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Development and Evaluation of Herbal Neem Soap

H. Norazlina*, A. Amirah Husna, H. Lili Shakirah

University College TATI, Jalan Panchor, Telok Kalong, 24000 Kemaman, MALAYSIA

*Corresponding author email: norazlina@uctati.edu.my

KEYWORDS

Neem leaves;
Neem soap;
Soap degradation;
Soap stability;
Neem extraction.

ABSTRACT

Azadirachta indica, or neem leaves, have demonstrated efficacy in medical and consumer goods because of the bioactive substances they contain. It is today regarded as a valuable source of distinctive natural materials for the creation of both industrial items and medications to treat a variety of ailments. The objectives of this research were to extract neem leaves by using the Soxhlet method and to produce bath soap from the extract. The obtained neem oil was confirmed by Fourier Transform Infrared (FT-IR) Spectroscopy. Four types of soaps were used; soap-based, aloe vera soap, neem soap, and commercial soap. After one month of storage at room temperature, it can be concluded that all of the soap types experienced weight loss over the one-month period, which may be due to water evaporation and the biodegradation of soap components when exposed to air. In thermal stability analysis, the soap sample was found to be stable after one month of storage at room temperature without any sign of change. Overall, all soaps showed no changes after one-month storage at room temperature but a little bit drier at 45 °C. Only neem soap maintained the moisture behavior, among others, throughout the analysis. The level of the soap's ability to cleanse the skin was tested using the foam test. The longest time of foam disappearance was shown by commercial soap, which was 87 minutes. However, a quick disappearance of foam was observed with aloe vera and neem soaps, which were 54 minutes and 56 minutes, respectively. The pH-alkalinity level of the soap was 8, proving that it is suitable for human skin. A survey analysis of the effectiveness of soap on consumers was done based on skin condition, skin moisture, soothing effects, smell, and sizing. Up to 80% of the ratings the neem soap was good and excellent.

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1.0 INTRODUCTION

The World Health Organisation (WHO) states that 80% of the population in poor nations receives their primary medical care from ethnomedicines [1]. On the other hand, half of the world's population still uses traditional medicines made from the active components of plants. Plant components and parts are traditionally utilized in ethnomedicine to cure a variety of illnesses. The most adaptable and practical medicinal plant discovered to date is neem (*Azadirachta indica A. Juss*). Every component of it is abundant in bioactive chemicals, which have long been utilized to treat a variety of illnesses, including infectious infections. Neem's nimbolide, azarirachtin, and gedunin are examples of bioactive chemicals that are said to have remarkable abilities to control a wide range of biological processes both in vivo and in vitro. *A. indica* has been used from prehistoric times to the present [2]. Said to have been practiced in south India between 10,000 and 4000 B.C., Siddha medicine is thought to be the oldest medical system. According to Tamil literature, the first plant to be included in the Siddha system was neem, also known as margosa [3]. Because the adverse effects of older antibiotics were less severe, the use of natural medicines instead of synthetic or chemical medications has increased recently [4–6]. Herbal components are found in medicines. Herbs can be used as plant extracts or as their active components directly. Because of the powerful antibacterial properties of herbal treatments and their benefits for basic healthcare, most individuals on this earth also use them.

A. indica has been researched as a biopesticide and as an anticancer, antimicrobial, anti-inflammatory, and chemopreventive agent. Additionally, it has been observed that differentiated cell tissue in A. indica culture produces active metabolites for various uses. On the other hand, not much research has been done on its possible application in cosmetics. For instance, the majority of research elucidated the antibacterial characteristics in medical diseases like dandruff, acne, and personal hygiene [7–8]. Using commercial neem, diluted neem extract with coconut oil, aloe vera, vitamin E, and pure neem leaf extract, a range of neem-based lotions were developed for stability testing using various formulations [9]. The neem extract was kept at 25 °C for a year and at 45 °C for three months. At 25 °C, none of the produced lotions showed signs of color changes or layer separation. After a year of analysis, the moisture level stabilized and no granules formed. The neem-based lotion with coconut oil and aloe vera mix had the highest level of stability. The sample did not exhibit any layer formation, color change, or change in moisture content during the testing period at 25 °C and 45 °C.

The role of the healthy human stratum corneum (SC) acid mantle in maintaining the skin's natural antibacterial activity and other bioprocesses like lipid production and desquamation [10–12]. A prior study set out to find out if a skin-cleansing product was gentler on the skin since its pH was the same as the skin's pH [13]. The study used a well-established Forearm Controlled Application Test (FCAT) protocol in clinical studies to compare "skin pH" cleansing systems with neutral pH cleansing systems. The findings demonstrated that, in comparison to skin-cleansing systems with neutral pH circumstances, those that are formulated exclusively or mostly with anionic surfactants under skin pH conditions may cause more skin dryness and irritation. The role of the healthy human SC acid mantle in maintaining the skin's natural antibacterial activity and other bioprocesses like lipid production and desquamation. On human SC samples, heterogeneity in *S. aureus* viability was noted [14].

Several studies have been reported on the stability of neem-based soaps [15–18]. The seed extract of Parkia speciosa Hassk was effectively used to create novel gold nanoparticles (AuNPs) [19]. Because of its hydroxyl functional group, this natural plant extract functions as a natural bioreductor, demonstrating the presence of flavonoids. For thirty days, AuNPs show outstanding stability colloids in hand soap with no appreciable changes to the particle size or structure. This work offers a simple method for producing AuNPs with exceptional stability for possible use in cosmetics, particularly hand soap products. The bioefficacy of neem insecticidal soaps (NIS) in reducing the occurrence of Bhendi disease (*Abelmoschus esculentus (L.) Moench*) in a field setting was developed [20]. To address this issue, a laboratory formulation of Neem Insecticidal Soap (NIS @ 2%) was created, and its effectiveness was assessed. The field treated with NIS yielded the highest percentage of fruit (59.26 q/ha), whereas the fields treated with neem gold yielded the lowest percentage (53.31 q/ha) and the control field yielded the highest (53.25%). Therefore, it has been determined that using NIS to control the Bhendi yellow vein mosaic virus (BYVMV) will maximize their output at a minimal cost and without compromising the environment.

A study was done to find a natural antibacterial ingredient for liquid hand soap that included neem oil and lemongrass essential oil [21]. The outcomes demonstrated that the liquid soap had a characteristic neem oil scent and was transparent with a yellowish tint. The various liquid hand soap formulations' pH values fall between 4 and 10, which is the recognized pH range. The range of foam stability was 25.35% to 78.38%, in that order. Sterile hand soap can stop Staphylococcus aureus from growing. Liquid hand soap had an inhibitory zone diameter of 1.98–2.61 cm. Thus, it has been demonstrated that the antibacterial properties of neem oil and lemongrass essential oil in liquid hand soap formulation are beneficial. Owoicho reported the quality evaluation of soaps produced from the need to seem oil and shea-butter oil [22]. The physicochemical characteristics of the soaps, such as their pH, total fatty matter (TFM), free caustic alkali, matter insoluble in alcohol (MIA), cleaning and washing qualities, and foam stability, were also evaluated to determine their quality. The analysis of the soaps revealed that they are all high-quality, skin-safe soaps.

Neem and castor oil were combined to create soap [23]. The blend with a yield of 70.4%, foamability of 11.8 cm, pH of 10.42, and high cleansing power was judged to be the best, consisting of 60 ml of neem oil and 40 ml of castor oil. It was discovered that the outcomes agreed with the two commercial samples that were utilized as controls. In a prior study, ten distinct kinds of herbal soaps were made utilizing extracts from guava and neem leaves combined with five different kinds of oils (coconut, teal, olive, mustard, and sunflower) [24]. Turmeric, indigo, milk powder, henna, and coffee powder were employed as coloring agents in this technique. Lemon grass leaf extract was employed as a flavoring ingredient. Following soap preparation, many soap attributes were examined, including the soap's foaming ability, yield percentage, lathering strength, cleaning ability, hardness, and moisture content of the samples. Analysis reveals that the soap made with coconut oil has the highest grade, while the soap made with sunflower oil is of inferior quality. Additionally, because guava leaf extract contains antibacterial properties, it has been determined that soap made with it can be used to wash wounds.

This work was aimed at using the blends of soap-based and neem oils to produce and determine a soap sample with the optimum quality parameters. The choice of the aforementioned oils was informed by the fact that they are nonedible, available, less expensive, and have favorable medicinal properties for soap synthesis.

2.0 METHODOLOGY

2.1 Materials and equipment

The neem leaves were obtained from the neem trees at University College TATI, Kemaman. In pre-treatment, the neem leaves were rinsed with water. They were dried in an oven, at 109 ^{0}C, for 28 hrs and were blended to powder using a blender for 1 minute.

2.2 Extraction of Neem Oil

60 g of powdered neem leaves were weighed into the thimble, and 300 ml of 95% ethanol, the solvent, was added before putting the thimble into the Soxhlet apparatus and heating it. The setup was heated for roughly 12 hrs, at 80 ^{o}C after the thimble was fixed into the Soxhlet apparatus. The oil from the leaves was mixed and carried with the ethanol droplets. The liquid in the Soxhlet apparatus turned from a clear to a light-yellow tint as shown in Figure 2. As the process went on, the light-yellow color got darker as more oil was extracted via the capillary tube of the thimble. The neem oil was separated from the ethanol solution by using a Rotary Evaporator at the speed of 70 rpm. The bath temperature was set to 79 ^{o}C and the pressure was set to 240 Torr. The final product was pure neem oil.

Figure 1: Dried neem leaves

Figure 2: Soxhlet extraction using ethanol solution

2.3 Neem Soap Formulation

Four fresh neem leaves and 3.5 ml of aloe vera extract were placed in a stone mortar, and they were mashed until smooth. The mixture was then filtered to ensure that the soap formulation became super smooth. Furthermore, 7.5 ml of neem oil, 0.45 ml of vitamin E, 1.0 ml of fragrance, and 0.5 mica powder were mixed with the neem and aloe vera. The resulting mixture was stirred until well combined. Subsequently, 25 g of soap base was double-boiled in water at 110 ˚C to prevent heat losses. Once the soap base had melted, the earlier mixture was poured into the beaker. Then, 0.005 ml of cosmetic grade dye was added, and everything was mixed until well blended. The soap mixture was poured into small molds, and the mixture was allowed to rest at room temperature. After 24 hours, the soap was ready to use. Three types of soaps were prepared; soap-based, aloe vera soap, and neem soap. The commercialized soup was used as a control as for comparison in the analysis.

2.4 Neem Analysis

Perkin-Elmer Model Fourier Transmission Infrared Spectroscopy (FT-IR) was used to characterize the functional groups of neem leaves. At room temperature, the transmission of infrared spectra was recorded in the 400 cm^{-1} to 4000 cm^{-1} regions. In the thermal stability test, the soap samples were stored at room temperature and in an oven at 45 ^{o}C for one month. The changes in color, fragrance, and moisture were observed.

3.0 RESULTS AND DISCUSSION

3.1 FT-IR Analysis

The FT-IR analysis is an accurate analysis to confirm the molecule and substance presence in the soap. The successful synthesized neem oil was confirmed by Fourier Transform Infrared (FT-IR) analysis as shown in Figure 3 and similar to other studies [25]. FT-IR analysis shows the appearance of a broad peak of OH stretch at a spectrum of 3457 cm^{-1} with H bonds in a carboxylic acid. The C-H bend is present at 1459 cm^{-1} and the C=C stretch appeared at 1645 cm^{-1}. The sharp intensity which indicates the presence of strain vibration C=O as ester appeared at wavelength 1112 cm^{-1}.

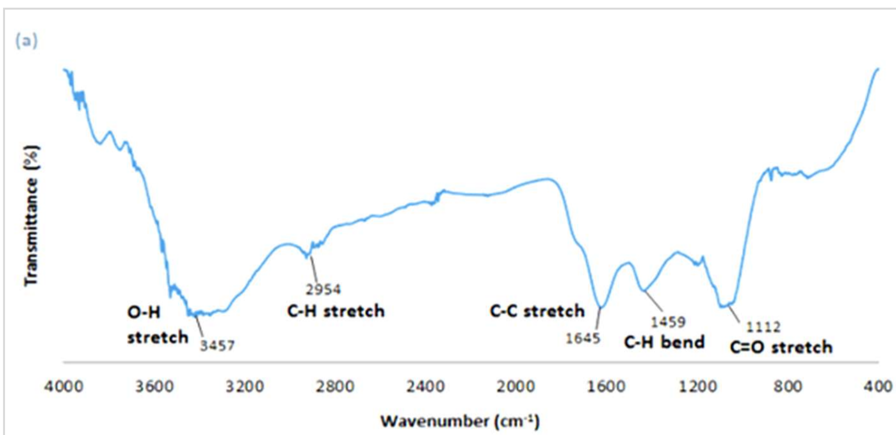


Figure 3: FT-IR analysis of neem oil

3.2 Weight Loss Analysis

The weight loss of different soap types under varying conditions and related it to their biodegradation potential. Higher weight loss potentially indicates faster biodegradation. Figure 4 shows the weight loss of soap exposed to air in one month. The weight loss of different types of soap exposed to air at room temperature (25 °C) over one month was studied. The four types of soap included soap-based, aloe vera soap, neem soap, and commercial soap. The weights were recorded for each week, from Week 1 to Week 4. The soap-based had a weight loss of -0.04 g, aloe vera soap had a weight loss of -0.08 g, neem soap had a weight loss of -0.07 g, and commercial soap had a weight loss of -0.06 g. From this data, it can be concluded that all the soap types experienced weight loss over the one-month period, which may be due to water evaporation and the biodegradation of soap components when exposed to air. Aloe vera soap exhibited the highest weight loss, suggesting the presence of more biodegradable components or a greater loss of water content compared to the other soaps. The soap-based based showed the least weight loss, indicating it may be less prone to biodegradation or water loss under the same conditions [26]. This information provides insight into the environmental impact of these soaps, with higher biodegradation rates potentially making them more eco-friendly. However, assessing their overall environmental friendliness would require considering additional factors such as biodegradation rate in different environmental conditions and their impact on ecosystems.

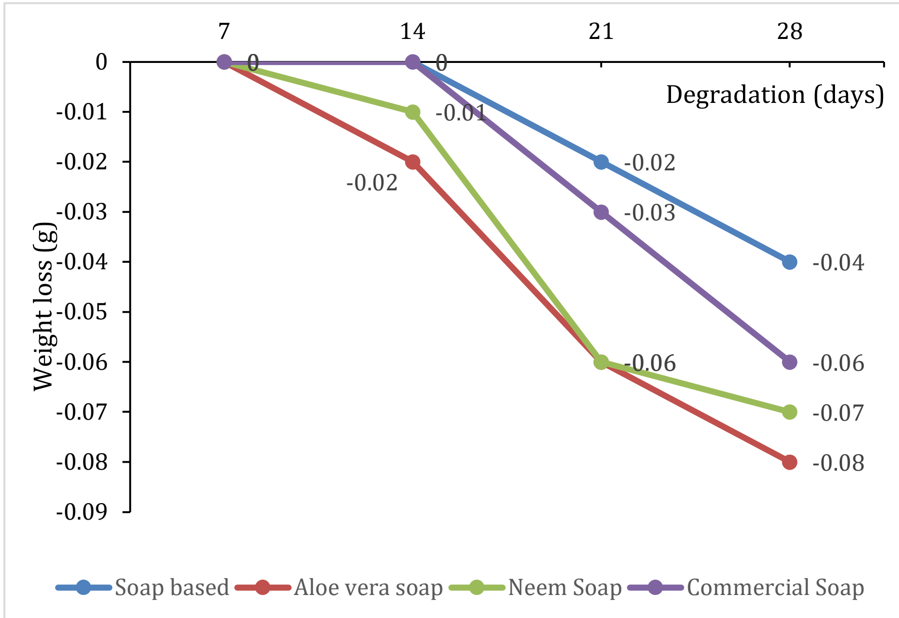


Figure 4: Weight loss trend of soaps

3.3 Degradation Stability Test

The European Cosmetic Toiletry and Perfumery Association (COLIPA) produced the guidelines on stability testing of cosmetic products [27]. The purpose of this paper is to lay out standards for forecasting and guaranteeing the stability of goods on the market. The evaluation of the stability test will vary based on the kind of product and packaging such as color, odor and appearance, pH, viscosity, and weight changes. Stability tests were performed on four types of soap samples, (soap-based, aloe vera soap, neem soap, and commercial soap) under two different conditions which are room temperature and at 45 ˚C for one-month observation. Every soap condition such as humidity, assessed changes in texture, fragrance, weight loss, and overall quality over time were recorded. This conclusion is based on the observation that all soap samples, including neem soap, remained in their original state without significant changes in color, fragrance, or moisture content under these accelerated conditions and tabulated in Table 1. Figure 5 exhibits the appearance of neem soap before and after the stability test. At room temperature analysis, the soap maintained the solid form without any changes in color, moisture, and fragrance. Otherwise, the color of the soap became darker and drier after one month of observation at 45 ˚C. Overall, all soaps showed no changes after one-month storage at room temperature but a little bit drier at 45 ˚C. Only neem soap maintained the moisture behavior among others over time of analysis.

Table 1: Soap stability within one month of observation

Soap Types	**Temperature of Stability Test**	
	25 °C	**45 °C**
Soap based	Still in solid form, no color changed, fragrance and moisture remained constant	Still, in solid form, no color changed, fragrance remained, a little drier
Aloe vera soap		Still in solid form, the color became darker, fragrance remained, a little drier
Neem soap		Still in solid form, color became darker, fragrance remained, moisture remained constant
Commercial soap		Still in solid form, no color changed, fragrance remained, a little drier

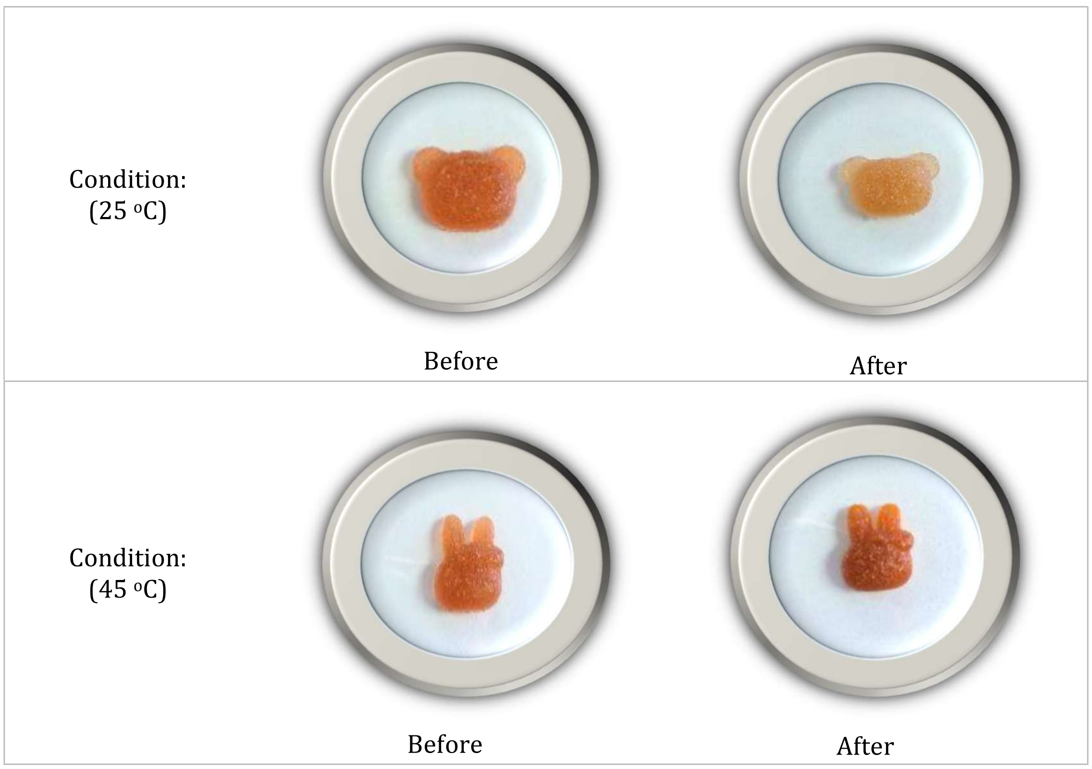
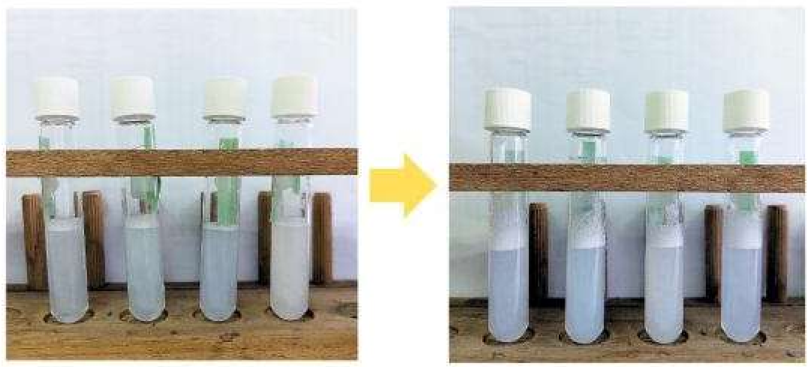


Figure 5: Neem soap condition after one month of stability test under different temperatures

3.4 Foam Stability Test

Figure 6 shows the formation of foam for the soaps. The observation on foam disappearance is tabulated in Table 2. The foam that appears in soap may act as a cleaning agent. Foaming agents are compounds found in certain soaps, which is the basic explanation for why these soaps foam. Ammonium lauryl sulphate and, much more frequently, sodium dodecyl sulphate (also known as sodium laureth sulphate) are common foaming agents used in consumer products [28]. These chemicals serve as surfactants in addition to foaming agents. By breaking up oil or sebum on the skin, a surfactant lowers the surface tension of water and makes it easier for debris to be washed off.

From these results, conclusions were decided about the foam stability and its potential correlation with cleaning ability. The time it takes for the foam to disappear may indicate the soap's ability to maintain its cleaning action over time. A longer-lasting foam, as seen with the commercial soap, could suggest that it maintains its cleaning action for a longer period, which might be perceived as a higher cleaning ability. However, a quick disappearance of foam, as observed with aloe vera and neem soaps, does not necessarily mean lower cleaning efficacy. Some soaps are formulated to be low-foaming yet highly effective at cleaning.



a) before b) after

Figure 6: Foam stability of soap

Table 2: Observation of foam disappearance

Soap types	Soap weight (g)	Volume of water (ml)	Time taken for disappearance (min)
Soap based	2	5	75
Aloe vera	2	5	54
Neem	2	5	56
Commercial	2	5	87

3.5 pH Analysis

When considering the potential of soap to soothe skin and not cause irritation, the pH value is a significant factor. The pH scale ranges from 0 to 14, with 7 being neutral. Human skin typically has a pH of around 5.5, which is slightly acidic. Soaps with a pH closer to that of human skin are generally considered to be more gentle and less likely to irritate. Figure 7 displays the obtained pH of the four types of soaps. After being exposed to soap, the pH of the skin will immediately rise and then return to its normal level within 5 to 10 minutes. The elevated pH can potentially open up the pores, allowing the soap foam to bind with any excess soap or stains present on the skin [29]. Based on the pH values provided, all the soaps listed have an alkaline pH, which is higher than the natural pH of the skin. However, the soap-based, aloe vera soap, and neem soap have a pH of 8, which is closer to neutral compared to the commercial soap, which has a pH of 9. This suggests that the soap-based, aloe vera and neem soaps may be gentler on the skin and potentially less irritating than the commercial soap with a higher pH. The pH of the soap utilized in this study is between 8 and 9, which corresponds to the typical pH values for commercial soap (between 9 and 11) [30] as well as the pH range established by the National Standardization Agency of Indonesia (8 to 11) [31].

A pH that is too low or too high might cause skin discomfort. Skin irritation can occur when the pH is too low (designated as a strong acid). However, if the pH is excessively high (designated as a strong base), it might cause scaly skin. High pH levels suggest the presence of a considerable amount of free alkali, which causes skin irritation. Alkali that does not react with fatty acids during the saponification process contributes to the level of free alkali in soap [32–33].

Figure 7: pH value of soaps

3.6 Survey Study on Consumer Responses

The results of a structured survey on neem soap involved 10 consumers, five of them have sensitive skin, and another 5 with healthy skin. The persistence in neem soap used was within 10 days. The result will be determined by scale (poor = 1, average = 2, good = 3, very good = 4, excellent = 5). The data in Table 3 shows that consumers with sensitive skin were more likely to rate neem soap as good or excellent in terms of all the attributes measured, including skin condition, skin moisture, soothing effects, smell, and sizing. This suggests that neem soap may be a gentle and effective option for people with sensitive skin. Consumers with healthy skin also rated neem soap favorably, although not as highly as those with sensitive skin. This suggests that neem soap may be a good option for people with healthy skin who are looking for a natural and gentle skincare product. The overall satisfaction with neem soap was high, with 80% of consumers rating it as good or excellent. This suggests that neem soap is safe to use and can be used as organic skin care.

Table 3: Neem soap consumer responses

Skin condition	Skin moisture	Soothes on skin	Soap Smell	Soap Sizing
Consumers with skin problems	3	5	5	5
	5	5	5	5
	4	5	5	5
	5	5	5	5
	4	5	5	4
Consumers with healthy skin	5	5	5	5
	5	5	5	5
	5	5	5	5
	5	5	5	4
	4	5	5	5
Total score	45/50	50/50	50/50	48/50

4.0 CONCLUSIONS

The neem oil was successfully extracted by using the Soxhlet extraction method and was confirmed by FT-IR. The weight loss data from the stability tests suggested that aloe vera soap exhibited the highest weight loss, potentially indicating the presence of more biodegradable components or a greater loss of water content compared to the other soaps. The foam testing results indicated that the disappearance of foam does not necessarily correlate with lower cleaning efficacy. While longer-lasting foam, as observed with Commercial soap, may suggest a sustained cleaning action, quick foam disappearance with aloe vera and neem soaps does not necessarily indicate lower cleaning efficacy. The pH values of the soaps tested were found to be generally within acceptable range for skin health. The structured survey conducted with consumers who used neem soap demonstrated positive feedback, particularly in terms of skin moisture, soothing effects, soap smell, and soap sizing. These favorable responses from consumers with both sensitive and healthy skin suggest that neem soap may be a gentle and effective option for individuals with varying skin conditions. The survey provides valuable information on the potential benefits of neem-based soap for consumers and highlights its potential as a natural and gentle skincare product.

Author Contribution

A. Amirah Husna: Conceptualization, methodology, investigation. H. Lili Shakirah: Investigation, supervision. Author: Visualisation, Methodology, writing, and editing.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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