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RESEARCH PAPER

Comparative Evaluation of *Zingiber officinale* Roscoe and *Centella asiatica* (L.) Urb Extracts: Chemical Characterization, Lotion Formulation, and Antibacterial Activity Against *Staphylococcus epidermidis*

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Abstract: *Zingiber officinale* Roscoe and *Centella asiatica* (L.) Urb are medicinal plants widely utilized in traditional medicine due to their diverse bioactive compounds and potential antibacterial properties. This study aimed to compare the chemical constituents, physicochemical characteristics of lotion formulations, and antibacterial activities of ethanolic extracts from *Z. officinale* Roscoe and *C. Asiatica* (L.) Urb against *Staphylococcus epidermidis*. The extracts were prepared by maceration using 96% ethanol and analyzed using gas chromatography–mass spectrometry (GC-MS). The obtained extracts were incorporated into oil-in-water (o/w) lotion formulations and evaluated for organoleptic properties, pH, and antibacterial activity using the agar well diffusion method. GC-MS analysis identified zingiberene (36.24%) as the predominant compound in *Z. officinale* extract, followed by β-sesquiphellandrene (13.22%), 2-butanone (11.63%), farnesene (7.21%), β-bisabolene (7.14%), and eucalyptol (1,8-cineole) (3.68%). In contrast, *C. asiatica* extract contained hexadecanoic acid (28.17%), 9,12,15-octadecatrienoic acid (27.88%), oxacycloheptadec-8-en-2-one (22.15%), and neophytadiene (10.15%). Both extracts were successfully formulated into homogeneous lotions with acceptable physicochemical properties, including yellow to yellowish appearance, uniform texture, pleasant odor, and pH values ranging from 7 to 8. The lotion formulations exhibited antibacterial activity against *S. epidermidis*, with inhibition zones ranging from 28 to 29 mm,while clindamycin as the positive control showed an inhibition zone of 35 mm. These findings demonstrate that *Z. officinale* and *C. asiatica* extracts possess promising antibacterial potential when incorporated into topical lotion formulations and may serve as candidates for the development of natural-based pharmaceutical and cosmetic products.

Keywords: *Zingiber officinale* Roscoe, *Centella asiatica* (L.) Urb, GC-MS analysis, lotion formulation, antibacterial activity, *Staphylococcus epidermidis*

INTRODUCTION

Indonesia exhibits a biodiversity characterized by a wide range of plants, encompassing a diverse array of herbs, including *Zingiber officinale* and *Centella asiatica*. *Z. officinale* is known as Jahe in Indonesia, while *C. asiatica* is termed as Pegagan, which are popular as a spice and traditional medicine for healthcare. *Z. officinale* is rich in essential oils [1]. Pharmaceutically, it has safe and potent inhibitory activities against fibroblast elastase. On the other hand, it helps to maintain the young and healthy aspect of the skin [2], [3]. The previous study demonstrated Ginger essential oil has a higher level of antimicrobial activity against *E. coli, Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Salmonella typhi* [4]. A total of 447 phytochemical constituents have now been isolated and identified from this genus, with volatile oils, diarylheptanoids, gingerols, flavonoids, and terpenoids being the main components. Gingerols represent the key functional

compound of aromatic constituents. The principal constituent of Zingiber, a chemical which exhibits various pharmacological properties, including anticancer, anti-inflammatory, antioxidant, antibacterial, antinociceptive, hepatoprotective, and immunomodulatory ones [5].

Furthermore, *C.asiatica,* a perennially growing herbaceous creeper. This plant is characterized by its ability to thrive in high moisture environments and has a broad distribution across tropical and subtropical regions, with significant presence in various countries. A comprehensive chemical investigation of *C. asiatica* has yielded the identification of diverse secondary metabolites, including alkaloids, triterpenoids, glycosides, flavonoids, vitamins B, C, and various amino acids [6]. Moreover, pharmacological studies of *C. asiatica* indicate antimicrobial, wound healing, antioxidant, neuroprotective, anti-inflammatory, hepatoprotective, anti-cancer, anti-diabetic and hyperglycemic activity [7].

Extensive studies have investigated the antibacterial properties of *Z. officinale* and *C. asiatica* individually, highlighting their bioactive compounds such as flavonoids, terpenoids, and phenolics that exhibit significant antimicrobial activity [8], [9]. Previous studies have demonstrated their potential efficacy against various bacterial strains, including *S. epidermidis* [10]. However, there is a lack of comparative information on the comparative studies of these two plant extracts, particularly in a formulated skin care product such as a lotion, to enhance their antibacterial efficacy.

Most research focuses on the extraction, biological activity, and applications of each plant individually, yet no study has compared both plant, *Z.officinale* and *C. asiatica.* Based on this research gap, this study aimed to prepare ethanol extracts of *Zingiber officinale* Roscoe and *Centella asiatica* (L.) Urb, characterize their chemical constituents using gas chromatography–mass spectrometry (GC-MS), formulate extract-containing lotions, and compare their physicochemical properties and antibacterial activity against *S.epidermidis*. The findings of this study provide insight into the potential development of natural plant-based topical antibacterial formulations.

MATERIALS AND METHODS

MATERIALS

The plant materials used in this study were ginger rhizomes and pegagan leaves obtained from Lombok, West Nusa Tenggara, Indonesia. The identification of plant species was performed at the Department of Biology Laboratory, Faculty of Mathematics and Natural Sciences, University of Mataram, Indonesia.

The chemicals and reagents used for extraction and lotion preparation included ethanol 96%, propylene glycol, glycerin, triethanolamine (TEA), disodium ethylenediaminetetraacetic acid (Na_2EDTA), methyl paraben, distilled water, avocado oil, and commercial lotion base. For antibacterial evaluation, Mueller–Hinton Agar (MHA) medium, *S. epidermidis*, clindamycin, and distilled water were used as culture medium, test microorganism, positive control, and negative control, respectively.

METHODS

Sample Preparation and Plant Determination

Ginger and Pegagan were obtained from Lombok, West Nusa Tenggara Barat, Indonesia (115º46 – 119º05 East Latitude and 08º10 – 09º05 South Latitude). Determination test was conducted at Biology Department, Faculty of Mathematics and Natural Science, University of Mataram)

Extraction of Ginger (*Z.r Officinale)* and Pegagan (*C.asiatica*)

Ginger and Pegagan respectively prepared then performed as follows with modification [11]. The plant materials were cleaned, dried, and ground into powder. The powdered samples were extracted by maceration using 96% ethanol as the extraction solvent. The maceration process was conducted using a solid-to-solvent ratio of 1:3 (w/v). The extraction was carried out for three days with solvent replacement to maximize the recovery of bioactive compounds. After extraction, the filtrates were collected and concentrated using an evaporation process until thick extracts of ginger and pegagan were obtained. The obtained extracts were subsequently used for GC-MS analysis and lotion formulation.

GC-MS analysis

The chemical constituents of ginger and pegagan extracts were analyzed using gas chromatography–mass spectrometry (GC-MS) with a SHIMADZU GC-MS QP2010 Ultra system. The analytical procedure was performed according to a previous method with modification [12]. The GC-MS operating conditions were as follows: column oven temperature of 40 °C, injection temperature of 250 °C, pressure of 149.6 kPa, total flow of 144.1 mL/min, column flow of 2.77 mL/min, linear velocity of 60 cm/s, and purge flow of 3 mL/min under split mode conditions. The total analysis time was 19.33 min. The identification of compounds was performed by comparing the

obtained mass spectra with available reference libraries. The relative percentage composition of each compound was calculated based on the ratio between the individual peak area and the total chromatographic peak area.

Preparation of Ginger and Pegagan Extract Lotion

The lotion formulations were prepared based on a previous method with modification [13]. The aqueous phase consisted of propylene glycol, glycerin, triethanolamine (TEA), Na_2EDTA, methyl paraben, distilled water, and plant extract. The oil phase consisted of avocado oil. The thick extracts of ginger and pegagan were separately incorporated into the aqueous phase before mixing with the oil phase under continuous stirring to obtain homogeneous lotion formulations.

Three concentrations of each extract were prepared, namely 0.5 g, 0.75 g, and 1 g. Each extract concentration was mixed with 5 g commercial lotion base, followed by the addition of propylene glycol, TEA, Na_2EDTA, methyl paraben, avocado oil, and distilled water until the final weight reached 10 g.

The formulations were coded as ginger lotion (GL) and pegagan lotion (CL). The composition of each formulation is presented in Table 1.

Table 1. The ingredients of lotion ZL and CL

Ingredients	Concentration (w/w) *Z. officinale*			Concentration (w/w) *C. asiatica*		
Water phase:						
Extract	0.5 g	0.75 g	1 g	0.5 g	0.75	1 g
Propylene glycol	0.5 g	0.5 g	0.5 g	0.5 g	0.5 g	0.5 g
Glycerin	0.5 g	0.5 g	0.5 g	0.5 g	0.5 g	0.5 g
Triethanolamine (TEA)	0.5 g	0.5 g	0.5 g	0.5 g	0.5 g	0.5 g
Na_2EDTA	0.5 g	0.5 g	0.5 g	0.5 g	0.5 g	0.5 g
Methyl paraben	0.1 g	0.1 g	0.1 g	0.1 g	0.1 g	0.1 g
Distilled water	1.4 g	1.15 g	0.9 g	1.4 g	1.15 g	0.9 g
Oil phases:						
Avocado oil	1 g	1 g	1 g	1 g	1 g	1 g

Antibacterial activities of Ginger and Pegagan lotion

The antibacterial activity of ginger and pegagan extract lotions was evaluated against *S. epidermidis* using the agar well diffusion method[14]. The bacterial suspension was inoculated onto Mueller–Hinton Agar (MHA) medium, and lotion formulations were introduced into agar wells. Ginger lotion formulations were coded as J1, J2, and J3, representing extract concentrations of 0.5 g, 0.75 g, and 1 g, respectively. Similarly, pegagan lotion formulations were coded as P1, P2, and P3.

Clindamycin was used as the positive control, while distilled water was used as the negative control. The plates were incubated at 37 °C for 24 h. Antibacterial activity was determined by measuring the diameter of the clear inhibition zone surrounding each well using a vernier caliper. The inhibition zone diameter was expressed in millimeters.

Organoleptic analysis and pH test

The physical characteristics of the lotion formulations were evaluated through organoleptic observation, including color, texture, and odor assessment. The pH of each formulation was measured to evaluate its suitability for topical application. The pH evaluation was performed because the acidity or alkalinity of topical formulations may influence skin compatibility and product quality [13].

RESULTS AND DISCUSSION

Plant Determination

The plant determination was conducted at the Department of Biology Laboratory, Faculty of Mathematics and Natural Sciences, University of Mataram, with registration number 014/UN18.F7/LBL/2025. The sample of ginger in this study was *Zingiber officinale* Roscoe, and the sampel of pegagan was *Centella asiatica* (L.) Urb. The identification results confirmed the authenticity of the plant materials prior to extraction and further analysis.

Chemical composition of Ginger and Pegagan using GC-MS analysis

The chemical constituents of ethanol extracts from *Z. officinale* Roscoe and *C.asiatica* (L.) Urb were analyzed using gas chromatography–mass spectrometry (GC-MS). The results demonstrated different chemical profiles between the two plant

extracts. The GC-MS analysis of *Z. officinale* Roscoe extract identified several major compounds, including eucalyptol (1,8-cineole), benzene, 1-(1,5-dimethyl-4-hexenyl), zingiberene, farnesene, β-bisabolene, β-sesquiphellandrene, and zingerone. Among the identified compounds, zingiberene was detected as the predominant constituent with a relative abundance of 36.24%. Other major compounds included β-sesquiphellandrene (13.22%), 2-butanone (11.63%), farnesene (7.21%), β-bisabolene (7.14%), and eucalyptol (1,8-cineole) (3.68%) (Table 2).

Chemical Composition of *Z. officinale* Roscoe Extract

The GC-MS analysis demonstrated that *Z. officinale* Roscoe extract was characterized by a high abundance of sesquiterpene compounds, with zingiberene identified as the predominant constituent (36.24%). This result indicates that the ethanol extraction method used in this study was effective in extracting volatile and semi-volatile bioactive compounds from ginger rhizomes. The detected zingiberene content was higher compared with previous reports.

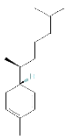
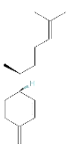
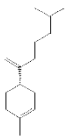
The dominant chemical constituent of *Z. officinale* Roscoe extract was Zingiberene (36.24%). This finding is higher than the previous study [15] that yielded Zingiberene ranging from 7.51% to 14.28% in *Z. officinale* Roscoe extract, while the presented result of zingiberene was 16.2 % in ginger essential oil [16]. Previous study reported reported 16.2% zingiberene content in Indonesian ginger essential oil. The higher zingiberene concentration observed in the present study may be associated with differences in ginger variety, geographical origin, cultivation conditions, maturity stage, and extraction techniques. [17].

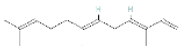
The chemical analysis of *Z. officinale* Roscoe extract revealed that the predominant compound is zingiberene, with a concentration of 36.24%. This level is considered high compared to previous studies. For instance, Sulejmanović et al. (2024) reported zingiberene content in ginger extract ranging from 7.51% to 14.28%, while Sasidharan, Venugopal, and Menon (2012) found a concentration of 16.3%. Similarly, Badrunanto et al. (2024) reported a content of 16.2% in ginger essential oil. These findings indicate that the ginger extract used in this study contains a significantly higher level of zingiberene, which may be attributed to factors such as plant variety, cultivation conditions, extraction methods, and harvest time.

In addition to zingiberene, the extract also contains other active compounds such as β-sesquiphellandrene (13.22%), 2-butanone (11.63%), β-bisabolene (7.41%), farnesene (7.21%), and eucalyptol (1,8-cineole) (3.68%). These compounds are known for their diverse biological activities, especially antioxidant, anti-inflammatory, and antimicrobial effects. For example, eucalyptol exhibits antibacterial activity against various pathogens, while β-bisabolene and farnesene contribute to the anti-inflammatory properties and characteristic aroma of ginger extract.

The complex composition and high zingiberene content suggest that ginger extract holds strong potential for pharmaceutical and cosmetic applications, particularly as an active ingredient in topical formulations such as lotions.

Table 2. Major chemical constituents identified in *Z. officinale* Roscoe extract

No	Major Compound	Chemical Structure
1	Zingiberene (36.24%)	
2	Beta sesquiphellandrene (13.22%)	
3	Beta bisabolene (7.14%)	

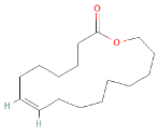
No	Major Compound	Chemical Structure
4	Farnesene (7.21%)	
5	Eucalyptol (1.8 cineole) (3.68%)	

Chemical Composition of C. *asiatica* (L.) Urb Extract

Unlike ginger extract, the chemical profile of C. *asiatica* (L.) Urb extract was dominated by fatty acid derivatives and volatile compounds. The major compounds identified were hexadecanoic acid (palmitic acid) (28.17%), 9,12,15-octadecatrienoic acid (27.88%), oxacycloheptadec-8-en-2-one (22.15%), and neophytadiene (10.15%). These findings are consistent with previous reports indicating that C. *asiatica* (L.) Urb contains various fatty acids and volatile compounds identified through GC-MS analysis [18]. Hexadecanoic acid, also known as palmitic acid (C16:0), is a saturated fatty acid commonly found in plants. It functions as a structural component of cell membranes, contributing to membrane integrity and stability. It also serves as a precursor for the biosynthesis of various lipids, including phospholipids and triglycerides. In addition, several phytochemical studies have reported that palmitic acid exhibits antimicrobial activity against certain bacteria and fungi and may contribute to the anti-inflammatory properties of plant extracts. Octadecatrienoic acid, commonly known as α-linolenic acid (ALA; C18:3, omega-3), is an essential polyunsaturated fatty acid found in C. *asiatica* (L.) Urb . This compound possesses antioxidant and anti-inflammatory properties and plays an important role in maintaining cell membrane fluidity. In plants, α-linolenic acid serves as a precursor for jasmonic acid biosynthesis, a signaling molecule involved in plant defense responses against biotic and abiotic stresses. In humans, α-linolenic acid has been associated with cardiovascular protection and the reduction of oxidative stress. Although these fatty acids exhibit biological activities, the major pharmacological effects of C. *asiatica* (L.) Urb — including wound healing, anti-inflammatory, antioxidant, neuroprotective, and collagen-stimulating activities—are primarily attributed to its triterpenoid compounds, particularly asiaticoside, madecassoside, asiatic acid, and madecassic acid [19].

The detection of 9,12,15-octadecatrienoic acid (α-linolenic acid; C18:3) also supports the biological potential of C. *asiatica* (L.) Urb . This polyunsaturated fatty acid has been associated with antioxidant and anti-inflammatory properties and plays an important role in plant defense mechanisms. Furthermore, neophytadiene, a volatile diterpene compound identified in this study, has also been reported as one of the phytochemical constituents detected in C. *asiatica* (L.) Urb extracts [20] Neophytadiene, a volatile organic compound found in plants, shows decreased levels under elevated carbon dioxide conditions due to multiple physiological and biochemical changes. Long-term exposure to high-carbon environments leads to reduced proteins associated with energy production pathways, such as the Calvin cycle, resulting in decreased photosynthesis and respiration in phytoplankton [21].

Table 2. Chemical constituents of C. *asiatica* (L.) Urb extract

No	Major Component	Chemical Structure
1	Neophytadiene	
2	Hexadecanoid acid	
3	Oxacycloheptadec-8-en-2-one	
4	9,12,15-Octadecatrienoic acid	

Evaluation of *Z. officinale* Roscoe and C. *asiatica* (L.) Urb Lotion Formulations

The successful incorporation of ginger and pegagan extracts into lotion formulations demonstrates the compatibility of both plant extracts with an oil-in-water (o/w) emulsion system. All formulations showed homogeneous texture, acceptable appearance, pleasant odor, and absence of visible cracking or phase separation. These characteristics indicate that the formulation components, including glycerin, propylene glycol, triethanolamine, methyl paraben, Na_2EDTA, distilled water, and avocado oil, provided adequate stability to maintain the physical properties of the lotion.

Table 4. Organoleptic properties and pH values of *Z. officinale* Roscoe and C. *asiatica* (L.) Urb extract lotion formulations

Lotion	Color	Texture	Odor	pH
Z. officinale Roscoe extract				
0.5 gr	Yellow	Homogen	Good	8
0.75 g	Yellow	Homogen	Good	8
1 g	Yellow	Homogen	Good	7
C. *asiatica* (L.) Urb extract				
0.5 gr	Yellowish	Homogen	Good	8
0.75 g	Yellowish	Homogen	Good	7
1 g	Yellowish	Homogen	Good	8

The homogeneous appearance observed in all formulations indicates that the mixing process was sufficient to produce uniform distribution of extract components within the lotion matrix. Physical stability is an important parameter for topical formulations because separation of oil and aqueous phases may affect active compound distribution and product effectiveness. The absence of phase separation and

the ability of the formulations to be redispersed after creaming suggest that the developed lotions possess acceptable short-term physical stability.

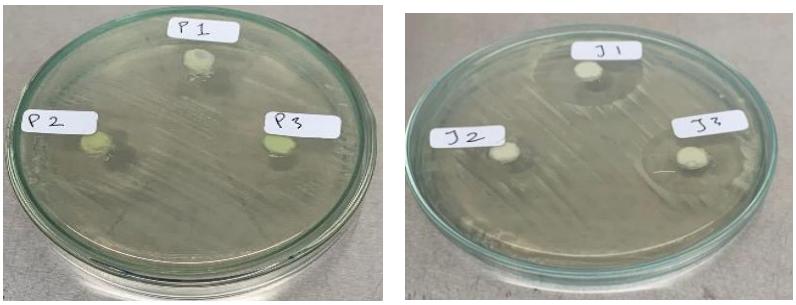
The organoleptic evaluation showed that *Z. officinale* Roscoe extract lotions exhibited a yellow appearance, while C. *asiatica* (L.) Urb extract lotions showed a yellowish appearance. The difference in color may be associated with variations in phytochemical composition between the two extracts. Ginger contains colored phenolic compounds such as gingerols and related compounds, whereas *C. asiatica* contains triterpenoids and other secondary metabolites that may contribute to its yellowish appearance.

The pH values of the formulations ranged from 7 to 8, indicating neutral to slightly alkaline characteristics. Similar findings have been reported for herbal lotion formulations containing ginger extract (Indriati et al. 2018). Although human skin generally has a slightly acidic pH (approximately 4.5–6.5), topical formulations with pH values close to neutral are generally acceptable when they do not cause irritation. The observed pH variation among formulations may be related to differences in extract concentration and interaction between plant-derived compounds and formulation components.

Overall, both ginger and pegagan extracts were successfully formulated into stable lotion preparations with favorable physicochemical characteristics. These results support the feasibility of using these plant extracts as active ingredients in natural-based topical products.

Antibacterial activities of ginger and pegagan lotion formulations

The antibacterial activity of ginger and pegagan extract lotion formulations was evaluated against *S.epidermidis* using the agar well diffusion method. Both ginger lotion (GL) and pegagan lotion (CL) formulations exhibited antibacterial activity, as indicated by the formation of clear inhibition zones around the wells (Figure 1). Ginger lotion formulations (J1, J2, and J3) produced inhibition zones ranging from 28–29 mm. The highest inhibition zone was observed in formulation J1 (29 mm), while formulations J2 and J3 produced inhibition zones of 28 mm. Similarly, pegagan lotion formulations (P1, P2, and P3) showed inhibition zones ranging from 28–29 mm, with the highest activity observed in formulation P3 (29 mm). The positive control, clindamycin, produced an inhibition zone diameter of 35 mm, whereas distilled water as the negative control showed no inhibition zone. These results demonstrate that both plant extract-based lotions exhibited antibacterial activity against *S. epidermidis*.



Scheme 1. Inhibition zone of ginger and pegagan lotion (J=ginger, P=pegagan)

Table 5. Diameter of inhibition zone of *GL* and *CL*

No.	Lotion	Sample Code	Average of Inbhbition zone diameter (mm)
1	GL	J1	29
2		J2	28
3		J3	28
4	CL	P1	28
5		P2	28
6		P3	29
Control (-): Aquades ; Control (+) : Clindamycin			0; 35

The lotion formulations developed using ginger and pegagan extracts demonstrated excellent physical characteristics and stability. Based on organoleptic observations and pH measurements (Table 1), all formulations exhibited a yellow to yellowish hue, stable texture without cracking, and a pleasant aroma. These attributes are essential for product quality assessment, especially in terms of user comfort and shelf life.

The pH values of all formulations ranged from 7 to 8, within the neutral to slightly alkaline range. This range is considered safe for topical application, as it does not irritate the skin and is compatible with various skin types, including sensitive skin. Minor variations in pH between formulations may result from differences in the active compound content and the natural acid-base properties of each extract [13].

From a stability perspective, the absence of cracking on the surface during the observation period indicates that the oil-in-water (o/w) emulsion formed possesses good physical stability. All formulations were also shown to be redispersible, meaning they could be rehomogenized after creaming, which is crucial for maintaining the uniformity and effectiveness of the active ingredients during storage and use.

The comparison between ginger and pegagan extracts revealed that both can be successfully incorporated into lotion formulations with relatively comparable characteristics. However, in terms of color, the yellow hue of ginger extract appeared more consistent than the yellowish tone of pegagan, possibly indicating differences in pigment or phenolic compound intensity.

Antimicrobial Potential Against *S.epidermidis*

The antimicrobial activity of both extracts, particularly against *S. epidermidis*, was a major focus of this study. Clindamycin is a lincosamide antibiotic widely used to treat infections caused by susceptible Gram-positive aerobic bacteria and anaerobic bacteria. It exerts its antibacterial effect by binding to the 50S subunit of the bacterial ribosome, thereby inhibiting protein synthesis. Specifically, clindamycin interferes with peptide chain elongation, resulting in a bacteriostatic effect, although it may exhibit bactericidal activity against highly susceptible organisms at high concentrations [22].

The antibacterial evaluation demonstrated that both ginger and pegagan extract lotions exhibited inhibitory activity against *S. epidermidis*, producing inhibition zones of 28–29 mm. These results indicate strong antibacterial potential of both formulations. Although clindamycin showed a higher inhibition zone (35 mm), the activity observed from the plant-based formulations confirms that natural extracts can provide significant antibacterial effects.

S. epidermidis is a Gram-positive, coagulase-negative bacterium commonly found as part of normal skin microbiota. However, it can act as an opportunistic pathogen associated with skin infections, biofilm formation, and inflammation. Therefore, the development of topical antibacterial agents targeting this microorganism is important, particularly for dermatological applications.

The antibacterial activity of ginger lotion may be associated with its high content of zingiberene and other terpenoid compounds. Previous studies have demonstrated that ginger-derived compounds exhibit antibacterial activity against Gram-positive bacteria, including *S.* species [4]. Terpenoid compounds may exert antimicrobial effects by disrupting bacterial membrane integrity, altering permeability, and interfering with essential cellular processes.

The antibacterial activity of pegagan lotion may be related to the presence of bioactive compounds such as fatty acids, neophytadiene, and other secondary metabolites. In addition, although not detected as major compounds by GC-MS in this study, triterpenoids such as asiaticoside and asiatic acid are known to contribute to the antimicrobial and wound-healing properties of *C.asiatica* (L.) Urb [19].

The comparable inhibition zones observed between ginger and pegagan lotions suggest that both extracts possess antibacterial potential despite differences in their chemical composition. Ginger may provide stronger antimicrobial effects due to its terpene-rich profile, whereas pegagan may provide additional benefits related to tissue repair and anti-inflammatory activity. Therefore, these two medicinal plants represent promising candidates for the development of natural topical antibacterial formulations.

Scientific and Practical Implications

This study provides evidence that *Z. officinale* Roscoe and *C.asiatica* extracts can be successfully incorporated into lotion formulations while maintaining acceptable physicochemical properties and antibacterial activity against *S. epidermidis*. The comparative approach highlights the differences between ginger-derived terpene compounds and pegagan-derived fatty acid and secondary metabolite profiles.

The findings support the potential application of these plant extracts as natural active ingredients in cosmetic and pharmaceutical topical preparations. However, further investigations involving long-term stability testing, cytotoxicity evaluation, determination of minimum inhibitory concentration (MIC), and in

vivo efficacy studies are required to confirm their safety and therapeutic potential.

CONCLUSION

Chemical characterization showed that the *Z.r officinale* Roscoe extract contained several major constituents, including eucalyptol (1,8-cineole), zingiberene, farnesene, β-bisabolene, β-sesquiphellandrene, and zingerone. In contrast, the *C.asiatica* (L.) Urb extract was characterized by the presence of neophytadiene, hexadecanoic acid (palmitic acid), and oxacycloheptadecane. The lotion formulated with *Z. officinale* Roscoe (ZL) exhibited a yellow appearance, homogeneous consistency, a pleasant odor, and an appropriate pH. Similarly, the *C. asiatica* (L.) Urb lotion (CL) displayed a yellowish color, homogeneous texture, a pleasant odor, and a pH of 8. At 0.5, 0.75, and 1 (w/w), respectively both lotion formulations demonstrated marked antibacterial activity against *Staphylococcus epidermidis*, producing inhibition zones of approximately 28–29 mm. These results indicate that lotions containing *Z. officinale* Roscoe and *C. asiatica* (L.) Urb possess considerable antibacterial potential and could be further developed as natural therapeutic and pharmaceutical products.

ACKNOWLEDGEMENTS

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