Research Article
Sciences of Pharmacy

LC-HRMS Profiling and Formulation of Emulgel from Olae (*Etlingera calophrys*) as an Anti-inflammatory Agent

Muhammad Asman Setiawan, Karmilah Karmilah, Musdalipah Musdalipah, Agung Wibawa Mahatva Yodha, Eny Nurhikma, Asmaul Mutmainna, Nirwati Rusli

[The author informations are in the declarations section. This article is published by ETFLIN in Sciences of Pharmacy, Volume 5, Issue 4, 2026, Page 375-0. DOI: 10.58920/sciphar0504733]

Received
04 July 2026

Revised
28 July 2026

Accepted
24 August 2026

Published
26 October 2026

Editor
Garnadi Jafar

Keywords: Zingiberaceae, anti-inflammatory, yakuchinone A, emulgel, protein denaturation.

CC BY 4.0

AUTHOR (2026)

Abstract: *Etlingera calophrys*, commonly known as olae, is an endemic plant in the family Zingiberaceae, traditionally recognized for its anti-inflammatory properties, although scientific studies remain limited. This study aims to identify bioactive compounds in olae rhizomes using Liquid Chromatography–High Resolution Mass Spectrometry (LC-HRMS) and to develop an emulgel formulation as a more stable and effective topical delivery system. Olae rhizome was extracted by maceration using 96% ethanol, and the metabolite profile was analyzed by LC-HRMS. The emulgel was prepared in concentrations of 1%, 2%, 3% and evaluated for organoleptic properties, pH, adhesion, spreadability, irritation, homogeneity, and stability. In vitro anti-inflammatory activity was evaluated using the bovine serum albumin (BSA) protein denaturation inhibition assay. LC-HRMS analysis identified compounds yakuchinone A, 4-methoxybenzaldehyde, betaine, choline, maxacalcitol, and (9-cis)-Retinal, which are known to have biological activity in inhibiting inflammatory mediators. The formulation of an emulgel was successfully produced and met the physical and stability evaluation parameters, including organoleptic, homogeneity, pH, adhesion, spreadability, irritation, and stability. The results of in vitro anti-inflammatory activity showed that the emulgel had anti-inflammatory activity with IC_{50} values of 70.54 mg/L, 64.86 mg/L, and 52.55 mg/L, respectively. However, these results represent preliminary acellular anti-inflammatory activity and do not establish transdermal permeability or therapeutic efficacy. Further studies involving extract-release and skin-permeation testing, cell-based anti-inflammatory models, toxicity assessment, and in vivo validation are required to determine the topical therapeutic potential of *E. calophrys* rhizome emulgel.

Introduction

Etlingera is a diverse genus within the Zingiberaceae family, comprising approximately 150–200 species worldwide, including six species reported on Java and approximately 48 species on Sulawesi. Seven species are known to be endemic to Southeast Sulawesi (1). Several of which have demonstrated important pharmacological activities (2–5). For example, *Etlingera elatior* fruit exhibits hepatoprotective, antibacterial, antioxidant, and antidiabetic activities (6, 7), while the stem of *Etlingera calophrys* has been reported to possess antioxidant activity (8, 9). The rhizome of *Etlingera alba* demonstrates antioxidant and anticancer potential (10, 11), whereas the fruit and stem of *Etlingera rubroloba* exhibit antioxidant, anticancer, antidiabetic, and anti-inflammatory activities (12, 13). These findings indicate that *Etlingera* species contain diverse bioactive compounds with considerable pharmacological potential, particularly antioxidant, antimicrobial, and anti-inflammatory properties (14–16). Among the endemic species of Sulawesi, *E. calophrys*, locally known as Olae, has traditionally been used by local communities to treat wounds and pain. However, scientific information regarding its phytochemical composition and biological activities remains limited. Therefore, further investigation of its metabolite profile and anti-inflammatory potential is warranted to provide scientific evidence supporting its traditional use and to identify compounds that may contribute to its biological activity.

Tee *et al.* (3) conducted anti-inflammatory research on *E. calophrys* rhizome with sodium diclofenac as a positive control. The results showed that *E. calophrys* rhizome has anti-inflammatory activity with an IC_{50} value of 3.44 mg/L, which is classified as very strong. The Liquid

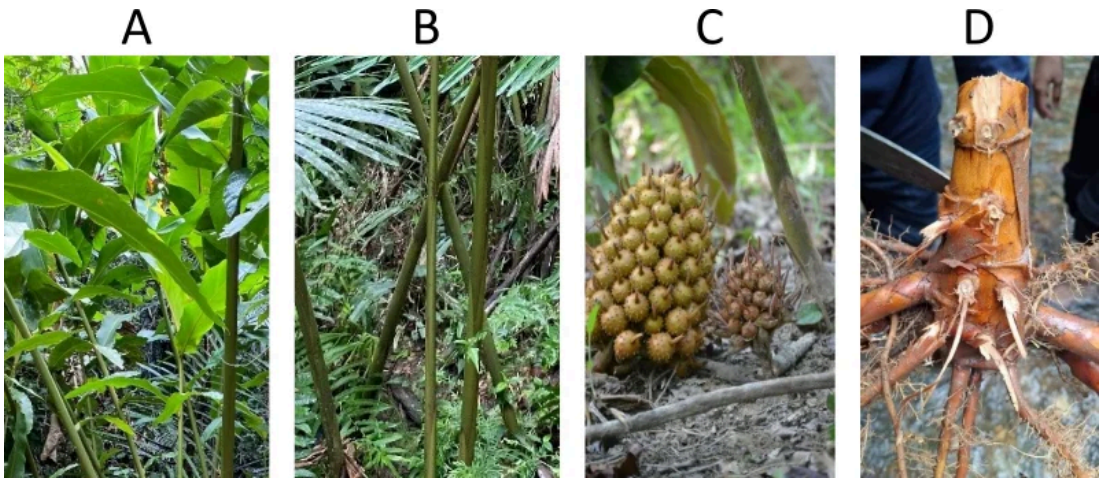


Figure 1. Part of *Etlingera calophrys* plant: (A) leaf ; (B) stem; (C) fruit; (D) rhizome.

Chromatography–High Resolution Mass Spectrometry (LC-HRMS) approach allows for a more in-depth identification of bioactive compounds in *E. calophrys* rhizomes, thereby providing a scientific basis for the plant's pharmacological activity.

Currently, skin inflammation is generally treated with corticosteroids and nonsteroidal anti-inflammatory drugs (NSAIDs) (17). However, long-term use of both types of drugs can cause various side effects, such as itching, irritation, dry skin, folliculitis, hypertrichosis, acne-like rashes, hypopigmentation, allergic contact dermatitis, skin maceration, striae, and miliaria (18). This condition has prompted the development of safer alternative therapies. One of which is through the use of medicinal plants like *E. calophrys* rhizome, known to have anti-inflammatory potential with lower toxicity risks. The development of topical anti-inflammatory formulations is necessary, as they can be applied directly to the affected area, allowing the medication to penetrate the skin optimally (19).

Information regarding the composition of active compounds obtained from LC-HRMS analysis is an important basis for the development of appropriate dosage forms, especially for improving the effectiveness of bioactive compound delivery to target tissues. An emulgel was selected as the topical dosage form because it combines the advantages of emulsions and gels, making it suitable for incorporating plant extracts containing both hydrophilic and lipophilic compounds (19). Compared with conventional creams or ointments, emulgels may offer favorable spreadability, ease of application, and user acceptability, while accommodating compounds with different physicochemical properties (21, 22). The emulsion phase may facilitate the dispersion and solubilization of lipophilic compounds, whereas the polymeric gel matrix may contribute to the physical stability, consistency, and retention of the formulation on the skin surface (17). These characteristics make emulgel a potentially suitable delivery system for *E. calophrys* rhizome extract.

However, the effects of the formulation on the release, skin permeation, and local availability of bioactive compounds remain to be established. Therefore, this study focused on developing and evaluating the physicochemical characteristics and preliminary *in vitro* anti-inflammatory activity of *E. calophrys* rhizome extract emulgel. Incorporation of the crude extract into the emulgel matrix may affect the availability of its constituents during *in vitro* testing through interactions with the Carbomer-HPMC network and partitioning between the aqueous and oil phases, which may subsequently influence compound release and diffusion into the assay medium.

The objective of the study is 1) to characterize the metabolite profile of *E. calophrys* rhizome extract using LC-HRMS; 2) formulate the extract into an emulgel; and 3) evaluate the physicochemical properties, stability, irritation potential, and *in vitro* anti-inflammatory activity of the resulting formulations. The results of this study are expected to provide a scientific basis for the development of natural-based emulgels as candidates for safe, stable, and effective anti-inflammatory preparations.

Methodology

Plant Material

The *E. calophrys* plant (see **Figure 1**) was identified at the Center for Biosystematics and Evolution Research, National Research and Innovation Agency (BRIN), Cibinong, Bogor, Indonesia, with certificate number 957/IPH.1.01/If.07/V/2019. The rhizome was obtained from Simbalai Village, Loea District, East Kolaka Regency, Southeast Sulawesi. Rhizome samples were collected, washed, sorted, and then dried at 45 °C for three days. Once dry, the simplisia was ground into a fine powder and stored in a clean, dry, tightly sealed container protected from light (3).

Extraction

A total of 500 g of dried *E. calophrys* rhizome powder was macerated with 5 L of 96% ethanol at a solid-to-solvent ratio of 1:10 (w/v) for 3 × 24 h at room temperature with periodic stirring. The maceration filtrate was separated by filtration, and the resulting filtrate was concentrated under reduced pressure at 45 °C using a Stuart RE300 (USA) rotary evaporator at a rotation speed of 80 rpm until a thick extract was obtained (3). A total of 25 g of concentrated extract was obtained, corresponding to an extraction yield of 5.0%. The resulting *E. calophrys* rhizome extract was subsequently analyzed by LC-HRMS for chemical profiling and used as the active ingredient in the

Table 1. Anti-inflammatory emulgel formula from *Etlingera calophrys* rhizome.

Ingredients	Concentration (%)				Range	Function
	F0	F1	F2	F3		
E. calophrys rhizome extract	0	1	2	3	-	Active ingredient
Carbomer 980	2	2	2	2	0.5-2%	Gelling Agent
HPMC	0.25	0.25	0.25	0.25	0.25-5%	Gelling Agent
Span 80	1.5	1.5	1.5	1.5	1-10%	Emulgator
Tween 80	8.5	8.5	8.5	8.5	1-10%	Emulgator
Propylene glycol	10	10	10	10	10-24%	Humectant
Benzoic acid	0.2	0.2	0.2	0.2	0.02-0.5%	Preservative
BHT	0.1	0.1	0.1	0.1	0.0075-0.1%	Antioxidant
Triethanolamine (TEA)	1	1	1	1	1%	pH Adjustment
Purified water q.s.	100%	100%	100%	100%	Up to 100%	Solvent

formulation of emulgel.

Identification of Secondary Metabolites by LC-HRMS

Approximately 50 mg of dried extract was ultrasonically extracted (Branson Ultrasonic Corporation, Danbury, CT, USA) with 1.5 mL of methanol at 30 °C for 15 min. The extract was filtered through a 0.2 µm PTFE syringe filter (SY25TF, mdi), and the filtrate was transferred into an LC-MS vial for analysis. Metabolite profiling was performed using a UHPLC-Q Exactive Plus Orbitrap high-resolution mass spectrometer (Thermo Scientific™, Waltham, MA, USA) equipped with an Accucore™ Phenyl Hexyl column (100 × 2.1 mm, 2.6 µm). Chromatographic separation was carried out using 0.1% formic acid in water (mobile phase A) and acetonitrile (mobile phase B) with a linear gradient elution program at a flow rate of 0.3 mL min^{-1}, an injection volume of 0.5 µL, and an autosampler temperature of 10 °C. Full-scan mass spectra were acquired over an *m/z* range of 100–1500 in both positive and negative electrospray ionization (ESI) modes at a resolving power of 70,000 FWHM, and MS/MS spectra were obtained using stepped collision energies of 18, 35, and 53 eV. Raw LC-HRMS data were processed using Compound Discoverer™ (Thermo Fisher Scientific) for peak detection, retention time alignment, isotope grouping, feature extraction, and metabolite annotation. Compound annotation was performed by matching accurate precursor masses, isotope patterns, and MS/MS fragmentation spectra against the mzCloud™, ChemSpider™, and PubChem databases. The precursor and fragment mass tolerances were set at 5 ppm and 10ppm, respectively, and common adduct ions, including $[M+H]^+$, $[M+Na]^+$, $[M+NH_4]^+$, $[M-H]^-$, and $[M+HCOO]^-$, were considered during annotation. Metabolites were reported as putatively annotated compounds (MSI Level 2) based on accurate mass and MS/MS spectral matching, whereas compounds assigned only from accurate mass without definitive MS/MS confirmation were reported as candidate molecular formulas (MSI Level 3) according to the Metabolomics Standards Initiative (MSI) (20).

Formulation of *Etlingera calophrys* Rhizome Emulgel

The process of emulgel preparation begins with the preparation of the gel base, which is done by dispersing HPMC in 4 mL of hot distilled water and leaving it for 30 min. In a separate container, Carbopol is also dispersed in 5 mL of hot water and left for 15 min to expand. After that, the expanded Carbopol base is crushed, then TEA is added and mixed with the HPMC base until a clear and homogeneous gel is formed. The next step is to prepare the emulsion phase, in which the water phase ingredients: extract, tween 80, propylene glycol, and distilled water, and the oil phase: benzoic acid, Span 80, BHT are heated to 70 °C on a hot plate. Once both phases reach the appropriate temperature, the oil phase is mixed into the water phase while stirring until a homogeneous emulsion is formed. The final step is to mix the emulsion mass into the gel base while grinding slowly until a homogeneous emulgel preparation is formed. The formula from *E. calophrys* rhizome is presented in **Table 1**.

Anti-Inflammatory Activity: Protein Denaturation Method

The anti-inflammatory activity test method using the protein denaturation technique was carried out by preparing a test solution consisting of 2 mL of bovine serum albumin (BSA) 1%, 2.8 mL phosphate buffer solution (PBS, pH 6.4), and varying volumes of sample extract to obtain final concentrations of 50, 40, 30, 20, and 10 mg/L. A control solution was prepared without the addition of extract. Next, the mixture was incubated at 37.5 °C for 10–15 min, then heated at 65 °C for 5 min to trigger the protein denaturation process. After cooling, the absorbance was measured at a wavelength of 650 nm. As a comparison, sodium diclofenac at the same concentrations (50, 40, 30, 20, and 10 mg/L) was used as a positive control and subjected to the same treatment (23, 24).

Characterization of Emulgel Preparations

Organoleptic Test: This was done by directly observing the color, smell, and consistency of the emulgel base that had been made (25).

Homogeneity Test: A sufficient amount of emulgel preparation is applied to a glass object and covered with another glass object, then placed on white paper and observed for uneven particles (26).

pH Test: About 1 g of emulgel is dissolved in 10 mL of distilled water. Next, universal pH indicator paper is dipped into the mixture for a few moments. The color change that occurs is compared to the color standard on the outside of the container (26).

Table 2. Profiling of secondary metabolite compounds in *Etlingera calophrys* rhizome extract.

No	RT (min)	Molecular Weight	Name	Relative area (%)
1	0.75	103.10	Choline	2.29
2	0.84	117.08	Betaine	3.91
3	0.85	137.05	Methyl isonicotinate	0.77
4	6.84	185.21	Tributylamine	1.91
5	9.75	317.29	2-Amino-1, 3, 4-octadecanetriol	1.84
6	9.78	433.21	Mycophenolate mofetil	0.79
7	10.02	144.06	1-Naphthol	0.95
8	10.21	330.07	Aflatoxin G2	6.82
9	10.58	344.09	Bagremycin B	4.85
10	11.79	314.08	Aflatoxin B2	1.81
11	12.09	312.17	Yakuchinone A	2.18
12	12.09	136.05	4-Methoxybenzaldehyde	13.24
13	12.24	190.17	1, 3-di-tert-butylbenzene	17.82
14	12.51	288.21	Testosterone	3.31
15	12.67	350.24	Tetrahydro-11-deoxycortisol	0.80
16	13.07	318.22	5-OxoETE	2.84
17	13.07	108.09	4-Vinylcyclohexene	2.58
18	13.65	348.23	3.17.21-Trihydroxypregn-2-en-1-one	2.16
19	14.62	264.25	2-[(5Z)-5-tetradecenylcyclobutanone	1.16
20	14.88	390.28	Bis (2-ethylhexyl) phthalate	0.76
21	15.34	284.21	(9cis)-Retinal	26.06
22	15.96	418.31	Maxacalcitol	1.15

Adhesion Test: 0.5 g of emulgel is placed in the center of two glass objects with a 1 kg load for 5 min. Both ends of the objects are attached to the device. Adhesion is calculated as the time required for the two glass objects to separate (26).

Spreadability Test: The spreadability of formulations was determined by placing 0.5 g of emulgel on a clean transparent glass plate and covering it with a s glass plate. Loads of 50, 100, 150, and 200 g were applied sequentially to the upper plate, with each load maintained for 1 min. The test was performed in triplicate for each formulation, and the results were expressed as mean ± standard deviation (SD) (25).

Irritation Test: Ten volunteers were sought. The test was conducted by applying 0.5 g of emulgel to the inner forearm. The test was conducted for 15 min, 3 times a day in the morning, afternoon, and evening for 1 day. A positive irritation reaction was indicated by redness, itching, or swelling of the treated skin area (25).

Stability Test (Cycling Test): The four emulgel formulations were stored at 2-8 °C for one day, followed by storage at 40 °C for one day (one cycle). The examination was conducted for 3 cycles, totaling 6 days, and physical changes in the emulgel preparations before and after the cycling test were observed using the same testing method as in the room temperature storage test (26).

Data Analysis

Data analysis includes the profile of bioactive compounds obtained from LC-HRMS and *in vitro* anti-inflammatory activity testing. LC-HRMS data is used to identify secondary metabolites in *E. calophrys* rhizome extracts based on molecular mass, chemical formula, and ion fragmentation patterns with reference to literature, thereby obtaining compounds with anti-inflammatory potential. *In vitro* anti-inflammatory activity tests were analyzed from absorbance values to calculate the % of protein denaturation inhibition and determine the IC_{50} value through linear regression between log concentration and % inhibition. In addition, the results of the physical evaluation of the preparation (pH, homogeneity, spreadability, adhesiveness, and stability) were analyzed descriptively to ensure the quality and stability of the emulgel as an effective topical preparation.

Results and Discussion

Profiling of the Chemical Components

Analysis of secondary metabolites in *E. calophrys* rhizomes using Liquid Chromatography–High Resolution Mass Spectrometry (LC-HRMS) successfully identified various bioactive compounds belonging to the phenolic, flavonoid, and steroid groups. Some of the main compounds detected include yakuchinone A, 4-methoxybenzaldehyde, betaine, choline, maxacalcitol, and (9-cis)-retinal (**Table 2**). These compounds are known to have important biological activities, particularly in inhibiting inflammatory mediators and protecting cells from oxidative stress (5, 8, 27, 28).

Chemical composition analysis successfully identified 22 major compounds with retention times (RT) ranging from 0.75 to 15.96 min. The analysis results showed that *E. calophrys* rhizomes contain various bioactive compounds belonging to the alkaloid, phenolic, steroid, and fatty acid derivative groups, which are known to have important pharmacological activities, particularly as anti-inflammatory agents and antioxidants. The compounds with the highest concentrations includes (9-cis)-Retinal (26.06%), 1, 3-di-tert-butylbenzene (17.82%), 4-methoxybenzaldehyde (13.24%), aflatoxin G2 (6.82%), bagremycin B (4.85%), betaine (3.91%), testosterone (3.31%), 5-OxoETE (2.84%), 4-Vinylcyclohexene (2.58%),

Table 3. Evaluation of *Etlingera calophrys* rhizome emulgel.

Formula	Organoleptic			Homogeneity	Adhesive strength (s)	Spreadability (cm)	pH	Irritation
	Smell	Shape	Color					
Before the cycling test								
F0	-	Semi-solid	White	Homogeneous	1.80	4.1	4.5	non-irritating
F1	Distinctive odor	Semi-solid	Light brown	Homogeneous	1.79	5.6	5.0	non-irritating
F2	Distinctive odor	Semi-solid	Brown	Homogeneous	1.65	5.45	5.0	non-irritating
F3	Distinctive odor	Semi-solid	Brown	Homogeneous	1.52	5.8	5.0	non-irritating
After the cycling test								
F0	-	Semi-solid	White	Homogeneous	1.75	4.1	4.5	non-irritating
F1	Distinctive odor	Semi-solid	Light brown	Homogeneous	1.50	5.5	5.0	non-irritating
F2	Distinctive odor	Semi-solid	Brown	Homogeneous	1.45	5.45	5.0	non-irritating
F3	Distinctive odor	Semi-solid	Brown	Homogeneous	1.33	5.6	5.0	non-irritating

choline (2.29%), yakuchinone A (2.18%), and maxacalcitol (1.15%). These compounds are known to have strong biological activity in inhibiting inflammatory mediators such as prostaglandins and proinflammatory cytokines (5, 27, 29, 30). For example, yakuchinone A is a phenolic compound that has been reported to suppress the activity of COX-2 and NO synthase enzymes (2, 30, 31), while (9-cis)-Retinal has antioxidant effects that can suppress oxidative stress, which causes inflammation (32).

Based on the LC-HRMS analysis results presented in **Table 2**, several metabolites labeled as putatively annotated metabolites show similarities to compounds reported as Aflatoxin B2 and Aflatoxin G2. However, it should be emphasized that this identification was obtained through an untargeted metabolomics approach based on accurate mass matching and MS/MS spectra against a metabolite database. Therefore, it cannot be interpreted as definitive evidence of the presence of aflatoxins in *E. calophrys* rhizomes. In accordance with the Metabolomics Standards Initiative (MSI) guidelines, these annotations remain at the level of putative identification and require further confirmation using targeted analysis with authentic standards or other spectroscopic techniques before they can be declared as definitive identifications. Therefore, this study focused on metabolites with higher biological relevance, particularly phenolic and steroid compounds tentatively identified in the LC-HRMS profiles.

Overall, the LC-HRMS results indicate that *E. calophrys* rhizomes are rich in phenolic and steroid compounds that contribute to anti-inflammatory and antioxidant activities. The predominance of these two compound groups indicates that *E. calophrys* rhizomes have the potential for antioxidant and anti-inflammatory activity. This metabolite composition provides a scientific basis for the traditional use of *E. calophrys* rhizomes as a natural medicine while supporting their development as a source of anti-inflammatory active ingredients.

Characterization of Emulgel Preparations

The physical properties of the anti-inflammatory emulgel preparation of *E. calophrys* rhizome were tested for organoleptic properties, homogeneity, pH, adhesive strength, spreadability, irritation, and stability. Observations were made over a period of 4 weeks at room temperature storage (**Table 3**).

Physical and stability evaluation of *E. calophrys* rhizome emulgel includes organoleptic observation, homogeneity, adhesion, spreadability, pH, and irritation potential. All formulas (F0–F3) exhibit a soft and homogeneous semi-solid form (**Figure 2**). The control formula (F0) was white with no distinctive aroma. In



Figure 2. Anti-inflammatory of *Etlingera calophrys* rhizome emulgel: (F0) blank, (F1) 1%, (F2) 2%, (F3) 3%.

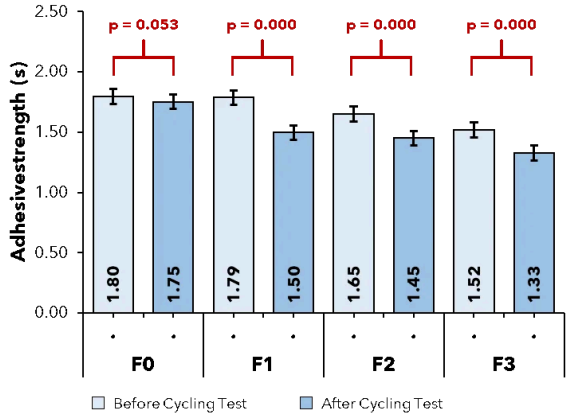


Figure 3. Comparison of the adhesive strength of *Etlingera calophrys* rhizome emulgel before and after the cycling test.

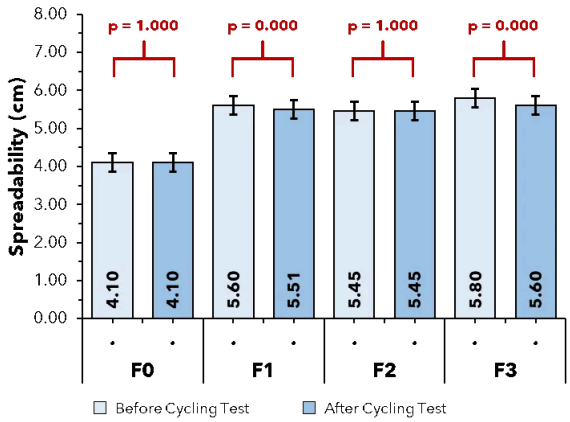


Figure 4. Comparison of the spreadability of *Etlingera calophrys* rhizome emulgel before and after the cycling test.

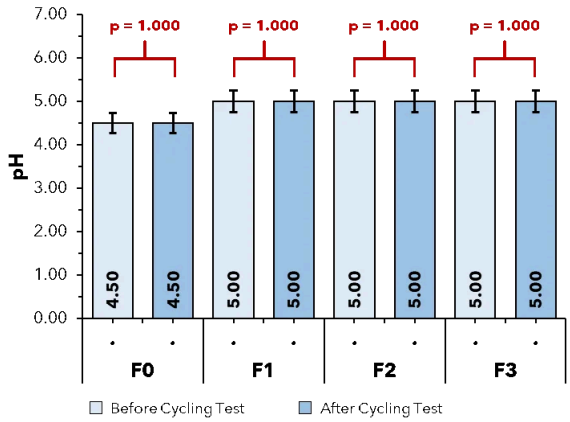


Figure 5. Comparison of the pH values of *Etlingera calophrys* rhizome emulgel before and after the cycling test.

contrast, the extract-containing formulas (F1–F3) were light to dark brown with a distinctive *E. calophrys* rhizome aroma that intensified with increasing extract concentration. These differences in color and aroma indicate that the extract content influences the preparation's visual and sensory characteristics.

In general, all formulations were still able to maintain their physical characteristics after undergoing accelerated stability testing, although slight changes occurred in some parameters. The adhesion values of all formulations tended to decrease after the cycling test. The control formulation (F0) decreased from 1.80 to 1.75 s; however, based on statistical analysis, this change was not statistically significant ($p = 0.053$; $p > 0.05$). In contrast, formulations F1, F2, and F3 exhibited statistically significant decreases in adhesion strength after the cycling test ($p < 0.001$), from 1.79 to 1.50 s, 1.65 to 1.45 s, and 1.52 to 1.33 s, respectively (**Figure 3**). The decrease in adhesion is thought to be related to changes in the gel's structural network due to the heating and cooling cycles, which caused a slight decrease in the formulation's viscosity. Nevertheless, the adhesion values obtained are within an acceptable range for topical formulations, so they are expected to maintain contact between the formulation and the skin surface.

In the spreadability test, formulations F0 and F2 showed no change after the cycling test ($p = 1.000$), with their values remaining at 4.10 cm and 5.45 cm, respectively (**Figure 4**). Meanwhile, formulation F1 experienced a slight decrease in spreadability from 5.60 to 5.5 cm, and formulation F3 from 5.80 to 5.60 cm, which was statistically significant ($p < 0.001$). Despite these decreases, all formulations still exhibited a spreadability within the 4–7 cm range, thereby meeting the criteria for good spreadability in semisolid formulations. Adequate spreadability is essential to ensure ease of application and even distribution of the formulation across the skin's surface.

The pH parameter showed the most stable results compared to the other parameters. The pH values of all formulations remained unchanged after the cycling test, with formulation F0 maintaining a pH of 4.50, while F1, F2, and F3 each remained at a pH of 5.00. Statistical analysis showed that there were no significant differences between the pre- and post-cycling test values for all formulations ($p = 1.000$). These pH values remain within the physiological pH range of the skin (approximately 4.5–6.5), so they are not expected to cause irritation and remain safe for topical use.

Overall, the test results showed that the cycling test had only a minor effect on the adhesion and spreadability of some formulations, while the pH remained stable throughout the testing, as seen in **Figure 5**. These findings indicate that *E. calophrys* rhizome emulgel exhibits good physical stability after accelerated storage and continues to meet quality requirements as a topical preparation. Although there was a decrease in adhesion and spreadability in some formulations, these changes did not significantly affect the physical performance of the preparations and remained within acceptable limits.

Anti-Inflammatory Activity: Protein Denaturation Method

Measurement of anti-inflammatory activity at a maximum wavelength of 660 nm using a UV-Vis spectrophotometer. The anti-inflammatory activity of *E. calophrys* rhizome emulgel preparations was determined based on the IC_{50}

Table 4. The Inhibition of *Etlingera calophrys* rhizome emulgel.

Formula	Concentration	Absorbance			% Inhibition			
	mg/L	P1	P2	P3	P1	P2	P3	Average
F1	10	0.271	0.293	0.259	13.419	1.347	6.498	7.088
	20	0.263	0.264	0.242	15.974	11.111	12.635	13.24
	30	0.262	0.242	0.235	16.294	18.519	15.162	16.658
	40	0.245	0.218	0.178	21.725	26.599	35.74	28.022
	50	0.216	0.205	0.138	30.99	30.976	50.181	37.382
F2	10	0.277	0.254	0.271	8.278	15.333	13.141	12.251
	20	0.241	0.267	0.25	20.199	11	19.872	17.024
	30	0.233	0.239	0.215	22.848	20.333	31.09	24.757
	40	0.205	0.208	0.207	32.119	30.667	33.654	32.147
	50	0.202	0.182	0.18	33.113	39.333	42.308	38.251
F3	10	0.233	0.254	0.2	0.851	23.03	11.894	11.925
	20	0.196	0.205	0.196	16.596	37.879	13.656	22.71
	30	0.191	0.194	0.185	18.723	41.212	18.502	26.146
	40	0.172	0.189	0.156	26.809	42.727	31.278	33.604
	50	0.12	0.141	0.117	48.936	57.273	48.458	51.556
Positive control	10	0.454	0.452	0.453	6.198	6.418	6.597	6.405
	20	0.336	0.335	0.337	30.579	30.642	30.515	30.579
	30	0.277	0.278	0.276	42.769	42.443	43.093	42.768
	40	0.193	0.192	0.194	60.124	60.248	60	60.124
	50	0.116	0.115	0.117	76.033	76.19	75.876	76.033

value, which is the concentration capable of inhibiting 50% of the protein denaturation process, as an indicator of the anti-inflammatory potential of the preparation (**Table 4**).

The anti-inflammatory activity test was conducted *in vitro* using the protein denaturation method, which is based on the principle that anti-inflammatory agents can inhibit denaturation or damage to protein structures due to heat exposure (31, 33). The protein denaturation process resembles the inflammatory mechanism in the body, where body proteins (such as albumin) can change structure due to oxidative stress or immune reactions (34, 35). In this study, sodium diclofenac was used as a positive control because it is a nonsteroidal anti-inflammatory drug (NSAID) that works by inhibiting the cyclooxygenase (COX) enzyme, thereby reducing the production of inflammatory mediators (36, 37).

The results of *in vitro* anti-inflammatory activity testing of emulgel showed that the % of inhibition increased with increasing extract concentration in all formulas. Formulas F1, F2, and F3 showed the highest average inhibition percentages at a concentration of 50 mg/L, at 30.382%, 38.25%, and 51.55%, respectively. This indicates a positive relationship between increasing extract concentration and protein denaturation inhibition ability. Compared to the positive control (sodium diclofenac), which showed an average inhibition of 76.03% at a concentration of 50 mg/L, the anti-inflammatory activity of *E. calophrys* extract emulgel was still lower, but showed strong potential, especially in formula F3 with the highest

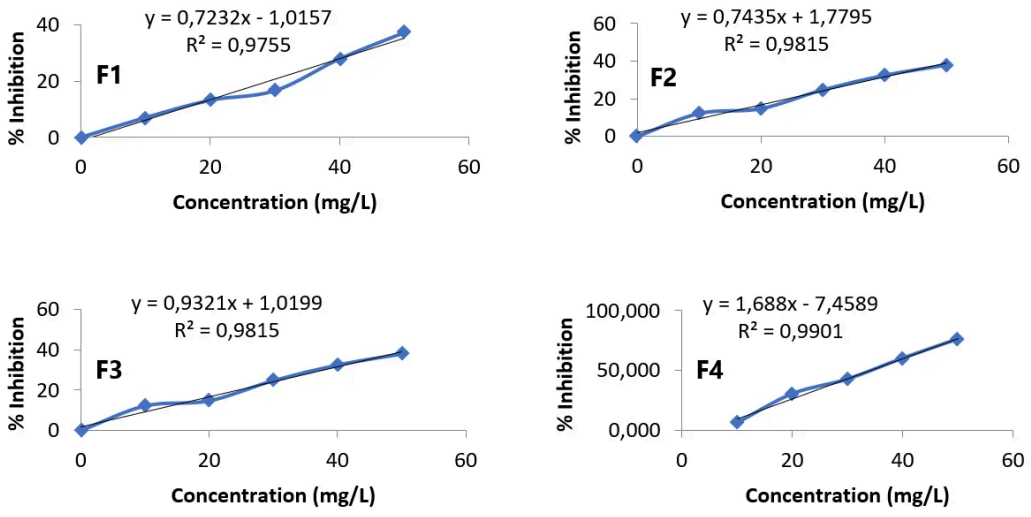


Figure 6. Graph of inhibition anti-inflammatory activity of *Etlingera calophrys* rhizome emulgel and positive control.

Table 5. IC_{50} Value of *Etlingera calophrys* rhizome emulgel.

Formula	IC_{50} (mg/L)	Category
F1	70.54	Weak
F2	64.86	Weak
F3	52.55	Weak
Positive control (diclofenac sodium)	34.04	Moderate

extract concentration (3%) **(Figure 6**). This formula had the highest inhibitory activity among all formulations, indicating that increasing the extract concentration can enhance anti-inflammatory efficacy.

In vitro anti-inflammatory activity testing results indicate that all *E. calophrys* rhizome extract emulgel formulations have anti-inflammatory potential, as evidenced by the IC_{50} values obtained. Formula F1 with an extract concentration of 1% showed an IC_{50} value of 70.54 mg/L, while F2 (2%) and F3 (3%) had IC_{50} values of 64.86 mg/L and 52.55 mg/L, respectively (**Table 5**). The decrease in IC_{50} value with increasing extract concentration indicates an inverse relationship between the concentration of the active substance and the IC_{50} value (2), meaning that the higher the extract concentration, the stronger the anti-inflammatory activity.

Test results show that all emulgel formulas have weak anti-inflammatory activity, with IC_{50} values of 70.54 mg/L (F1), 64.86 mg/L (F2), and 52.55 mg/L (F3), respectively. Based on general classification, A compound has a very strong anti-inflammatory when IC_{50} < 10 mg/L, strong IC_{50} 10-30 mg/L, moderate IC_{50} 31-50 mg/l, weak IC_{50} 51-100 mg/l, and very weak IC_{50} > 100 mg/L (31, 38). For comparison, sodium diclofenac showed an IC_{50} value of 34.04 mg/L, which is classified as moderate. The decrease in IC_{50} values with increasing extract concentration indicates a positive dose-response relationship, where an increase in active substance content enhances anti-inflammatory activity (39). Although this indicates an improvement in apparent anti-inflammatory activity with increasing extract concentration, the response was not proportional to the threefold increase in extract concentration. This non-linear relationship may be associated with the physicochemical properties of the emulgel matrix. At higher extract concentrations, interactions between the extract constituents and the Carbomer-HPMC polymer network, as well as partitioning between the aqueous and oil phases, may influence the fraction of active constituents released into the assay medium (40). However, this interpretation remains hypothetical because extract-release kinetics and diffusion were not directly evaluated in the present study. Although the activity of the *E. calophrys* rhizome extract was still below the positive control, these results indicate that *E. calophrys* rhizome has potential as a natural source for the development of anti-inflammatory topical preparations.

This study has several limitations that should be taken into account when interpreting the results. Metabolite identification using an untargeted LC-HRMS approach remains tentative (putative annotation) based on matching accurate mass and MS/MS spectra against databases; therefore, none of the reported compounds, including metabolite candidates showing similarity to aflatoxins, can yet be declared definitively identified without confirmation using authentic standards, targeted LC-MS/MS analysis, or spectroscopic techniques such as NMR. The anti-inflammatory activity in this study was evaluated only through an *in vitro* protein denaturation assay. Therefore, the results obtained cannot yet comprehensively describe the anti-inflammatory mechanism at either the cellular or organismal level. Therefore, further research is needed to confirm the identity of the metabolites, evaluate the safety of the extract through validated mycotoxin analysis, and test anti-inflammatory activity using cell-based assays and *in vivo* models so that the pharmacological potential of *E. calophrys* rhizomes as an active ingredient in topical preparations can be more thoroughly demonstrated. In addition, optimization of the emulgel formulation is also necessary to improve its physical characteristics, stability, and the effectiveness of delivering bioactive compounds to target tissues.

Conclusion

The present study demonstrated that *E. calophrys* rhizome can be successfully formulated into a physically stable emulgel that fulfilled the evaluated physicochemical quality parameters. LC-HRMS-based untargeted metabolite profiling tentatively revealed the presence of several phenolic and steroid-like metabolites that may contribute to the biological activity of the extract. However, these metabolite annotations remain putative and require confirmation using authentic reference standards and targeted analytical approaches. The emulgel exhibited weak *in vitro* anti-inflammatory activity, with IC_{50} values ranging from 52.54 to 70.54 mg/L, indicating that although the extract possesses measurable biological activity, its anti-inflammatory potency remains limited under the experimental conditions employed. Future studies should evaluate extract-release kinetics and skin permeation, cytotoxicity, and anti-inflammatory activity using cell-based models such as LPS-induced RAW 264.7 macrophages, followed by appropriate *in vivo* studies.

Abbreviations

LC-HRMS = Liquid Chromatography–High Resolution Mass Spectrometry; NSAIDs = nonsteroidal anti-inflammatory drugs; HPMC = Hydroxypropyl methylcellulose; TEA= Triethanolamine; BHT= Butylated hydroxytoluene.

Declaration

Author Information

Muhammad Asman Setiawan *(*Corresponding author)*, Department of Dental Health, Politeknik Bina Husada, Kendari, Southeast Sulawesi, Indonesia. **Contribution:** Writing – Original Draft, Funding Acquisition, Project Administration, Conceptualization.

Karmilah Karmilah, Department of Pharmacy, Politeknik

Bina Husada, Kendari, Southeast Sulawesi, Indonesia. **Contribution:** Investigation, Validation, Conceptualization, Data Curation .

Musdalipah Musdalipah, Department of Pharmacy, Politeknik Bina Husada, Kendari, Southeast Sulawesi, Indonesia. **Contribution:** Conceptualization, Formal Analysis, Supervision, Visualization, Methodology.

Agung Wibawa Mahatva Yodha, Department of Pharmacy, Politeknik Bina Husada, Kendari, Southeast Sulawesi, Indonesia. **Contribution:** Investigation, Formal Analysis, Data Curation.

Eny Nurhikma, Department of Pharmacy, Politeknik Bina Husada, Kendari, Southeast Sulawesi, Indonesia. **Contribution:** Methodology, Resources.

Asmaul Mutmainna, Department of Pharmacy, Politeknik Bina Husada, Kendari, Southeast Sulawesi, Indonesia. **Contribution:** Resources, Validation.

Nirwati Rusli, Department of Pharmacy, Politeknik Bina Husada, Kendari, Southeast Sulawesi, Indonesia. **Contribution:** Data Curation, Supervision.

Acknowledgment
During the preparation of this manuscript, the authors used ChatGPT-4 solely as an assistant for language editing, grammar correction, and improving readability. No data, figures, or original research concepts were generated using artificial intelligence. The authors thoroughly reviewed and edited all AI-assisted text, take full responsibility for the contents of the published article, and approved the final manuscript prior to submission.

Conflict of Interest
The authors declare no conflict of interest.

Data Availability
The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Statement
The study was conducted with ethical approval from Komisi Etik Penelitian Kesehatan Politeknik Bina Husada Kendari, approval number: 041/POLTEKBINHUS.5/KEPK/III/2026.

Funding Information
This work was funded by the Ministry of Higher Education, Science, and Technology of the Republic of Indonesia (KemendiktiSaintek) under grant number 205/C3/DT.05.00/PL-BATCH II/2025.

References
1. Jabbar A, Wahyuono S, Sahidin I, Puspitasari I. Free radical scavenging activity of methanol extract and compounds isolated from stems of *Etlingera rubroloba* A.D Poulsen. Int J Pharm Res. 2021;13(01):1099–105. doi: https://doi.org/10.31838/ijpr/2021.13.01.179

2. Karmilah K, Yodha AWM, Hamsidi R, Daud NS, Malaka MH, Musdalipah M, et al. Antioxidant and Anti-inflammatory Activities of Diarylheptanoid from Etlingera calophrys Fruit. molekul. 2024;19(3):604. doi: https://doi.org/10.20884/1.jm.2024.19.3.12413

3. Tee SA, Alam S, Sastyarina Y, Yodha AWM, Reymon R, Setiawan MA, et al. Characterization of essential oils and biological activities of Etlingera spp. from different agroecology in Southeast Sulawesi, Indonesia. Biodiversitas. 2025;26(4):1653–65. doi: https://doi.org/10.13057/biodiv/d260416

4. Aswan M, Arafah N, Sahidin I, Imran, Suryani, Ngkoimani LO. Composition Chemistry And Distribution to Quality of Essential Oil From Rhizome E.elatior and E.calophyris By Gas Chromatography-Mass Spectrometry (GC-MS). IOP Conf. Ser.: Mater. Sci. Eng. 2020;797(1):012018. doi: https://doi.org/10.1088/1757-899x/797/1/012018

5. Hamsidi R, Karmilah K, Daud NS, Malaka MH, Yodha AWM, Musdalipah M, et al. Chemotaxonomy in the Etlingera Genus from Sulawesi, Indonesia: Design and molecular docking of antioxidant marker. Biodiversitas. 2024;25(2):449–57. doi: https://doi.org/10.13057/biodiv/d250202

6. Sahidin S, Salsabila S, Wahyuni W, Adryan F, Imran I. Potensi Antibakteri Ekstrak Metanol dan Senyawa Aromatik dari Buah Wualae (Etlingera elatior). Valensi. 2019;5(1):1-7. doi: https://doi.org/10.15408/jkv.v5i1.8658

7. Fristiohady A, Wahyuni W, Yusuf MI, Malik F, Purnama LOMJ, Bafadal M, et al. Hepatoprotective activity of *Etlingera elatior* (Jack) R.M. Smith extract against ccl4 - induced hepatic toxicity in male wistar rats. Rese. Jour. of Pharm. and Technol. 2020;13(10):4585. doi: https://doi.org/10.5958/0974-360x.2020.00807.0

8. I S, Wahyuni W, Malaka MH, A J, Imran I, Manggau MA. Evaluation of antiradical scavenger activity of extract and compounds from etlingera calophrys stems. Asian J Pharm Clin Res. 2018;11(2):238. doi: https://doi.org/10.22159/ajpcr.2018.v11i2.22535

9. Chusniasih D, Tutik T. Uji Toksisitas dengan Metode Brine Shrimp Lethality Test (BSLT) dan Identifikasi Komponen Fitokimia Ekstrak Aseton Kulit Buah Kakao (*Theobroma cacao* L.). Anal.Environ.Chem. 2020;5(02):192-201. doi: https://doi.org/10.23960/aec.v5.i2.2020.p192-201

10. . W, Diantini A, Ghozali M, Subarnas A, Julaeha E, Amalia R, et al. Phytochemical Screening, Toxicity Activity and Antioxidant Capacity of Ethanolic Extract of Etlingera alba Rhizome. Pakistan J. of Biological Sciences. 2021;24(7):807-814. doi: https://doi.org/10.3923/pjbs.2021.807.814

11. Wahyuni W, Diantini A, Ghozali M, Subarnas A, Julaeha E, Amalia R, et al. In-Vitro Anticancer Activity of Chemical Constituents from Etlingera alba Poulsen against Triple Negative Breast Cancer and in silico Approaches towards Matrix metalloproteinase-1 Inhibition. Indonesian J. Sci.

Technol. 2022;7(2):251-278. doi: https://doi.org/10.17509/ijost.v7i2.50547

12. Ilyas Y. M, Sahidin I, Jabbar A, Yodha AWM, Diantini A, Pradipta IS, et al. Effect of Immunomodulating Extract and Some Isolates from Etlingera rubroloba A.D. Poulsen Fruits on Diabetic Patients with Tuberculosis. Molecules. 2023;28(5):2401. doi: https://doi.org/10.3390/molecules28052401

13. Jabbar A, Ilyas Y M, Wahyuni, Hamzah H, Windarsih A, Pratiwi SUT, et al. LC-MS analysis, antioxidant and anti-inflamatory activity, isolation of secondary metabolite of ethanol extract stem of Etlingera rubroloba AD Poulsen. Case Studies in Chemical and Environmental Engineering. 2024;10(4):100780. doi: https://doi.org/10.1016/j.cscee.2024.100780

14. Utami YP, Yulianty R, Djabir YY, Alam G. Antioxidant Activity, Total Phenolic and Total Flavonoid Contents of Etlingera elatior (Jack) R.M. Smith from North Luwu, Indonesia. Trop J Nat Prod Res. 2024;8(1):5955–61. https://doi.org/10.26538/tjnpr/v8i1.34

15. Zubair MS, Khairunisa SQ, Widodo A, Nasronudin, Pitopang R. Antiviral screening on Alpinia eremochlamys, Etlingera flexuosa, and Etlingera acanthoides extracts against HIV-infected MT-4 cells. Heliyon. 2021;7(4):e06710. doi: https://doi.org/10.1016/j.heliyon.2021.e06710

16. Juwita T, Melyani Pu I, Levita J. Torch Ginger (Etlingera elatior): A Review on its Botanical Aspects, Phytoconstituents and Pharmacological Activities. Pakistan J. of Biological Sciences. 2018;21(4):151-165. doi: https://doi.org/10.3923/pjbs.2018.151.165

17. Jurca T, Józsa L, Suciu R, Pallag A, Marian E, Bácskay I, et al. Formulation of Topical Dosage Forms Containing Synthetic and Natural Anti-Inflammatory Agents for the Treatment of Rheumatoid Arthritis. Molecules. 2020;26(1):24. doi: https://doi.org/10.3390/molecules26010024

18. Hoang TX, Dang NM, Bae KG, Kim JY. Anti-Inflammatory and Antioxidant Effects of Topical Formulations Containing Plant Extracts, Methylsulfonylmethane, and Peptiskin® in In Vitro Models of Arthritis. Pharmaceuticals. 2025;18(9):1270. doi: https://doi.org/10.3390/ph18091270

19. Karwal K, Mukovozov I. Topical AHA in Dermatology: Formulations, Mechanisms of Action, Efficacy, and Future Perspectives. Cosmetics. 2023;10(5):131. doi: https://doi.org/10.3390/cosmetics10050131

20. Rafi M, Hayati F, Umar AH, Septaningsih DA, Rachmatiah T. LC-HRMS-based metabolomics to evaluate the phytochemical profile and antioxidant capacity of Cosmos caudatus with different extraction methods and solvents. Arabian Journal of Chemistry. 2023;16(9):105065. doi: https://doi.org/10.1016/j.arabjc.2023.105065

21. Waghmare ND, Kanchan A. Hiwe, Ravindra L. Bakal, Pooja R. Hatwar, Nagesh G. Khansole, Umesh S. Saware. Emulgel: A Novel Topical Drug Delivery System. Asian J Pharm Res Dev. 2025;13(2):82-91. doi: https://doi.org/10.22270/ajprd.v13i2.1545

22. Bisht B, Dutta D, Bisht M. Emulgels: A Promising Topical Drug Delivery System. Afr J Biomed Res. 2024;27(4):14439–47. doi: https://doi.org/10.53555/ajbr.v27i4s.7280

23. Musdalipah M, Sahidin I, Muhidin M, Fristiohady A. Bioactive Compound Profiling and Biological Potential of Walay Rhizome (Zingiberaceae) from Southeast Sulawesi: GC-MS and LC-MS Analysis. Trop J Nat Prod Res. 2024;8(12):9686–94. doi: https://doi.org/10.26538/tjnpr/v8i12.49

24. Fayez N, Khalil W, Abdel-Sattar E, Abdel-Fattah AFM. In vitro and in vivo assessment of the anti-inflammatory activity of olive leaf extract in rats. Inflammopharmacol. 2023;31(3):1529-1538. doi: https://doi.org/10.1007/s10787-023-01208-x

25. Nurhikma E, Wulaisfan R, Musdalipah M, Fauziah Y, Rusli N. Formulasi sediaan masker gel peel off ekstrak daun walay (meistera chinensis) asal sulawesi tenggara. Jkk. 2023;10(2):141-148. doi: https://doi.org/10.32539/jkk.v10i2.19864

26. Muliasari H, Almira D, Anugrah Subaidah W. Formulation and Evaluation of Anti-inflammatory Emulgel of *Brucea javanica* (L.) Merr Seed Extracts. Jkr. 2022;7(1):66-73. doi: https://doi.org/10.20473/jkr.v7i1.36010

27. Liu MC, Chou FY, Chien YA, Chen YJ, Abe M, Furusho K, et al. Comparative pharmacokinetics of maxacalcitol in healthy Taiwanese and Japanese subjects. Heliyon. 2020;6(3):e03538. doi: https://doi.org/10.1016/j.heliyon.2020.e03538

28. Shukla S, Mishra A. Metal complexes used as anti-inflammatory agents: Synthesis, characterization and anti-inflammatory action of VO(II)-complexes. Arabian Journal of Chemistry. 2019;12(7):1715-1721. doi: https://doi.org/10.1016/j.arabjc.2014.08.020

29. Arumugam MK, Paal MC, Donohue TM, Ganesan M, Osna NA, Kharbanda KK. Beneficial Effects of Betaine: A Comprehensive Review. Biology. 2021;10(6):456. doi: https://doi.org/10.3390/biology10060456

30. Bayati S, Yazdanparast R. Antioxidant and free radical scavenging potential of yakuchinone B derivatives in reduction of lipofuscin formation using H2O2-treated neuroblastoma cells. Iran Biomed J. 2011;15(4):134-42. doi: https://doi.org/10.6091/ibj.1010.2012.

31. Vanucci-Bacqué C, Bedos-Belval F. Anti-inflammatory activity of naturally occuring diarylheptanoids – A review. Bioorganic & Medicinal Chemistry. 2021;31(2):115971. doi: https://doi.org/10.1016/j.bmc.2020.115971

32. Park MK, Jhun JY, Lee SY, Oh HJ, Park MJ, Byun JK, et al. Retinal attenuates inflammatory arthritis by reciprocal regulation of IL-17-producing T cells and Foxp3+ regulatory T cells and the inhibition of osteoclastogenesis. Immunology Letters. 2012;148(1):59-68. doi: https://doi.org/10.1016/j.imlet.2012.05.008

33. Pérez-Salas JL, Moreno-Jiménez MR, Rocha-Guzmán NE, González-Laredo RF, Medina-Torres L, Gallegos-Infante JA. In Vitro and Ex Vivo Models for Screening Topical Anti-Inflammatory Drugs. Sci. Pharm. 2023;91(2):20. doi: https://doi.org/10.3390/scipharm91020020

34. DGhosoon A, Heba H, Adnan B, Abdel-Rahem Rami, Al-Remawi Mayyas, Mohamad, A., et al. (2026). Anti-inflammatory activity of Mandragora autumnalis ethanolic extract: In vitro and cellular mechanistic insights. Pharmaceuticals, 19(3), 483. doi: https://doi.org/10.3390/ph19030483.

35. Derbel H, Elleuch J, Mahfoudh W, Michaud P, Fendri I, Abdelkafi S. In Vitro Antioxidant and Anti-Inflammatory Activities of Bioactive Proteins and Peptides from Rhodomonas sp. Applied Sciences. 2023;13(5):3202. doi: https://doi.org/10.3390/app13053202

36. Rastogi S, Iqbal MS, Ohri D. In vitro study of anti-inflammatory and antioxidant activity of some medicinal plants and their interrelationship. Asian J Pharm Clin Res. 2018;11(4):195. doi: https://doi.org/10.22159/ajpcr.2018.v11i4.23583

37. Hasan MK, Akhter S, Fatema K, Hossain MR, Sultana T, Uzzaman M. Selective modification of diclofenac to reduce the adverse effects; A computer-aided drug design approach. Informatics in Medicine Unlocked. 2023;36:101159. doi: https://doi.org/10.1016/j.imu.2023.101159

38. Al Bashera M, Mosaddik A, El-Saber Batiha G, Alqarni M, Islam MA, Zouganelis GD, et al. In Vivo and In Vitro Evaluation of Preventive Activity of Inflammation and Free Radical Scavenging Potential of Plant Extracts from Oldenlandia corymbosa L. Applied Sciences. 2021;11(19):9073. doi: https://doi.org/10.3390/app11199073

39. Ruiz-Ruiz JC, Matus-Basto AJ, Acereto-Escoffié P, Segura-Campos MR. Antioxidant and anti-inflammatory activities of phenolic compounds isolated from *Melipona beecheii* honey. Food and Agricultural Immunology. 2017;28(6):1424-1437. doi: https://doi.org/10.1080/09540105.2017.1347148

40. Khafi M, Hertiani T, Murwanti R, Bayu Irawan M, Marzuki A, Dwi Salim R. Formulation and Stability Test of HPMC and Carbomer 940 based-Gel Formulation Containing Plantago major L. hydroalcoholic extract. Majalah Farmaseutik. 2025;21(2):198. doi: https://doi.org/10.22146/farmaseutik.v21i2.95893

Additional Information

How to Cite

APA 7th Edition: Setiawan, M., Karmilah, K., Musdalipah, M., Yodha, A., Nurhikma, E., Mutmainna, A. & Rusli, N. (2026). LC-HRMS Profiling and Formulation of Emulgel from Olae (Etlingera calophrys) as an Anti-inflammatory Agent. Sciences of Pharmacy, 5(4), 375-0. https://doi.org/10.58920/sciphar0504733

Vancouver: Setiawan M, Karmilah K, Musdalipah M, Yodha A, Nurhikma E, Mutmainna A, Rusli N. LC-HRMS Profiling and Formulation of Emulgel from Olae (Etlingera calophrys) as an Anti-inflammatory Agent. Sciences of Pharmacy. 2026;5(4):375-0. https://doi.org/10.58920/sciphar0504733

Harvard: Setiawan, M., Karmilah, K., Musdalipah, M., Yodha, A., Nurhikma, E., Mutmainna, A. & Rusli, N. (2026) 'LC-HRMS Profiling and Formulation of Emulgel from Olae (Etlingera calophrys) as an Anti-inflammatory Agent', Sciences of Pharmacy, 5(4), pp. 375-0. doi: 10.58920/sciphar0504733

Publisher Note

All claims expressed in this article are solely those of the authors and do not necessarily reflect the views of the publisher, the editors, or the reviewers. Any product that may be evaluated in this article, or claim made by its manufacturer, is not guaranteed or endorsed by the publisher. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Open Access

This article is licensed under a Creative Commons Attribution 4.0 International License. You may share and adapt the material with proper credit to the original author(s) and source, include a link to the license, and indicate if changes were made.