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A Systematic Review on the Sensitivity of Bacteria to Different Plant Extracts used in Soap Formulation

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Abstract:- This systematic review investigates the antimicrobial susceptibility of various plant extracts used in soap formulations, with a focus on their preparation, characterization, and activity against Escherichia coli, Staphylococcus aureus and Pseudomonas aeruginosa. The review includes articles published between 2015 and 2024 that specifically investigate the sensitivity of bacteria to different plant extracts in soap formulations. Studies without an official English translation, without provided zone of inhibition data, or that focus on fungi were excluded. Relevant studies were systematically selected from Google Scholar, ResearchGate, and Elsevier. A total of 30 studies were identified. The prepared soaps were characterized by evaluating sensory characteristics such as odor, color, and texture, as well as physical characteristics like foam height and stability. The disk-diffusion method was used to analyze the antimicrobial activity of the plant extracts against various types of bacteria. The effectiveness of each extract was determined by measuring the zone of inhibition in millimeters. The results of the review demonstrate variations in antimicrobial activity among different plant-based soaps, with some extracts showing larger zones of inhibition, indicating stronger activity against bacteria.

Keywords:- *Natural Antiseptics; Bacterial Resistance; Zone Of Inhibition; Escherichia Coli; Staphylococcus Aureus; Pseudomonas Aeruginosa.*

I. INTRODUCTION

The growing incidence of antibiotic-resistant bacteria has inspired a renewed emphasis on natural antibacterial compounds, notably in personal care products like soap. Sensitive microorganisms, such as *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*, play a crucial role in many illnesses, necessitating the development of effective antibacterial formulations. Recent research has revealed the ability of plant extracts in soap compositions to treat certain infections. For example, liquid soaps containing groundcherry leaf extract and papaya leaf extract had significant antibacterial action, as proven by detectable inhibitory zones against *S. aureus*, *E. coli*, and *P. aeruginosa* (Chadhari et al., 2016; Wijayawardhana et al., 2021). This demonstrates the effectiveness of herbal compounds in not just improving antibacterial effects, but also addressing customer demand for softer, plant-based solutions.

In addition to antibacterial activity, the physicochemical properties of these herbal soaps are important for overall performance and customer appeal. Organoleptic properties, such as aroma, texture, and appearance, as well as the formability of the manufactured soaps, have a substantial impact on consumer pleasure (Narkhede 2010). For example, compositions including extracts of *Nyctanthes arbor-tristis* and *Murraya koenigii* not only shown significant antibacterial activity against *E. coli* and *P. aeruginosa*, while still retaining desired physical features as pH balance and foam retention (Wijayawardhana et al., 2021). Furthermore, studies show that soaps containing plant extracts such as *Azadirachta indica* effectively suppress a variety of infections, including *E. coli* and C. albicans, validating their historic usage for skin diseases (Maundu et al., 2005). As the amount of literature grows, the creation of herbal soaps is a viable option for generating effective hygiene products that take use of natural ingredients' antibacterial qualities while appealing to current customer requirements for safety and sustainability.

II. METHODOLOGY

The study aimed to conduct a systematic review of plant extracts used in the formulation of antimicrobial soaps, with a particular emphasis on the antibacterial efficacy of these soaps against *Escherichia coli*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa*. The review adhered to the PRISMA guidelines (see Fig. 1) to systematically select and assess relevant studies for inclusion, ensuring a comprehensive evaluation of the antimicrobial properties of plant-based soaps.

A. Data Sources

Published materials were selected from trusted resource platforms, including Elsevier, Google Scholar, and ResearchGate, which provided access to a wide range of peer-reviewed studies. The focus was on *Escherichia coli*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa*.

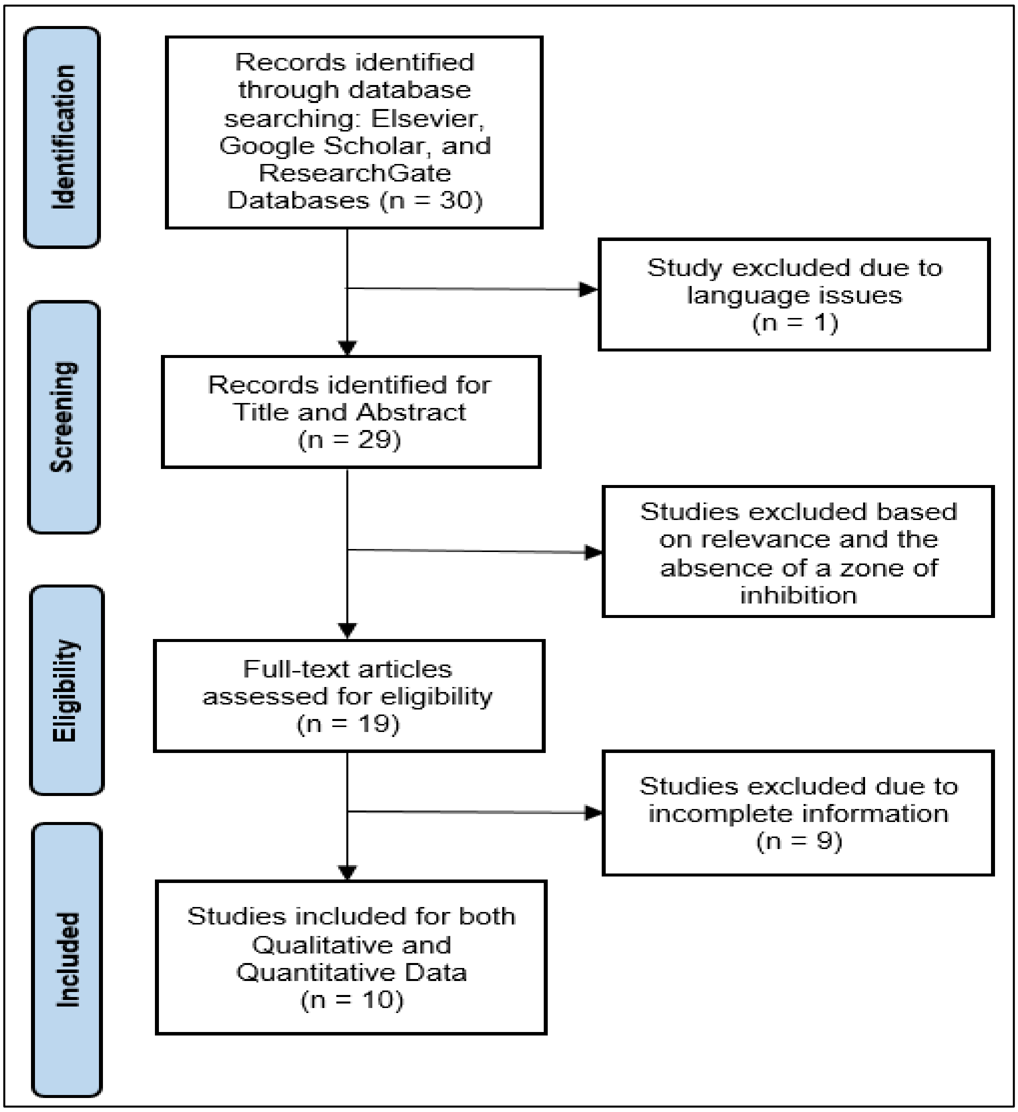

Fig. 1. Flow Diagram of the Selection of Studies using the PRISMA Guidelines

B. Literature Search

To conduct an effective search for this review. The keywords used for the search were organized into three main sets. The first set of keywords focused on the types of bacteria under investigation and included terms such as "*Escherichia coli*," "*Staphylococcus aureus*," and "*Pseudomonas aeruginosa*." These three bacteria were selected due to their relevance in studies related to antimicrobial properties and bacterial resistance. The second set of keywords related to plant extracts and their uses in soap formulation, including terms like "plant extracts," "antibacterial activity," "natural antimicrobials," "soap formulation," "phytochemicals," and "antimicrobial properties of plants." These terms ensured the inclusion of studies examining plant-based antimicrobial agents in soap formulations. The third set of keywords focused on bacterial resistance and sensitivity to plant extracts, such as "bacterial resistance," "antimicrobial resistance," "sensitivity to plant extracts," and "antibacterial activity against bacteria.".

The search was refined to include studies published between 2015 and 2024, ensuring that the material was relevant and current. The search for literature for this review has begun with a total of 30 research articles of general soap formulation using plant extract. From these, one (1) study was excluded due to the language.

C. Inclusion and Exclusion

The studies included in this review were classed according to: (1) articles that focused on microbial soaps made with plant extracts; (2) articles that evaluated the soaps' antibacterial efficacy against Escherichia coli, Staphylococcus aureus, and Pseudomonas aeruginosa; (3) articles that observed the soaps' organoleptic properties, including their color, texture, and odor; (4) articles that provided data on pH and foamability (foam height); and (5) articles that included zone of inhibition measurements for antibacterial activity.

Studies were excluded if they: (1) evaluated bacteria other than *Escherichia coli*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa*; (2) did not provide information on the zone of inhibition; (3) were written in a language other than English; (4) concentrated on fungi instead of bacteria; or (5) had missing or incomplete data.

D. Search Results

A total of 30 studies was found through searches in databases such as Elsivier, Google Scholar, and ResearchGate. After reviewing the titles and abstracts, one study was excluded because of issues with language. Therefore, 19 full-text papers were reviewed for eligibility. Ten of these studies were excluded because they lacked a zone of inhibition, which was an important outcome for the review. Additionally, 9 studies were removed due to incomplete data, making them unsuitable for analysis. At last, ten papers were selected for the final review, giving both qualitative and quantitative data that align the inclusion criteria.

E. Data Extraction

In these studies, ten of the thirty studies were chosen for detailed analysis. Each selected study focused on microbial soaps formulated with specific plant extracts and assessed their antibacterial efficacy against *E. coli*, *S. aureus*, and *P. aeruginosa*. The studies also evaluated the soaps' organoleptic properties, including color, texture, and odor. Additionally, each study reported data on the soap's pH levels and foamability (foam height), to assess the functional properties of the soap formulations. For antibacterial activity, zones of inhibition measurements were consistently included, indicating the efficacy of plant extracts in controlling bacterial growth. This data will allow for a comparative analysis across different plant-based soap formulations and bacterial sensitivities.

F. Statistical Analysis

After compiling and reviewing the qualitative aspects of the 10 selected studies, the papers was examined to determine its suitability for both quantitative and qualitative analysis. Studies that included data on the antibacterial effectiveness of plant extracts in soap formulations, particularly against *E. coli*, *S. aureus*, and *P. aeruginosa*, were included. In addition, research that detailed the soaps' organoleptic properties, pH levels, foamability, and zone of inhibition measurements was considered. This process enabled the integration of both qualitative and quantitative findings, ensuring the results were consistent with the objectives of the review and providing a thorough evaluation of the potential of plant-based antimicrobial soaps.

III. RESULTS AND DISCUSSION

A. Plant Extracts used in Soap Formulation

Different plants are organized in Table I with the corresponding parts extracted and final extract mixed with the formulations of soaps that is shown in Table II.

The most common part of plants utilized as extracts in the soaps is the leaf. This can be seen in half of the studies we have evaluated. Methodologies of the studies show that they chop the parts, soaked in ethanol or methanol then filtered for the extract incorporated with other ingredients such as sodium hydroxide (NaOH) and other plant-derived or synthetic oils (See Table II). These studies have formulated several samples ranging from one (1) to nine (9) which have varying percentages of the plant extracts

B. Qualitative Results

The studies we have assessed were narrowed down to have specific parameters. The organoleptic characteristics stated in the studies of the prepared soaps are further distinguished in Table III.

- *Organoleptic Characteristic of the Prepared Soaps*

The organoleptic qualities of the prepared soaps, as shown in Table III, give valuable details about their sensory appeal. The table shows differences in odor, color, and texture among soap compositions.

- *Odor*

The odor characteristics differ significantly depending on the plant extract used. Soaps from *Physalis angulata L.* And *Carica papaya L.* have a lily-like or ground cherry leaf scent. *Nyctanthes arbor-tristis* and *Murraya koenigii* have fragrant aromas. However, soaps from *Syzygium polyanthum* have typical bay leaf odor. While, some plant extracts, such as those from *Ixora coccinea*, lack odor data and are labeled as "ND" (no data), which refers to data not included in the original paper

- *Color*

The soap exhibits different colors primarily in the shade of green and brown. The soap formed from *Physalis angulata* leaves is brown, whereas the soaps made from *Carica papaya* are in the shade of green. This color variation could be attributed to the natural pigments found in plant extracts. However, the soap formed from *Eupatorium odoratum* and *Piper betle* stands out with its clear yellow color, implying that certain extracts may produce distinct colors to the soap.

- *Texture*

The soaps show a diverse range of texture from thick to smooth and firm. The soap produced from *Ixora coccinea* root extract is smooth and dark brown. The soap from *Ocimum tenuiflorum* has a smooth and firm texture, implying a more durable and possibly longer-lasting bar. In contrast, the soap is made from *Eupatorium odoratum* and *Piper betle*, which has a liquid feel and implies a very distinct sensory experience. The texture can be influenced by the type of fats and oils used in the soap formulation as well as the addition of plant extracts.

Table 1. Overview of the Plant Extracts

Plant Species	Common Name	Part of Plant	Utilized Substance	Soap State	Reference
Physalis angulata L.	Groundcherry	Leaf	Ethanolic extract	Liquid	Febriana et al.
Carica papaya L.	Papaya	Leaf	Ethanolic extract	Liquid	Handayani et al.
Nyctanthes arbor-tristis	Night jasmine	Leaf	Methanolic extract	Solid	Badave et al.
Murraya koenigii	Curry tree	Leaf	Methanolic extract	Solid	
Azadirachta indica	Neem tree	-	Oil [a]	Solid	Devi et al.
Ocimum tenuiflorum	Holy basil or Tulsi	-	Oil [a]		
Premna pubescens B.	Buas buas	Leaf	Ethanolic extract	Liquid	Yuniarti et al.
Ixora coccinea	Jungle flame or Santan	Root	Ethanolic extract	Solid	Mohammed et al.
Ocimum tenuiflorum	Holy basil or Tulsi	-	Powder [a]	Solid	Krishna et al.
Eupatorium odoratum	Jack in the bush or Siam weed	Leaf	Ethanolic extract	Liquid	Jumrah and Rosmaniar
Piper betle L.	Betel	Leaf	Ethanolic extract		
Zingiber officinale var. *rubrum*	Red ginger	Whole	Ethanolic extract	Liquid	Nurleni et al.
Syzygium polyanthum	Indonesian bay leaf	Leaf	Ethanolic extract	Liquid	Wahdaniah et al.

Some of the substances utilized in the formulation of the soaps were not extracted by the researchers themselves. The dashes (-) signify the lack of the specific data provided in the original studies.
[a] Pre-made or bought substances

Table 2. Formulation of the Soaps

Reference	Main Ingredients	Unit	Samples								
			A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*
Febriana et al.	Leaf extract of *Physalis angulata* L.	% conc.	10	15	20	NA	NA	NA	NA	NA	NA
Handayani et al.	Leaf extract of *Carica papaya* L.	grams	3	4	5	NA	NA	NA	NA	NA	NA
Badave et al.	Leaf extract of *Nycanthes arbor-tristis*	% conc.	20	-	NA	NA	NA	NA	NA	NA	NA
	Leaf extract of *Murraya koenigii*	% conc.	-	20	NA	NA	NA	NA	NA	NA	NA
Devi et al.	Oil of *Azadirachta indica*	milliliter	2	2	NA	NA	NA	NA	NA	NA	NA
	Oil of *Ocimum tenuiflorum*	milliliter	2	2	NA	NA	NA	NA	NA	NA	NA
	NaOH	grams	29.5	1.6	NA	NA	NA	NA	NA	NA	NA
Yuniarti et al.	Leaf extract of *Premna pubescens* B.	% conc.	5	10	15	NA	NA	NA	NA	NA	NA
Mohammed et al.	Root extract of *Ixora coccinea*	grams	1	1	1	1	1	1	1	1	1
	Coconut oil	grams	54.4	58.4	60.4	-	-	-	-	-	-
	Olive oil	grams	-	-	-	54.4	58.4	60.4	-	-	-
	Peanut oil	grams	-	-	-	-	-	-	54.4	58.4	60.4
Krishna et al.	Powdered *Ocimum tenuiflorum*	grams	5	NA	NA	NA	NA	NA	NA	NA	NA
Jumrah and Rosmaniar	Leaf extract of *Eupatorium odoratum*	% conc.	25	50	75	NA	NA	NA	NA	NA	NAx
	Leaf extract of *Piper betle* L.	% conc.	75	50	25	NA	NA	NA	NA	NA	NA
Nurleni et al.	Extract of *Zingiber officinale* var. *rubrum*	% conc.	3	5	7	NA	NA	NA	NA	NA	NA

Wahdaniah et al.	Leaf extract of *Syzygium polyanthum*	grams	0.3	0.6	0.9	NA	NA	NA	NA	NA	NA

The studies we have evaluated have a varying number of samples or formulations for their soaps. NA means not applicable—referring to those data that are not conducted by the original researchers; **-** is used to signify that an ingredient is not used in the formulation of the soaps.

Table 3 Organoleptic Characteristics of the Prepared Soaps

Plant Extract	Soap sample	Odor	Color	Texture	Reference
Leaf extract of *Physalis angulata* L.	All 3	Groundcherry leaves	Brown	Thick	Febriana et al.
Leaf extract of *Carica papaya* L.	A	Lily	Green	Thick	Handayani et al.
	B	Lily	Green	Thick	
	C	Lily	Deep green	Thick	
Leaf extract of *Nycanthes arbor-tristis*	A	Aromatic	Green	Sticky	Badave et al.
Leaf extract of *Murraya koenigii*	B	Aromatic	Dark green	Oily	
Oils of *Azadirachta indica* and *Ocimum tenuiflorum*	A	Aromatic	Light pink	ND	Devi et al.
	B	Aromatic	Light pink	ND	
Leaf extract of *Premna pubescens* B.	A	Distinctive smell	Dark green	Thick	Yuniarti et al.
	B	Distinctive smell	Deep green	Thick	
	C	Distinctive smell	Blackish green	Thick	
Root extract of *Ixora coccinea*	All 9	ND	Dark brown	Smooth	Mohammed et al.
Powdered *Ocimum tenuiflorum*	A	Mild, pleasant fragrance	Light green	Smooth and firm	Krishna et al.
Leaf extracts of *Eupatorium odoratum* and *Piper betle* L.	All 3	Distinctive aroma	Clear yellow	Liquid	Jumrah and Rosmaniar
Extract of Red Ginger	All 3	Ginger aroma	Light brown	Semisolid	Nurleni et al.
Leaf extract of *Syzygium polyanthum*	A	Typical bay leaf	Brownish	A little thick	Wahdaniah et al.
	B	Typical bay leaf	Greenish brown	A little thick	
	C	Typical bay leaf	Greenish brown	A little thick	

ND = No Data

C. Quantitative Results

The components of the soap require fat that is essential in its foaming ability such as the natural or synthetic oils.

➢ *Foamability of the Formulated Soaps*

In majority of the studies, foam height tests were conducted by utilizing a mixture of a small amount of soap blend into at least quintuple or decuple amount of distilled water in a measuring cylinder and shaking it in intervals of twenty-five (25) strokes (Devi et al., 2021; Mohammed et al., 2019; and Krishna et al., 2024) or for a fixed amount of time (see Table IV). For example, one (1) milliliter of Premna pubescens B. soap sample was shaken with fifty (50) milliliters of distilled water for twenty (20) seconds (Yuniarti et al., 2022).

Table 4 . Foamability of Prepared Soaps

Plant Extract	Sample	Foam Height (mm)	Reference
Leaf extract of Groundcherry	All	24-36	Febriana et al.
Leaf extract of *Carica papaya* L.	A	25	Handayani et al.
	B	22	
	C	15	
Leaf extract of *Nycanthes arbor-tristis*	A	50	Badave et al.
Leaf extract of *Murraya koenigii*	B	40	
Oils of *Azadirachta indica* and *Ocimum tenuiflorum*	A	25	Devi et al.
	B	30	
Leaf extract of *Premna pubescens* B.	A	50	Yuniarti et al.
	B	70	
	C	90	
Root extract of *Ixora coccinea*	A	114	Mohammed et al.
	B	144	
	C	122	
	D	116	
	E	128	
	F	92	
	G	94	
	H	104	
	I	92	
Powdered *Ocimum tenuiflorum*	A	156.3	Krishna et al.
Leaf extracts of *Eupatorium odoratum* and *Piper betle* L.	A	120	Jumrah and Rosmaniar
	B	130	
	C	145	
Extract of Red Ginger	A	44	Nurleni et al.
	B	41	
	C	45	
Leaf extract of *Syzygium polyanthum*	A	20	Wahdaniah et al.
	B	20	
	C	20	

The soap formulations with a higher amount of plant extract including those made with the root of *Ixora coccinea* (Mohammed et al., 2019) demonstrates a significant amount of foam for these were prepared with a larger percentage of oil as seen in Table II, with the powdered *Ocimum tenuiflorum* (Krishna et al., 2024) with the highest at 156.3 millimeters. The studies conducted with lower concentrations or amounts of plant extract demonstrated a significantly lower foamability as seen in the heights ranging from 15–25 (Handayani et al., 2024) or all formulations at twenty (20) millimeters (Wahdaniah et al., 2024).

Despite having the same percentage of concentration in the formulation, the soaps made with the leaf extracts of *Nyctanthes arbor-tristis* and *Murraya koenigii* resulted in different heights of foam. Relationships like this are not seen in other studies considering that Badave et al. (2023) prepared separate soaps with different extracts while other studies with multiple extracts only applied differing amounts between these extracts in their samples.

With small increases in the preparations of the soaps formulated in the studies by Febriana et al. (2023), Jumrah and Rosmaniar (2023) and Nurleni et al. (2024), an apparent deviation in the foam heights of different soap formulations were reported wherein there was an observable direct change in foam height.

➢ *pH of the Formulated Soaps*

The findings suggest that soaps made with plant extract are fairly neutral (Badave et al, 2023; and Devi et al, 2021), or mostly lean on the basic range of the pH scale.

The study conducted by Nurleni et al. (2024) showcases a decreasing effect on pH as the amount of *Zingiber officinale* var. *rubrum* extract added in the soap formula increases with an evaluation of 6.5 at 3% concentration, 6.3 at 5% concentration and 6.1 at 7% concentration. The same can be observed in the *Ixora coccinea*-formulated samples G, H and I of Mohammed et al. (2019); although the other six (6) of the samples evaluated in the studies does not show this correlation as it either increases or decreases (6.6 shifts to 7.1 then 6.8 when the percent concentration is increasing).

Additionally, there are studies that show constant results or minimal changes in pH such as Wahdaniah et al. (2024) who prepared soaps with varying grams of *Syzygium polyanthum* leaf extract and have recorded a constant degree of acidity with pH values of 9, and the pH of the three (3) prepared soaps with *Premna pubescens* B. that vary between 10.2 and 10.3, respectively.

Several articles (Febriana et al., 2023; Handayani et al., 2024; Jumrah and Rosmaniar, 2023) tested the soaps and obtained pH levels proportionate to the percent concentration of the plant extracts.

Table 5. pH of the Prepared Soap

Plant Extract	Sample	pH	Reference
Leaf extract of Groundcherry	ALL	11.26-11.80	Febriana et al.
Leaf extract of *Carica papaya* L.	A	8.75	Handayani et al.
	B	9.9	
	C	10.91	
Leaf extract of *Nyctanthes arbor-tristis*	A	7	Badave et al.
Leaf extract of *Murraya koenigii*	B	7	
Oils of *Azadirachta indica* and *Ocimum tenuiflorum*	A	7.3	Devi et al.
	B	7.0	
Leaf extract of *Premna pubescens* B.	A	10.2	Yuniarti et al.
	B	10.2	
	C	10.3	
Root extract of *Ixora coccinea*	A	6.6	Mohammed et al.
	B	7.1	
	C	6.8	
	D	7.3	
	E	7.5	
	F	6.9	
	G	7.2	
	H	7.6	
	I	6.9	
Powdered *Ocimum tenuiflorum*	A	7.2	Krishna et al.
Leaf extracts of *Eupatorium odoratum* and *Piper betle* L.	A	9.25	Jumrah and Rosmaniar
	B	9.34	
	C	9.84	
Extract of Red Ginger	A	6.5	Nurleni et al.
	B	6.3	
	C	6.1	
Leaf extract of *Syzygium polyanthum*	A	9	Wahdaniah et al.
	B	9	
	C	9	

➢ *Diameter of Inhibition Zones*

Table VI (see on Page 7) presents the diameter of the inhibited bacteria of each study using the two disc-diffusion methods: paper disc-diffusion method (5 studies), agar well diffusion method (4 studies) and an unspecified agar diffusion method.

In all studies, there is at least one (1) among *Escherichia coli*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* selected to test the antimicrobial activity of the formulated plant-based soaps.

The products of Jumrah & Rosmaniar (2023) and Wahdaniah et al. (2024) exhibit significant inhibitory activities against *E. coli*. While the soaps made with the extracts of siam weed and betel leaves hinder bacterial growth around the soap discs for 20.9 to 22.3 millimeters, those formulated with the leaf extract of Indonesian bay leaf averages a zone of inhibition of 9.99 millimeters.

The ground cherry liquid soap has inhibition zones of 7.97, 14.82 and 17.6 millimeters against *S. aureus* demonstrating a direct proportion to the percent concentration of the plant extract added to the formula (Febriana et al., 2023). Similarly, the increasing amount of buas buas extract shows an average efficiency in inhibiting bacterial growth as the diameters of inhibited zones range from 14.2 to 16.0 millimeters.

Few studies presented the antibacterial activity of plant extract-formulated soaps against *E. coli* and *P. aeruginosa* across the classification of inhibition zones (David and Stout, 1971). The results of red ginger soap show inhibition zones with an average of 9.63 millimeters against *E. coli* and 12.16 millimeters against *S. aureus* (Nurleni et al., 2024). However, the study conducted by Handayani et al. (2024) utilizing papaya leaves has the lowest weakest antibacterial activity amongst the ten (10) studies assessed for the review with zones of inhibition below five (5) millimeters.

Table 6. Categorization of Inhibition Zones

Diameter of Zone of Inhibition (mm)	Activity
≤5	Weak
6–10	Moderate
11–20	Strong
≥21	Very strong

Of the ten (10) research articles we have reviewed, four (4) have aimed to target all three (3) of the bacteria. Krishna et al. (2024) prepared a soap with tulsi powder that resulted in strong activities against the bacteria. Another study showed antibacterial activities in the same division as it also utilized tulsi but in the form of an oil and with an added ingredient: Neem tree oil (Devi et al., 2021). On the sensitivity testing on the study done by Badave et al. (2023), the two prepared soaps with different plant extracts added in each had coordinating results: the curry tree soap had equal zones (17 mm) in countering *E. coli* and *S. aureus* while it subdued the growth of *P. aeruginosa* for 20 millimeters; and it was observed that the night jasmine soap formed an inhibition zone of 23 millimeters for both *P. aeruginosa* and *S. aureus* whereas no inhibition was detected against *E. coli*. The ethanolic extract of santan root as a soap with deviating natural vegetable oil concentrations shows exceptional inhibitory activity against all three of the bacteria throughout the nine (9) formulations (Mohammed et al., 2019). However, this result was dependent on the high concentration of vegetable oils for these are composed of bioactive materials. Furthermore, this study has the largest zone of inhibition among all ten (10) reviewed articles with an incredible 38 millimeters and a lowest amount of 26 millimeters.

Table 7. Sensitivity

Plant Extract	Sample	Zone of Inhibition (mm)			Study
		Escherichia coli	*Pseudomonas aeruginosa*	*Staphylococcus aureus*	
Leaf extract of Groundcherry	A	-	-	7.97	Febriana et al.
	B	-	-	14.82	
	C	-	-	17.6	
Leaf extract of *Carica papaya* L.	A	2.84	-	2.06	Handayani et al.
	B	3.41	-	2.21	

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	C	3.71	-	2.46	
Leaf extract of *Nyctanthes arbor-tristis*	A	NI	23	23	Badave et al.
Leaf extract of *Murraya koenigii*	B	17	20	17	
Oils of *Azadirachta indica* and *Ocimum tenuiflorum*	A	13	12	14	Devi et al.
	B	16	15	18	
Leaf extract of *Premna pubescens* B.	A	-	-	14.2	Yuniarti et al.
	B	-	-	15.0	
	C	-	-	16.0	
Root extract of *Ixora coccinea*	A	32	32	34	Mohammed et al.
	B	34	36	38	
	C	32	34	36	
	D	26	28	32	
	E	28	30	30	
	F	31	31	32	
	G	30	30	34	
	H	28	32	32	
	I	30	34	31	
Powdered *Ocimum tenuiflorum*	A	15.3	14.7	18.5	Krishna et al.
Leaf extracts of *Eupatorium odoratum* and *Piper betle* L.	A	20.9	-	-	Jumrah and Rosmaniar
	B	22.3	-	-	
	C	22.06	-	-	
Extract of Red Ginger	A	6.01	-	9.03	Nurleni et al.
	B	10.32	-	12.21	
	C	12.58	-	15.26	
Leaf extract of *Syzygium polyanthum*	A	8.27	-	-	Wahdaniah et al.
	B	10.55	-	-	
	C	11.16	-	-	

Not every paper from the ten (10) papers we reviewed examined all three (3) bacteria. - is used to signify that the bacteria was not assessed for its sensitivity.

IV. CONCLUSION

In conclusion, the research on plant extracts utilized in soap formulations suggests a viable path for producing effective antibacterial solutions to meet the rising issue of sensitive bacteria such as *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*. Herbal soaps formulated with extracts from a variety of plants, including groundcherry, papaya, *Nyctanthes arbor-tristis*, and *Murraya koenigii*, consistently show significant antibacterial activity, as evidenced by inhibition zones observed in agar diffusion tests. This demonstrates the possibility of natural components to operate as effective alternatives to synthetic antibacterial agents, addressing both microbe resistance and customer demands for safer, plant-based goods.

Furthermore, the physicochemical qualities of these herbal soaps are critical to their overall effectiveness and user appeal. According to studies, organoleptic features such as aroma, texture, and appearance, as well as the formability of formulated soaps, have a substantial impact on consumer satisfaction. Well-formulated herbal soaps not only preserve optimal pH levels and foam retention, but they also have antimicrobial capabilities similar to conventional antibacterial soaps. This shows that, with proper formulation, herbal soaps can reach or surpass traditional product performance requirements while also providing extra advantages associated with natural components.

Additionally, using a larger spectrum of plant extracts into soap compositions, such as those from *Ixora coccinea*, *Ocimum tenuiflorum*, and *Syzygium polyanthum*, may improve antibacterial activity and expand appeal. The synergistic effects of mixing various extracts may result in increased antimicrobial activity and better skin health advantages, making these solutions not only efficient against bacteria but also advantageous to general dermal health.

As we look forward to future research, there is a good chance that further investigation into the composition of herbal soaps may provide unique products that are both ecologically friendly and extremely efficient against resistant bacteria strains. These natural formulations have the potential to significantly contribute to public health initiatives, particularly in encouraging safe hygiene behaviors for both users and the environment. Herbal soaps provide an important step toward long-term health solutions in personal care products by harnessing the antibacterial capabilities of diverse plant extracts while maintaining high quality and safety requirements. This ongoing study may pave the path for a new generation of hygiene products that meet customer expectations for efficacy, safety, and environmental responsibility.

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