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Formulation and Physical Stability Evaluation of Herbal Liniment Containing Various Ginger Varieties (*Zingiber officinale*)

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ABSTRACT

Background: Musculoskeletal pain is a common health problem that can reduce the quality of life. Topical liniments are often used to relieve pain; however, long-term use of synthetic liniments carries a risk of skin irritation. Herbal-based liniments made from ginger rhizome (*Zingiber officinale*) are relatively safer, provide a warming sensation, and among their biological activities are anti-inflammatory and analgesic effects.
Aims: This experimental study aimed to evaluate the physical stability of a herbal liniment with variations of ginger: red, gajah, and emprit.
Methods: Three formulas were created, each containing 10% ginger extract in virgin coconut oil as a base. The evaluation was conducted over 28 days at room temperature (25 ± 2 °C), covering organoleptic properties, pH, homogeneity, viscosity, and transferable volume.
Results: The results showed good physical stability: pH 5.00–5.66, viscosity 5.00–5.60 cP, maintained homogeneity, and volume >95%. Statistical analysis ($p > 0.05$) revealed no significant differences among the formulas. However, the dark brown color did not meet this standard.
Conclusion: This herbal liniment is stable and has the potential to be developed as a topical preparation based on natural ingredients; however, color optimization is needed for better consumer acceptance.

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1. Introduction

Musculoskeletal disorders affect a person's quality of life due to various factors, such as chronic pain, physical function impairment, and psychosocial impacts. These disorders can be experienced by individuals with rheumatoid arthritis, degenerative conditions, post-surgery, or fibromyalgia (Alhashim *et al*., 2025). This condition also affects mental health and is associated with psychological disorders such as depression, anxiety, and mood changes, which further worsen an individual's perception of their health and quality of life (Maccarone *et al*., 2022; Althomali *et al*., 2021). This disease can affect people from all walks of life—not only manual laborers but also office workers such as teachers (Maccarone *et al*., 2022). On a national level, the prevalence of this disease is not yet adequately documented; however, several studies have found that in East Java and Central Java, the incidence of back pain and osteoarthritis ranges from 2.8% to 13.6%, primarily due to age (Moradi-Lakeh *et al.,* 2017). Young doctors in Indonesia, due to heavy workloads and lack of exercise, experience complaints in the neck, upper back, and lower back at a rate of 63.5% (Phedy & Gatam. 2016), while dental professionals suffer from back, lumbar, and upper neck complaints as a result of poor ergonomic posture and prolonged sitting (Kholinne *et al*., 2025).

The general management of musculoskeletal pain involves the use of nonsteroidal anti-inflammatory drugs (NSAIDs), administered either orally or topically. Topical use reduces the side effects associated with oral administration, such as systemic effects on the digestive and gastrointestinal tracts. Topical application is effective for acute musculoskeletal cases and for individuals at high risk of side effects from oral administration (Tieppo Francio *et al*., 2017; Shi *et al*., 2023). However, for chronic cases that require long-term use, herbal-based topical preparations, such as liniments, are increasingly popular because they are considered to have safer side effects and lower toxicity (Kopustinskiene *et al*., 2022; Sarkar *et al*., 2024).

Liniments are generally liquids containing active ingredients that treat and relieve specific skin conditions. They are formulated for easy application and quick absorption, delivering effects such as anti-inflammatory, analgesic, or antiseptic benefits depending on the active ingredients. Liniments are used for local effects on the skin or musculoskeletal system (Suhail *et al*., 2021; Oliveira & Almeida. 2023). Herbal liniments consist of mixtures of plant extracts and oils with specific therapeutic activities (Zhang *et al*., 2020).

Ginger *(Zingiber officinale*) is rich in bioactive compounds and has various therapeutic effects. The main components of ginger, particularly gingerol and shogaol (Setyawati *et al*., 2024), have analgesic, anti-inflammatory, antimicrobial (Verma *et al*., 2025), and antioxidant (Setyawati *et al*., 2024) effects. which are beneficial for treating musculoskeletal conditions. These multiple actions as a therapy for musculoskeletal issues can accelerate recovery by reducing swelling and pain in inflamed tissues, causing vasodilation that improves local blood circulation when the liniment is applied (Pagano *et al*., 2020), and preventing secondary infection in wounds or damaged skin (Handrianto, 2016).

Ginger has mild side effects when used topically (Supu *et al*., 2019). In contrast. several ginger varieties are commonly used in Indonesia, including red ginger (*Zingiber officinale var. rubrum*), gajah ginger (*Zingiber officinale var. Rosc.),* and small white ginger (*Zingiber officinale var. Amarum*), each with different physicochemical properties and active compound contents (Supu *et al*., 2019). Red ginger generally contains higher levels of bioactive compounds than the others (Govindarajan & Connell, 1983). Previous research has been conducted on the use of red ginger as a pain reliever for the muscles and joints (Athaillah & Lianda, 2021). However, to date, there is still limited research directly comparing the physical stability of herbal liniment preparations formulated from these various ginger varieties, Most previous studies have focused on pharmacological activities or other dosage forms, such as gels or ointments, rather than comprehensively evaluating the physical stability of liniments as liquid topical preparations.

Based on the above description, this study aimed to formulate an herbal liniment containing various ginger varieties, namely red ginger, gajah ginger, and small white ginger, and to evaluate

their physical stability through organoleptic, pH, homogeneity, viscosity, and volume displacement tests during the storage period (Ahmady *et al*., 2020; Pârvănescu *et al*., 2025; Sampaopan & Suksaeree, 2022). The results of this study are expected to make a scientific contribute to the development of stable, safe, and potentially effective herbal liniment preparations as alternative topical therapies for musculoskeletal pain.

The novelty of this study lies in comparing the physical stability of herbal liniment preparations formulated from three ginger varieties (Zingiber officinale var. rubrum, var. Rosc., and var. Amarum) in virgin coconut oil base, which has limitation of information previously explored in existing literature.

2. Methods

This experimental study was conducted to determine the effect of different types of ginger rhizomes *(Zingiber officinale)* on the physical stability of herbal liniment preparations. The research was conducted at the Pharmaceutical Technology Laboratory of Anwar Medika University. The ginger rhizome simplicia was obtained through wet sorting, washing, slicing to a thickness of ±2 mm, air-drying, and dry sorting. The dried simplicia was then ground and sieved using a 60-mesh sieve to obtain uniform particles. The simplicia powder was then extracted using the maceration method for three days with ethanol as the solvent.

The different formulations consisted of herbal liniments containing extracts of red ginger, gajah ginger, and emprit ginger. The main ingredients used in this study were extracts of red ginger rhizome, gajah ginger, and emprit ginger, all extracted using 95% ethanol, Virgin Coconut Oil (VCO) was used as the liniment base. The other added ingredients were menthol and camphor. The specifications of the materials used were pharmaceutical grade. The equipment used included an analytical balance, measuring glass, beaker glass, spatula, hot plate, magnetic stirrer, pH meter, viscometer, liniment bottles, and other supporting tools.

The liniment was formulated in three formulas, each with a ginger extract concentration of 10%. Formula I contained red ginger extract, Formula II contained gajah ginger extract, and Formula III contained emprit ginger extract. The process of making the liniment was prepared by dissolving menthol and camphor in a portion of the VCO base, after which ginger extract was added according to the formula. The mixture was stirred constantly using a magnetic stirrer until a homogeneous liniment was obtained, which was then placed in a tightly closed container.

Physical stability testing was conducted over 28 days of storage at room temperature (25 ± 2 °C). Testing was performed on days 0, 7, 14, 21, and 28. The physical stability parameters tested included organoleptic tests, pH tests, homogeneity tests, viscosity tests, and delivered volume tests. The organoleptic test was performed by visually observing the color, odor, and form of the preparation. The pH was measured using a calibrated pH meter to ensure that the preparation's pH was aligned with that of the skin. The homogeneity test involved applying the preparation to an object glass to ensure that there were no lumps or phase separation. Viscosity tests were conducted using a viscometer at room temperature to determine the consistency of the preparation, while delivered volume tests were performed to assess the ability of the preparation to be optimally dispensed from the container.

Table 1. Specifications of the planned preparation

Number	Evaluation	Specifications
1	Preparation color	Yellowish brown
2	Preparation odor	Clove or Cinnamon aroma
3	Dosage form and consistency	Massage oil. liquid
4	Preparation pH	4.5-6.5 (Gunawan, 2019)
5	Homogeity	Homogeneous (Handayani *et al*., 2023)

6	Viscosity	2.3-6.0 cps (Gunawan, 2019)
7	Transferable volume	Not less than 95% (Nuzaibah, 2023)

The results of the physical stability tests were analyzed descriptively and statistically. Statistical analysis was performed using a one-way ANOVA test to determine whether there were differences in the physical characteristics of the liniment formulas. A p-value > 0.05 was considered to indicate no statistically significant difference between formulas.

3. Results and Discussion

3.1 Plant determination

Plant identification was performed to ensure the botanical identity of the materials used in this study, red ginger rhizome (*Zingiber officinale var. rubrum*), gajah ginger (*Zingiber officinale var Rosc.*), and emprit ginger (*Zingiber officinale Roscoe var. amarum*) were determined at the UPT Herbal Materia Medica Laboratory in Batu, Indonesia. The results showed that the three samples matched the intended species, with determination numbers 000.9.3/2240/102.20/2025 (red ginger), 000.9.3/2238/102.20/2025 (gajah ginger), and 000.9.3/2239/102.20/2025 (emprit ginger). These results confirm the authenticity of the plant materials used in the formulation of herbal liniments.

3.2. Preparation of Simplicia and Extracts

Ethanol was chosen based on its ability to extract active compounds and its relatively safe and economical properties. The thick extract obtained had a yield of 10.4%, indicating that the extraction process was efficient.

3.3. Phytochemical screening

The results of the phytochemical screening of the ginger extract are shown in Figure 1 and summarized in Table 1.

Table 2. Phytochemical screening results of ginger extract

Screening	**Extract**		
	Red ginger	**Gajah ginger**	**Emprit ginger**
Alkaloids	+	-	+
Flavonoids	-	-	-
Tannins	-	-	-
Saponins	-	-	-
Terpenoids	+	+	+
Phenols	-	-	-

Extracts of red and emprit ginger showed positive reactions to alkaloid and terpenoid compounds, while extracts of gajah ginger showed a positive reaction to terpenoid compounds. The presence of alkaloids was indicated by the formation of precipitates with Mayer's, Dragendorff's, and Wagner's reagents, while terpenoids were indicated by a change in color to green. These compounds are known to possess analgesic and anti-inflammatory properties, supporting the use of ginger extract as an active ingredient in liniment formulations. In addition, the presence of these secondary metabolites is suspected to contribute to the characteristic brownish-black color of the liniment.

3.4. Herbal Liniment Formulation

The herbal liniment was formulated by mixing peppermint oil, Virgin Coconut Oil (VCO), and ginger extract until a homogeneous preparation was obtained, Clove and cinnamon were added as supplementary ingredients. The three resulting formulas were in liquid form with uniform physical characteristics.

Table 3. Ginger Extract Yield Calculation Results

Material	Formula I (%) (Red ginger extract)	Formula II (%) (Gajah ginger extract)	Formula III (%) (Emprit ginger extract)
Ginger extract	10	10	10
Peppermint oil	5	5	5
Clove flower	3	3	3
Cinnamon	3	3	3
Virgin coconut oil ad	100	100	100

Figure 1. Results of liniment preparations A. Formula I, Red ginger, B. Formula II. Gajah ginger, C. Formula III. Emprit ginger

3.4. Physical Stability Test

The physical stability test was conducted using the real-time study method for 21 days at room temperature (25 ± 2 °C) and protected from the sunlight. The parameters observed included organoleptic properties, pH, homogeneity, viscosity, and displaced volumes. As shown in Table 4, all liniment formulas had a blackish-brown color, characteristic scent, and liquid form during storage up to the 21st day, without any significant changes. The resulting color did not fully meet the expected specifications, which is suspected to be due to the relatively high concentration of the ginger extract. However, its stability indicates that there was no physical degradation during storage. The intended organoleptic specifications for this formula were a yellowish-brown color, characteristic scent, and thin consistency, as determined during the orientation. According to Table 4, the results of the organoleptic tests over 21 days for the three formulas and their three replicates showed no changes. The color specification results did not match the initial formulation design. This is likely because the 10% ginger extract was too dense, causing the color to tend toward blackish-brown. At high concentrations of ginger extract, phenolic compounds (shogaol and gingerol) with strong antioxidant properties contribute to the color of the liniment. Additionally, natural pigments produce darker colors owing to molecular interactions and their chemical properties during the extraction and formulation processes (Alqahtani *et al*., 2024; Plana *et al*., 2025). To improve the color, possible steps include reducing the ginger extract concentration, selecting an appropriate maceration method in tperms of both solvent and technique, or adding natural antioxidants. As for the aroma, the initial

formulation was designed to feature clove or cinnamon scents. The resulting aroma was a distinctive combination of spicy scents.

Table 4. Organoleptic test results

Day to	Type of observation	Replication	Organoleptic		
			F1	F2	F3
0	Color	R1	Blackish brown	Blackish brown	Blackish brown
	Odor		Typical	Typical	Typical
	Consistency		Thin	Thin	Thin
	Color	R2	Blackish brown	Blackish brown	Blackish brown
	Odor		Typical	Typical	Typical
	Consistency		Thin	Thin	Thin
	Color	R3	Blackish brown	Blackish brown	Blackish brown
	Odor		Typical	Typical	Typical
	Consistency		Thin	Thin	Thin
7	Color	R1	Blackish brown	Blackish brown	Blackish brown
	Odor		Typical	Typical	Typical
	Consistency		Thin	Thin	Thin
	Color	R2	Blackish brown	Blackish brown	Blackish brown
	Odor		Typical	Typical	Typical
	Consistency		Thin	Thin	Thin
	Color	R3	Blackish brown	Blackish brown	Blackish brown
	Odor		Typical	Typical	Typical
	Consistency		Thin	Thin	Thin
14	Color	R1	Blackish brown	Blackish brown	Blackish brown
	Odor		Typical	Typical	Typical
	Consistency		Thin	Thin	Thin
	Color	R2	Blackish brown	Blackish brown	Blackish brown
	Odor		Typical	Typical	Typical
	Consistency		Thin	Thin	Thin
	Color	R3	Blackish brown	Blackish brown	Blackish brown
	Odor		Typical	Typical	Typical
	Consistency		Thin	Thin	Thin
21	Color	R1	Blackish brown	Blackish brown	Blackish brown
	Odor		Typical	Typical	Typical
	Consistency		Thin	Thin	Thin
	Color	R2	Blackish brown	Blackish brown	Blackish brown
	Odor		Typical	Typical	Typical
	Consistency		Thin	Thin	Thin
	Color	R3	Blackish brown	Blackish brown	Blackish brown
	Odor		Typical	Typical	Typical
	Consistency		Thin	Thin	Thin

As shown in Table 5, the pH values of all the formulas during storage for up to 21 d ranged from 5.00 to 5.66. In the fourth week, there was an increase in pH, which may have been caused by environmental factors, such as temperature and inadequate storage conditions. The pH increase remained within a range that matched the skin pH and the preparation's specifications, indicating that the product is safe for topical use. Statistical testing using the Kruskal-Wallis test in Table 6 showed

a significance value of 0.901 ($p > 0.05$), indicating no significant difference among the three formulations regarding pH.

Table 5. pH test results for ginger varieties

Day to	Specification	pH								
		F1			F2			F3		
		R1	R2	R3	R1	R2	R3	R1	R2	R3
0	4.5 – 6.5	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
7		5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
14		5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
21		5.60	5.60	5.60	5.60	5.60	5.60	5.60	5.60	5.60

Table 6. Kruskal Wallis Test Results for pH

Test Statistics[a.b]	
	Results pH
Kruskal-Wallis H	.209
df	2
Asymp. Sig.	.901

The results of the homogeneity test for the three samples are presented in Table 8, Homogeneity testing indicated that all preparations remained homogeneous without any coarse particles or phase separation, signifying the physical stability of the liniment over 21 days of storage.

The results of the viscosity tests are presented in Table 8, The viscosity values during the 21 days of storage ranged from 5.00 to 5.60 cP, There was an increase in viscosity in the third week; however. the values still met the quality requirements for oil preparation viscosity, which is 2.3–6.0 cP (Syaputri *et al*., 2023). This shows that the preparation remains easy to apply. The increase in viscosity values on the 3rd and 4th measurements is possibly due to interactions between the ingredients during storage, which made the liquid thicker. The results of the Kruskal-Wallis test in Table 9 show a significance value of 1.000 ($p > 0.05$), indicating that there is no significant difference among the three formulations with respect to viscosity.

Tabel 7. Homogeneity Test Results

Day to	Specification	Homogeneity								
		F1			F2			F3		
		R1	R2	R3	R1	R2	R3	R1	R2	R3
0	Homogeneus/even color (Handayani *et al*., 2023)	√	√	√	√	√	√	√	√	√
7		√	√	√	√	√	√	√	√	√
14		√	√	√	√	√	√	√	√	√
21		√	√	√	√	√	√	√	√	√

√ =homogeneus

Table 8. Viscosity Test Results of Ginger Variety Liniment

Day to	Specification	Viscosity (cP)								
		F1			F2			F3		
		R1	R2	R3	R1	R2	R3	R1	R2	R3
0	4.5 – 6.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
7		5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
14		5.41	5.41	5.41	5.47	5.47	5.47	5.6	5.6	5.6
21		5.66	5.66	5.66	5.66	5.66	5.66	5.66	5.66	5.66

Table 9. Kruskal-Wallis Test Result for Viscosity

Test Statistics[a.b]	
	Risults Visco
Kruskal-Wallis H	.000
df	2
Asymp. Sig.	1.000

The results of the displaced volume test are shown in Table 10, which shows that all formulas had displaced volumes of 96–100% during the 21-day storage period. This value meets the requirements of not being less than 95% of the volume stated on the label (Nuzzaibahs & Ermawati. 2023); thus, the preparation is considered to meet quality standards in terms of ease of use. In Table 11, the statistical test results using Kruskal–Wallis show a significance value of 1.000 ($p > 0.05$), which means that there is no significant difference among the three formulations in terms of the displaced volume results.

Tabe10. Displaced volume test results

Day to	Spesification	Replication	Displaced Volume (%)		
			F1	F2	F3
0	Not less than 95%	R1	100	100	100
		R2	100	100	100
		R3	100	100	100
7		R1	99	99	99
		R2	99	99	99
		R3	99	99	99
14		R1	97	97	97
		R2	97	97	97
		R3	97	97	97
21		R1	96	96	96
		R2	96	96	96
		R3	96	96	96

Tabe 11. Kruskal-Wallis Test Result for Displaced Volume

Test Statistics[a.b]	
	Results Volume
Kruskal-Wallis H	.000
Df	2
Asymp. Sig.	1.000

Physical stability testing is conducted to ensure that the liniment is able to maintain its physical characteristics and quality during 21 days of storage, so that the preparation remains safe, effective, and comfortable to use. Stability parameters, such as organoleptic properties, pH, homogeneity, viscosity, and volume transferred, generally showed no significant differences among the three formulas at the beginning of production (D=0) and during storage (D=21 days) (Hasibuan *et al*., 2024; Wahidah *et al*., 2024; Widyaningrum *et al*., 2024).

4. Conclusions

Based on the results of the study, it can be concluded that the herbal liniment formulation containing extracts of red ginger rhizome, gajah ginger, and emprit ginger at a concentration of 10% showed good physical stability during the storage period. The parameters of pH, viscosity, homogeneity, and the volume transferred in all formulas met the quality requirements for topical preparations on observations on days 0, 7, 14, and 21, with three replications. However, the results of organoleptic testing showed that the color of the preparation did not yet meet the expected specifications. As a suggestion, the color of the preparation that does not conform to the initial specifications can be addressed by reducing the concentration of the extract or by performing extraction with a different method. The ginger extract liniment formulation has the potential to be developed as a natural ingredient medicinal preparation through biological activity tests, such as antioxidant activity or microbiological activity assays.

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6. Conflict of Interest Declaration

The authors declare that there is no conflict of interest regarding the publication of this article. The Authors confirmed that the paper was free of plagiarism.

7. Author Contribution Statement

All authors contributed equally to the research, data analysis, and writing and preparation of this scientific article.

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