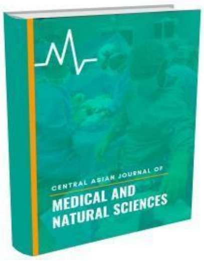

CENTRAL ASIAN JOURNAL OF
MEDICAL AND NATURAL SCIENCES
https://cajmns.centralasianstudies.org/index.php/CAJMNS
Volume: 07 Issue: 04 | October 2026 ISSN: 2660-4159

Article

Study of the Effect of Plant Extracts on the Physical and Biological Properties of Prepared Liquid Soap

Rafah J. Kadhim*[1], Ali Omairi Mohammed[2]

1,2. Department of Chemistry, College of Science, University of Tikrit, Tikrit, Iraq
*Correspondence: rafah.jwad84@tu.edu.iq

Abstract: Many medicinal plants contain organic compounds that can kill harmful microbes more effectively than synthetic chemicals. Given the undesirable side effects of synthetic chemicals, it's better to use medicated soap products. This study attempted to increase the antibacterial and antifungal effectiveness of a locally prepared liquid soap by adding some locally available plant leaf extracts (castor leaves, oleander leaves, olive leaves, colocynth fruits, wormwood leaves, myrtle leaves, and lemon leaves), and measure the biological effectiveness of enhanced soap against some types of pathogenic bacteria such as Gram-positive Staphylococcus aureus, Gram-negative Pseudomonas aeruginosa, and Gram-positive Streptococcus bacteria, As well as some species of Candida albicans, using standard laboratory methods such as the disk diffusion method. The antibacterial and antifungal efficacy of the liquid soap used in the study was observed to increase after the addition of plant extracts, and also increased with increasing concentrations of the added plant extracts.

Keywords: Soap, Additives, Plant Extracts

Citation: Kadhim, R. J., Mohammed, A. O. Study of the Effect of Plant Extracts on the Physical and Biological Properties of Prepared Liquid Soap. Central Asian Journal of Medical and Natural Science 2026, 7(4), 44-53.

Received: 05th May 2026
Revised: 30th May 2026
Accepted: 20th Jun 2026
Published: 13th Jul 2026

1. Introduction

Liquid soap is one of the most important products used daily for personal and public hygiene, as it effectively removes dirt and reduces the number of disease-causing microorganisms [1]. With growing concerns about microbial resistance to chemical disinfectants, scientific research has shifted toward developing cleaning products with enhanced biological efficacy using natural plant extracts that have antimicrobial properties, in addition to being safer and more environmentally friendly [2], [3]. In recent years, the use of plant extracts as natural additives in liquid soap formulations has gained significant attention due to their antimicrobial properties. Many plant-derived compounds, such as essential oils, flavonoids, alkaloids, and phenolic compounds, exhibit strong antibacterial and antifungal properties [4], [5]. Adding these extracts to liquid soap enhances its effectiveness against harmful microorganisms, providing a natural and environmentally friendly alternative to synthetic antimicrobials. Plant-based additives not only enhance the soap's ability to combat bacteria and fungi, but also add additional benefits, such as skin nourishment, anti-inflammatory effects, and a pleasant natural fragrance. Personal hygiene products, such as liquid soap, are among the most important materials for maintaining healthy skin and hair because of their ability to combat skin and hair microbes.

Common plant extracts used in soap formulations include neem, aloe vera, tea tree oil, and citrus extracts, all of which have been scientifically proven to inhibit microbial growth. This approach supports the growing demand for sustainable, non-toxic hygiene products, while reducing the risks associated with chemical preservatives and synthetic antimicrobial agents. This research explores the potential of using plant extracts as additives in liquid soap, highlighting their effectiveness in enhancing antimicrobial activity, their safety for human use, and their environmental benefits. However, some bacteria and fungi may develop resistance to the chemical compounds commonly found in these products, necessitating the search for natural alternatives that enhance their effectiveness.

This study aims to prepare liquid soap and improve its specifications by adding plant extracts, each separately, from castor oil (Ricinus communis) leaves, oleander (Nerium oleander) leaves, olive tree leaves, Citrullus colocynthis fruits, wormwood leaves, myrtle leaves, and lemon leaves.

These plants are known to contain effective chemical compounds, such as alkaloids, flavonoids, ricin, and terpenes, with antibacterial and antifungal properties, as follows:

1. Castor oil (Ricinus communis) leaves: The castor oil plant contains ricinoleic acid, known for its antibacterial and antifungal properties [6].
2. Oleander leaves (Nerium oleander): Its leaves contain glycosides such as olyandrine, which have a powerful antimicrobial effect [7].
3. Olive tree leaves: Contain oleurin, a compound effective against bacteria and fungi [8].
4. Colocynth (Citrullus colocynthis) fruits: Contain coloczinthine and coloczentine, known for their antibacterial properties [9].
5. Wormwood leaves: The plant contains terpenoids and flavonoids, which enhance antimicrobial activity [10].
6. Myrtus communis leaves: Contain tannins and flavonoids that inhibit the growth of bacteria and fungi [11].
7. Lemon leaves: Contain tannins, flavonoids, and coumarins, which have antibacterial and antifungal properties [12].

The study also aims to evaluate the effect of adding these extracts on the physical and chemical properties of liquid soap, such as pH, viscosity, and foam, in addition to measuring the biological effectiveness of the enhanced soap against some types of pathogenic bacteria, Such as Gram-positive Staphylococcus aureus, Gram-negative Pseudomonas aeruginosa, Gram-positive Streptococcus, and some Candida albicans, using standard laboratory methods such as disc diffusion.

2. Materials and Methods

1. Preparation of plant extracts:

The plant extracts are prepared from the targeted plants, which are castor oil (Ricinus communis) leaves, oleander (Nerium oleander) leaves, olive tree leaves, colocynthis (Citrullus colocynthis) fruits, wormwood leaves, myrtle leaves, and lemon leaves, each separately. This is done by taking the targeted part of the plant, washing it thoroughly, and drying it in the shade to preserve the effectiveness of the compounds. The dried plant material is ground and the active compounds are extracted using hot water to extract the water-soluble compounds. The extracts are filtered and concentrated by evaporation [13].

2. Prepare liquid soap:

a. Place (800 ml) of distilled water in a (1 liter) beaker, and add (120 g) of Texapon, which is the common trade name for sodium lauryl ether sulfate (SLES), with good stirring until it is completely dissolved in the distilled water.
b. Add (40 grams) of Cumberlan, which is the trade name for Cocamide DEA, to obtain a good consistency and stabilize the foam, then (20 grams) of Betaine, which is also known as Trimethylglycine (TMG), with mixing and stirring well to enhance the foam.

c. Add (10 grams) of glycerin to the mixture, Then add (10 grams) of table salt to obtain a thick consistency, and mix well.
d. The pH is adjusted to (5.5), which is the acidity of the skin. We obtain this level by adding citric acid, then (2 grams) of sodium benzoate is added as a preservative for the acidic medium.
e. Then add (0.15 g) of the coloring material with an amount of perfume (3 g) to (5 g) of glycerin and mix well, then add it to the mixture [14], [15].

3. Measuring some physical properties:

a. Measuring foam height and stability:

Weigh (1 g) of the prepared liquid soap and place it in a test tube. Add up to (10 ml) of distilled water. Shake the tube and then flip it over. Immediately measure the height of the resulting foam. Leave the tube for (5) minutes and measure the height of the resulting foam again after (5) minutes.

b. pH measurement:

Before testing, the pH meter was calibrated using a neutral solution (pH=7) and an acidic solution (pH=4). Then, a volume of (1 ml) of the prepared liquid soap sample is dissolved in (10 ml) of distilled water, shaken vigorously, and the electrode of the pH meter is immersed in it. It is left until the device reading stabilizes, then the value indicated by the calibrated pH meter is recorded. The pH of liquid soap should comply with the Standard Test Method for pH of Aqueous Solutions specified by [American Society for Testing and Materials (2015) (ASTM E70)]. The pH should be between (8.5-10) [16].

c. Specific gravity measurement:

Specific gravity is determined using a densitometer. This is done by weighing the empty densitometer (W0), then weighing it filled with distilled water (W1), and then weighing it again filled with a liquid soap sample (W2). Specific gravity is calculated using the formula shown below [17]:

Specific gravity = W2- W0/ W1- W0

d. Viscosity measurement:

The viscosity of the prepared liquid soap was measured using an Ostwald Viscometer at a temperature of (25°C), and its value was calculated according to the following equation:

$$\frac{n1}{n2} = \frac{p1t1}{p2t2}$$

4. Preparing liquid soap enriched with plant extracts:

Liquid soap enriched with plant extracts is prepared by preparing a (25%) solution of liquid soap using distilled water. Plant extracts are then added at varying concentrations (10%, 20%, 30%) to the liquid soap solution, and the ingredients are mixed well to ensure homogeneity and test their effectiveness [19].

5. Antimicrobial efficacy testing:

Antimicrobial efficacy is tested by preparing cultures containing various types of bacteria and fungi, such as the Gram-positive Staphylococcus aureus, the Gram-negative Pseudomonas aeruginosa, the Gram-positive Streptococcus pyogenes, and some types of Candida albicans (Candida albicans, Candida krusei, Candida tropicalis, and Candida glabrata) [18].

The ability of liquid soap samples enriched with plant extracts to inhibit microbial growth was tested using the disc diffusion method in the Department of Biology/College of Science/Tikrit University, where bacterial and fungal cultures were inoculated separately on a nutrient agar plate, and incubated at a temperature of (37°C) for (48) hours in an incubator.

The paper disk diffusion method (a standard method of the National Committee for Clinical Laboratory Standards (NCCLS)) was used to determine the inhibition zone. Approximately (15–20 ml) of Mueller-Hinton agar was poured onto sterile (90 mm) glass Petri dishes and allowed to solidify. The agar surface of each dish was then wiped with a sterile cotton swab dipped in a specific strain of microbes (bacteria or fungi). Paper discs of size (6 mm) were soaked in (100 microliters) of each sample of liquid soap, and placed on solidified agar plates at equal distances from the control plates. The plates were left for (30) minutes. Then the plates were incubated at a temperature of (37°C) for 48 hours.

3. Results and Discussion

1. Results of measuring some physical properties:

a. Foam height and stability test:

The foam height test was conducted to determine the amount of foam produced by liquid soap. Sodium lauryl sulfate (SLS), as a surfactant, plays an important role in producing soap foam, so a higher concentration of (SLS) leads to more foam formation [9]. The required foam height for liquid soap ranges between (13 and 220 mm). Based on this, good foam stability criteria were obtained, which assumes that between (60% and 70%) of the foam strength and stability is retained within five minutes [15], [20].

b. pH measurement:

A pH value of (9.5) was obtained for the prepared liquid soap, which is safe for use on the face and hands, as the normal pH range for liquid hand soap is between 8.5 and 10.5 [16].

c. Specific gravity measurement:

The specific gravity of a substance is defined as the ratio of the weight of the substance in air to the weight of water at the same volume and temperature [9]. Specific gravity is determined using a liquid density meter, which is easy to use. Specific gravity is related to viscosity, i.e., the higher the viscosity of a substance, the higher its specific gravity. Based on the measurement result, the specific gravity of the prepared liquid soap met the required standards and was (1.05 g/ml)[9] [17].

d. Viscosity measurement:

Viscosity is one of the criteria that can affect the level of product acceptance by consumers. The viscosity range for liquid soap is between (500 and 20,000) centipoise. Therefore, it can be concluded that the viscosity of the prepared liquid soap, which was (2,700) centipoise, meets quality requirements [20], [21].

2. Antimicrobial efficacy:

The addition of plant extracts is expected to enhance the effectiveness of liquid soap against bacteria and fungi. Effects may vary depending on the extract concentrations, with higher concentrations expected to have a stronger effect. Some plants are expected to be more effective against certain types of microbes. The effect of the active compounds in the extracts on the structure of the cell membranes of bacteria and fungi can be analyzed. The effect of the extracts on the quality of the liquid soap produced, such as scent, color, and foam, can be addressed. In short, using plant extracts in health and beauty products is an effective and natural way to enhance their antimicrobial properties.

This study demonstrates that extracts of castor bean (Ricinus communis) leaves, Nerium oleander leaves, olive tree leaves, Citrullus colocynthis fruit, wormwood leaves, myrtle leaves, and lemon leaves may be effective alternatives to synthetic chemicals, providing safer, more environmentally friendly options.

Samples of plant extracts added to the prepared liquid soap were arranged according to the following sequence, as in Table (1) below:

Table 1. Sample arrangement sequence

Sample (0)	Sample (1)	Sample (2)	Sample (3)	Sample (4)	Sample (5)	Sample (6)	Sample (7)
No extract liquid soap [control]	Castor leaf extract	Oleander leaf extract	Olive leaf extract	Bitter melon fruit extract	Worm leaf extract	Myrtle leaf extract	Lemon tree leaf extract

A. Antibacterial efficacy:

The ability of liquid soap samples enriched with plant extracts to inhibit the growth of three types of bacteria was tested using the disk diffusion method: the Gram-positive Staphylococcus aureus, the Gram-negative Pseudomonas aeruginosa, and the Gram-positive Streptococcus pyogenes. Plant extracts were added at different concentrations (10%, 20%, 30%) to the prepared liquid soap solution, and the measurement was carried out in the Department of Biology/College of Science/Tikrit University, and the results are shown in Tables (2), (3) and (4) below:

Table 2. Inhibition diameter for a concentration of (10%) of the plant extract added to the prepared liquid soap

Type of Bacteria	Sample (0)mm	Sample (1)mm	Sample (2)mm	Sample (3)mm	Sample (4)mm	Sample (5)mm	Sample (6)mm	Sample (7)mm
Staphylococcus aureus	2.9	5	17	10	18	9	6	11
Pseudomonas aeruginosa	5.1	19	26	17	31	21	26	16
Streptococcus pyogenes	2	9	18	14	28	8	10	5

Table (2) above shows the results of the effectiveness of adding a concentration of (10%) of each plant extract to the prepared liquid soap in inhibiting the growth of three different types of bacteria, by measuring the diameter of inhibition in millimeters (mm). The larger the diameter of inhibition, the greater the effectiveness of the extract in eliminating bacteria. As for the bacteria (Staphylococcus aureus), the highest effectiveness was for sample (4) with colocynth fruit extract (18 mm) and sample (2) with oleander leaf extract (17 mm), and the lowest effectiveness was for sample (1) with castor leaf extract (5 mm), while the other samples showed varying effectiveness between (6 mm) and (11 mm). As for the bacteria (Pseudomonas aeruginosa), sample (4) with colocynth fruit extract gave the highest effectiveness (31 mm), followed by sample (2) with oleander leaf extract (26 mm) and sample (6) with myrtle leaf extract (26 mm), and sample (7) with lemon leaf extract gave the least effectiveness (16 mm), and the other samples showed an effectiveness between them. While Streptococcus pyogenes bacteria showed the highest effectiveness in sample (4) with colocynth fruit extract (28 mm) and sample (2) with oleander leaf extract (18 mm), the lowest effectiveness was in sample (7) with lemon leaf extract (5 mm).

Table 3. Inhibition diameter for a concentration of (20%) of the plant extract added to the prepared liquid soap

Type of Bacteria	Sample (0)mm	Sample (1)mm	Sample (2)mm	Sample (3)mm	Sample (4)mm	Sample (5)mm	Sample (6)mm	Sample (7)mm
Staphylococcus aureus	3.5	9	19	14	22	12	11	18
Pseudomonas aeruginosa	5.2	21	34	21	36	24	33	22
Streptococcus pyogenes	2.3	13	20	17	23	12	14	11

While Table (3) above shows the results of the effectiveness of adding a concentration of (20%) of each plant extract to the prepared liquid soap in inhibiting the growth of the three different types of bacteria, with regard to the bacteria (Staphylococcus aureus), the highest effectiveness was for sample (4) with colocynth fruit extract (22 mm), followed by sample (2) with oleander leaf extract (19 mm), and sample (7) with lemon leaf extract (18), and the lowest effectiveness was for sample (1) with castor leaf extract (9 mm). As for the bacteria (Pseudomonas aeruginosa), sample (4) with colocynth fruit extract gave the highest effectiveness (36 ml), followed by sample (2) with oleander leaf extract (34 ml) and sample (6) with myrtle leaf extract (33 ml). Sample (1) with castor oil leaf extract and sample (3) with olive leaf extract gave the least effectiveness (21 ml) for each of them, and the other samples showed an average effectiveness between them. While Streptococcus pyogenes bacteria showed the highest effectiveness in sample (4) with colocynth fruit extract (23 mm) and sample (2) with oleander leaf extract (20 mm), the lowest effectiveness was in sample (7) with lemon leaf extract (11 mm).

Table 4. Inhibition diameter for a concentration of (30%) of the plant extract added to the prepared liquid soap

Type of Bacteria	Sample (0)mm	Sample (1)mm	Sample (2)mm	Sample (3)mm	Sample (4)mm	Sample (5)mm	Sample (6)mm	Sample (7)mm
Staphylococcus aureus	3.1	11	23	19	25	15	14	22.5
Pseudomonas aeruginosa	5.4	26	38	25	40	29	36	25
Streptococcus pyogenes	2.2	16	25	20	28	17	18.5	15

As Table (4) above shows, the results of the effectiveness of adding a concentration of (30%) of each plant extract to the prepared liquid soap in inhibiting the growth of these bacteria. As for the bacteria (Staphylococcus aureus), the highest effectiveness was for sample (4) with colocynth fruit extract (25 mm), followed by sample (2) with oleander leaf extract (23 mm), and sample (7) with lemon leaf extract (22.5), and the least effectiveness was for sample (1) with castor leaf extract (11 mm). As for the bacteria (Pseudomonas aeruginosa), sample (4) with colocynth fruit extract gave the highest effectiveness (40 ml), followed by sample (2) with oleander leaf extract (38 ml) and sample (6) with myrtle leaf extract (36 ml). Sample (7) with lemon leaf extract and sample (3) with olive leaf extract gave the least effectiveness (25 ml) for each of them, and the other samples showed an average effectiveness between them. While Streptococcus pyogenes bacteria showed the highest effectiveness in sample (4) with colocynth fruit extract (28 mm) and sample (2) with oleander leaf extract (25 mm), the lowest effectiveness was in sample (7) with lemon leaf extract (15 mm).

It is clear from the results shown in Tables (2, 3 and 4) above that all samples of prepared liquid soap showed an increase in the diameter of inhibition as a result of increasing the concentration of the added plant extract from (10%) to (20%) and then (30%). This indicates that the effectiveness of plant extracts increases with increasing concentration, which enhances their use as an antibacterial. Bitter melon fruit extract recorded the highest inhibition diameter across all bacterial species, followed by oleander leaf extract and myrtle leaf extract. Meanwhile, lemon and castor oil leaf extracts were relatively weak in efficacy compared to the other extracts. The response of bacteria to the added plant extracts also varied, with Pseudomonas aeruginosa being the most affected, followed by Streptococcus pyogenes and then Staphylococcus aureus, suggesting that some plant extracts may be more specific in targeting specific types of bacteria.

B. Antifungal activity:

The ability of liquid soap samples enriched with plant extracts to inhibit the growth of four species of Candida albicans fungi, (Candida albicans, Candida krusei, Candida tropicalis, and Candida glabrata) was tested using the disc diffusion method. Plant extracts were added at different concentrations (10%, 20%, 30%) to the prepared liquid soap solution, and the measurement was carried out in the Department of Biology/College of Science/Tikrit University, and the results are shown in Tables (5), (6) and (7) below:

Table 5. Inhibition diameter for a concentration of (10%) of the plant extract added to the prepared liquid soap

Type of Fungi	Sample (0)mm	Sample (1)mm	Sample (2)mm	Sample (3)mm	Sample (4)mm	Sample (5)mm	Sample (6)mm	Sample (7)mm
Candida albicans	9	19	25	19	28	12	21	23
Candida krusei	14	15	26	20	30	23	17	18
Candida tropicalis	3	4	11	3	12	12	4	5
Candida glabrata	0	3	9	2	10	3	2	4

Table (5) above shows the results of the effectiveness of adding a concentration of (10%) of each plant extract to the prepared liquid soap in inhibiting the growth of four different types of fungi of the genus (Candida), by measuring the diameter of inhibition in millimeters (mm). The larger the diameter of inhibition, the greater the effectiveness of the extract in eliminating fungi. As for the fungus (Candida albicans), the highest effectiveness was for sample (4) with colocynth fruit extract (28 ml), followed by sample (2) with oleander leaf extract (25 ml), and sample (7) with lemon leaf extract (23 ml). The least effectiveness was for sample (5) with wormwood leaf extract (12 ml). As for the fungus (Candida krusei), sample (4) with colocynth fruit extract gave the highest effectiveness (30 ml), followed by sample (2) with oleander leaf extract (26 ml) and sample (5) with wormwood leaf extract (23 ml). Sample (1) with castor leaf extract gave the least effectiveness (15 ml), and the other samples showed an effectiveness between them. While the fungus (Candida tropicalis) showed the highest effectiveness for sample (4) with colocynth fruit extract (12 mm) and sample (2) with oleander leaf extract (11 mm), the least effectiveness was for sample (3) with olive leaf extract (3 mm). As for the fungus (Candida glabrata), it gave the highest effectiveness (10 mm) and (9 mm) for each of samples (4) and (2) respectively, while samples (3), (6), (1) and (5) gave the least effectiveness, respectively.

Table 6. Inhibition diameter for a concentration of (20%) of the plant extract added to the prepared liquid soap

Type of Fungi	Sample (0)mm	Sample (1)mm	Sample (2)mm	Sample (3)mm	Sample (4)mm	Sample (5)mm	Sample (6)mm	Sample (7)mm
Candida albicans	9	21	28	19	30	13	23	25
Candida krusei	14	17	29	22	32	25	18	17
Candida tropicalis	3	6	15	5	16	11	4	3
Candida glabrata	0	5	11	5	12	2	3	2

Table (6) above gives the results of the effectiveness of adding a concentration of (20%) of each plant extract to the prepared liquid soap in inhibiting the growth of fungi of the genus (Candida), where the fungus (Candida albicans) gave the highest effectiveness for sample (4) with colocynth fruit extract (30 mm), followed by sample (2) with oleander leaf extract (28 mm), and sample (7) with lemon leaf extract (25). The least effective was for sample (5) with wormwood leaf extract (13 mm). As for the fungus (Candida krusei), sample (4) with colocynth fruit extract gave the highest effectiveness (32 mm), followed by sample (2) with oleander leaf extract (29 mm) and sample (5) with wormwood leaf extract (25 mm), Sample (1) and sample (7) with castor leaf extract and lemon leaf extract, respectively, gave the lowest effectiveness (17 mm). While the fungus (Candida tropicalis) showed the highest effectiveness for sample (4) with colocynth fruit extract (16 mm) and sample (2) with oleander leaf extract (15 mm), the least effectiveness was for sample (7) with lemon leaf extract (3 mm). As for the fungus (Candida glabrata), it gave the highest effectiveness (12 mm) and (11 mm) for samples (4) and (2) respectively, while samples (5) and (7) gave the least effectiveness (2 mm).

Table 7. Inhibition diameter for a concentration of (30%) of the plant extract added to the prepared liquid soap

Type of Fungi	Sample (0)mm	Sample (1)mm	Sample (2)mm	Sample (3)mm	Sample (4)mm	Sample (5)mm	Sample (6)mm	Sample (7)mm
Candida albicans	9	24	33	22	35	16	29	31
Candida krusei	14	23	34	25	38	23	22	19
Candida tropicalis	3	7	16	7	28	13	6	5
Candida glabrata	0	5	11	5	19	5	4	3

While Table (7) above gave the results of the effectiveness of adding a concentration of (30%) of each plant extract to the prepared liquid soap in inhibiting the growth of the above-mentioned fungi, where the fungus (Candida albicans) gave the highest effectiveness for sample (4) with colocynth fruit extract (35 mm), followed by sample (2) with oleander leaf extract (33 mm), and sample (7) with lemon leaf extract (31). The least effective was for sample (5) with wormwood leaf extract (16 ml). As for the fungus (Candida krusei), sample (4) with colocynth fruit extract gave the highest effectiveness (38 ml), followed by sample (2) with oleander leaf extract (34 ml) and sample (3) with wormwood leaf extract (25 ml), while sample (7) with lemon leaf extract gave the least effectiveness (19 ml). While the fungus (Candida tropicalis) showed the highest effectiveness, which was attributed to sample (4) with colocynth fruit extract (28 mm) and sample (2) with oleander leaf extract (16 mm), the lowest effectiveness was attributed to sample (7) with lemon leaf extract (5 mm). As for the fungus (Candida glabrata), it gave the highest effectiveness (19 mm) and (11 mm) for samples (4) and (2) respectively, while samples (7) and (6) gave the lowest effectiveness (3 mm) and (4 mm) respectively.

It is clear from the results shown in Tables (5, 6 and 7) above that all samples of prepared liquid soap showed an increase in the diameter of inhibition as a result of increasing the concentration of the added plant extract from (10%) to (20%) and then (30%). This indicates that the effectiveness of plant extracts increases with increasing concentration, which enhances their use as an antifungal. The colocynth fruit extract recorded the highest inhibition diameter across all fungal species, followed by the oleander leaf extract. The effectiveness of the lemon leaf extract was relatively weak compared to the other extracts. Fungi also varied in response to the added plant extracts, Candida krusei was the most affected fungus, followed by Candida albicans, Candida tropicalis, and Candida glabrata, respectively, indicating that some plant extracts may be more specific in inhibiting certain types of fungi.

4. Conclusion

The present study demonstrated that the addition of plant extracts significantly enhanced the antibacterial and antifungal properties of the prepared liquid soap. All tested extracts showed inhibitory activity against Staphylococcus aureus, Pseudomonas aeruginosa, Streptococcus pyogenes, Candida albicans, Candida krusei, Candida tropicalis, and Candida glabrata, with effectiveness increasing as the extract concentration increased from 10% to 30%. Among the tested extracts, Citrullus colocynthis fruit extract exhibited the strongest antimicrobial activity, followed by Nerium oleander and Myrtus communis extracts. The prepared liquid soap also met acceptable physicochemical characteristics, including pH, specific gravity, viscosity, and foam stability. These findings indicate that plant extracts can be successfully incorporated into liquid soap formulations as natural antimicrobial additives and may provide a safer and more environmentally friendly alternative to synthetic antimicrobial agents.

REFERENCES

[1] K. D. Mwambete and F. Lyombe, "Antimicrobial activity of medicated soaps commonly used by Dar es Salaam residents in Tanzania," Indian Journal of Pharmaceutical Sciences, vol. 73, no. 1, pp. 92–98, 2011.

[2] M. J. Richards, J. R. Edwards, D. H. Culver, and R. P. Gaynes, "Nosocomial infections in medical intensive care units in the United States, National Nosocomial Infections Surveillance System," Critical Care Medicine, vol. 27, no. 5, pp. 887–892, 1999.

[3] U.S. Food and Drug Administration (FDA), "FDA issues final rules on safety and effectiveness of antibacterial soaps," Sep. 28, 2016. [Online]. Available: https://www.fda.gov. [Accessed: Jun. 7, 2026].

[4] S. Prabuseenivasan, M. Jayakumar, and S. Ignacimuthu, "In vitro antibacterial activity of some plant essential oils," BMC Complementary and Alternative Medicine, vol. 6, art. no. 39, 2006.

[5] P. Kareru, J. M. Keriko, G. M. Kenji, G. Thiong'o, A. N. Gachanja, and H. N. Mukiira, "Antimicrobial activities of skincare preparations from plant extracts," African Journal of Traditional, Complementary and Alternative Medicines, vol. 7, no. 3, pp. 214–218, 2010.

[6] R. Singh, A. Kumar, and P. Sharma, “Phytochemical and pharmacological properties of Ricinus communis: A comprehensive review,” Discover Applied Sciences, 2024.

[7] A. E. Al-Snafi, “Bioactive ingredients and pharmacological effects of Nerium oleander,” IOSR Journal of Pharmacy, vol. 10, no. 9, pp. 19–32, 2020.

[8] F. Al-Rimawi, M. Sbeih, M. Amayreh, B. Rahhal, and S. Mudalal, “Evaluation of the antibacterial and antifungal properties of oleuropein, Olea europaea leaf extract, and Thymus vulgaris oil,” BMC Complementary Medicine and Therapies, vol. 24, art. no. 297, 2024.

[9] S. Pradhan et al., “Phytochemical analysis of Citrullus colocynthis (L.) Schrad and study of its antibacterial activity in vitro,” Journal of Pharmacognosy and Phytochemistry, vol. 12, no. 3, pp. 156–159, 2023.

[10] G. E.-S. Batiha et al., “Bioactive compounds, pharmacological actions, and pharmacokinetics of Wormwood (Artemisia absinthium),” Antibiotics, vol. 9, no. 6, art. no. 353, 2020.

[11] A. E. Al-Snafi et al., “The therapeutic value of Myrtus communis L.: An updated review,” Naunyn-Schmiedeberg's Archives of Pharmacology, vol. 397, pp. 4579–4600, 2024.

[12] M. Asker, S. E. El-Gengaihi, E. M. Hassan, M. A. Mohammed, and S. A. Abdelhamid, “Phytochemical constituents and antibacterial activity of Citrus lemon leaves,” Bulletin of the National Research Centre, vol. 44, art. no. 194, 2020.

[13] L. Gallina, C. Cravotto, G. Capaldi, G. Grillo, and G. Cravotto, “Plant extraction in water: Towards highly efficient industrial applications,” Processes, vol. 10, no. 11, art. no. 2233, 2022.

[14] Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD), Liquid Hand Soap Production. Los Baños, Philippines: PCAARRD, n.d.

[15] N. Widiani, A. Novitasari, O. P. Winandari, and D. A. Saputri, “Formulation and antibacterial activity testing of eco-soap based on sodium lauryl sulfate surfactant,” BIOMEDICH, vol. 13, no. 1, pp. 121–125, 2024.

[16] ASTM International, Standard Test Method for pH of Aqueous Solutions With the Glass Electrode (ASTM E70-19). West Conshohocken, PA, USA: ASTM International, 2019.

[17] Anton Paar GmbH, Density Measurement: Best Practices and Instrumentation Guide. Graz, Austria: Anton Paar GmbH, 2023.

[18] Clinical and Laboratory Standards Institute (CLSI), Performance Standards for Antimicrobial Disk Susceptibility Tests; Approved Standard—Twelfth Edition (CLSI Document M02-A12). Wayne, PA, USA: CLSI, 2015.

[19] C. Medina and F. Alvarez-Núñez, Handbook of Pharmaceutical Excipients, 6th ed. London, U.K.: Pharmaceutical Press; Washington, DC, USA: American Pharmacists Association, 2009.

[20] D. B. Narkhede, “Formulation and evaluation of coconut oil liquid soap,” International Journal of Pharma World Research, vol. 2, no. 3, pp. 1–15, 2010.

[21] S. Das, S. Agarwal, S. Samanta, M. Kumari, and R. Das, “Formulation and evaluation of herbal soap,” Journal of Pharmacognosy and Phytochemistry, vol. 13, no. 4, pp. 14–19, 2024.