>
<i>S. aureus</i> detection	Streak Plate	Negative
<i>E. coli</i> Detection	Streak Plate	Negative

gens significantly enhanced the product's safety profile, making it suitable for a wide range of applications and ensuring consumer protection.

Kamias extract is used in dishwashing liquid formulations because its natural enzymatic activity enhances grease-cutting performance and microbial control. Recent studies have demonstrated that Kamias extract, with its inherent acidulant properties, exhibits more effective degreasing capabilities compared to extracts from other herbs like lemongrass or mint, which are less acidic and do not possess similar enzymatic functions (Iwansyah *et al.*, 2021). Additionally, kamias extract has been shown to have antimicrobial properties, specifically against common pathogens, which further contributes to its efficacy in maintaining hygiene (Mokhtar and Aziz, 2016). Thus, the unique combination of acidic and antimicrobial properties in Kamias extract provides a distinct advantage in formulating more effective and safer dishwashing liquids.

## Conclusion

The evaluation of kamias (*A. bilimbi*) dishwashing liquid soap revealed a strong preference for its appearance, degreasing power, and overall quality, while opinions on fragrance and longevity of suds were more moderate. Similarly, the texture of the product received a moderate level of approval. Analysis of the product indicated a neutral pH and a specific gravity of 1.0290, denoting its density relative to water. Moreover, based on total plate count data, microbial assessment exhibited a notably low microbial presence, with the absence of *S. aureus* and *E. coli*, indicating a hygienic state conducive to safety across various applications. The study's findings suggest that Kamias dishwashing liquid soap possessed characteristics that rendered it suitable for potential marketability and productivity. This research explores kamias utilization in product development, particularly in dishwashing liquid production. Showcasing the unique combination of natural enzymatic activity and acidulant and antimicrobial properties of Kamias fruit extract provides a distinct advantage in formulating more effective and safer dishwashing liquids. Also, this study can potentially support local farmers in diversifying their income sources through Kamias cultivation and processing.

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## Conflict of interest

The authors declare that they have no conflict of interest.

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