FTIR Characterization of *Elaeis guineensis* and *Centella asiatica* Extracts and Preliminary Spreadability Assessment for Gel Development

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Abstract. Chronic wounds motivate the development of topical systems containing plant-derived constituents with potential relevance to tissue repair. This descriptive preformulation study characterized Elaeis guineensis and Centella asiatica leaf extracts by qualitative phytochemical screening and individual Fourier-transform infrared (FTIR) spectroscopy and summarized preliminary spreadability observations from three formulation variations. Both extracts tested positive for alkaloids, flavonoids, saponins, tannins, and steroids, whereas terpenoids were negative under the applied Liebermann-Burchard test. The individual FTIR spectra showed bands in the O-H, aliphatic C-H, carbonyl/aromatic, and fingerprint regions. Because spectra of the physical mixture, excipients, and final combined gel were not available, the present data do not establish extract-extract or extract-gel compatibility or formulation stability. The three formulation variations produced descriptive mean spread diameters of 5.02, 5.57, and 5.28 cm for variations 0.10, 0.05, and 0.025, respectively. However, D1 and D2 were perpendicular dimensions from a single spread event rather than independent replicates; therefore, the values cannot support formulation ranking or inferential comparison. These findings provide baseline characterization for future formulation work. Confirmatory studies should fully define botanical and formulation procedures, use reproducible FTIR acquisition, analyze the physical mixture and final gel, and perform independently replicated physicochemical and stability testing.

Keywords: Elaeis guineensis; Centella asiatica; FTIR; phytochemical screening; spreadability; preformulation; botanical extracts.

1 Introduction

Chronic wounds are characterized by delayed progression through the normal phases of tissue repair and frequently involve persistent inflammation, oxidative stress, micro-

© The Author(s) 2026
F. Maulina and S. Wahyuni (eds.), *Proceedings of the 3rd Malikussaleh International Conference on Health and Disaster Medicine (MICOHEDMED 2026)*, Advances in Health Sciences Research 97,
https://doi.org/10.2991/978-94-6239-836-8_9

bial burden, and impaired extracellular-matrix remodeling [1]. Topical semisolid systems are attractive for chronic-wound management because they can maintain prolonged contact with the wound surface and may serve as vehicles for bioactive botanical constituents [2]. Centella asiatica has been systematically reviewed for wound-healing applications, with reported effects involving wound contraction, granulation, re-epithelialization, and angiogenesis [3].

Elaeis guineensis (oil palm) and Centella asiatica (pegagan) have each been investigated for topical biomedical applications. E. guineensis leaf extract has shown wound-healing activity in an animal model [4], whereas C. asiatica has a broader evidence base describing wound contraction, granulation, re-epithelialization, and angiogenesis [3]. This provides a biological rationale for exploring both botanicals within a future topical system. However, evidence specifically characterizing their combined use remains limited. Before claims about a combination can be made, the individual materials should first be characterized and subsequent studies should directly examine the physical mixture and final formulation.

Fourier-transform infrared (FTIR) spectroscopy provides a rapid means of documenting functional-group features and can support compatibility studies when individual components, physical mixtures, excipients, and final formulations are analyzed under comparable conditions [5,6]. Qualitative phytochemical screening can indicate broad classes of secondary metabolites [7], while spreadability offers a preliminary description of how readily a semisolid preparation distributes over a surface [8]. Importantly, similarity between separate extract spectra or qualitative metabolite classes cannot by itself demonstrate compatibility, complementarity, synergism, or stability.

Accordingly, this study aimed to descriptively characterize the qualitative phytochemical profiles and individual FTIR spectral features of E. guineensis and C. asiatica extracts and to summarize the available preliminary spreadability observations relevant to future gel development. The available dataset does not include FTIR spectra of a physical mixture or final combination gel and therefore does not test compatibility, stability, synergism, formulation optimization, or wound-healing efficacy.

2 Material and Methods

2.1 Botanical Extracts and Preformulation Samples

Leaf extracts of C. asiatica and E. guineensis were used for qualitative phytochemical screening. FTIR records were available for two samples analyzed using a Bruker Alpha II instrument: dr-P, representing E. guineensis, and dr-KS, representing C. asiatica. The supplied study records did not document plant collection origin, botanical authentication or voucher number, plant-processing details, extraction solvent and ratio, extraction temperature or duration, extraction yield, drying procedure, storage conditions, batch information, extract concentration, or chemical standardization. These omissions limit independent reproducibility and should be fully documented in subsequent confirmatory work.

2.2 Qualitative Phytochemical Screening

Both extracts were screened for alkaloids using Mayer, Wagner, and Dragendorff reagents; flavonoids using Mg + HCl; saponins using distilled water and vigorous shaking; tannins using FeCl3; and terpenoids and steroids using the Liebermann-Burchard reaction. Positive responses were assigned from the characteristic precipitate, color, or stable-foam criteria recorded in the experimental worksheet.

2.3 FTIR Characterization

Individual FTIR spectra of dr-P and dr-KS were obtained using a Bruker Alpha II, and the experimentally labelled bands were transcribed from the supplied spectra. The available records did not specify the sampling technique (e.g., ATR or KBr), acquisition range, spectral resolution, number of scans, background correction, baseline or normalization procedures, instrument software, sample preparation, or independently prepared replicates. Consequently, the present FTIR analysis is restricted to descriptive characterization of the two individual botanical samples. It is not interpreted as a compatibility test because spectra of the physical mixture, relevant excipients, and final gel obtained under identical analytical conditions were not available.

2.4 Spreadability Assessment

Spreadability observations were available for three formulation variations labelled 0.10, 0.05, and 0.025. The supplied records did not define the component represented by these values or their units and did not provide the complete extract ratio, gelling agent, excipients, preservative, vehicle, quantities, batch composition, preparation sequence, mixing conditions, or final batch size. For each variation, D1 and D2 were two perpendicular diameters from one spread event and were averaged descriptively; they were not independent replicates. Information on sample mass or volume, plate dimensions and material, applied load, duration, temperature, initial diameter, predefined acceptable range, and independent repetitions was not available. Therefore, no inferential statistical comparison or formulation ranking was performed.

3 Results

3.1 Phytochemical Profile

Both botanical extracts showed the same qualitative presence/absence pattern for the six broad phytochemical classes evaluated. Alkaloids were positive in the Mayer, Wagner, and Dragendorff tests; flavonoids, saponins, tannins, and steroids were also detected; and terpenoids were negative under the applied test conditions. These qualitative findings indicate similarity only in the detected broad classes and do not establish constituent identity, relative abundance, chemical complementarity, synergism, or compatibility.

Table 1. Qualitative phytochemical screening of the two botanical extracts.

Compound class	Test/reagent	Centella asiatica	Elaeis guineensis
Alkaloid	Mayer	+	+
Alkaloid	Wagner	+	+
Alkaloid	Dragendorff	+	+
Flavonoid	Mg + HCl	+	+
Saponin	Aquadest + shaking	+	+
Tannin	FeCl3	+	+
Terpenoid	Liebermann-Burchard	-	-
Steroid	Liebermann-Burchard	+	+

3.2 FTIR Spectral Characteristics

The supplied individual FTIR datasets contained multiple labelled spectral features across the O-H, aliphatic C-H, carbonyl/aromatic, and fingerprint regions (Table 2). Values at 502.61 cm^{-1} for dr-KS and 859.57 cm^{-1} for dr-P were present in the supplied processed datasets. However, because the original instrument-generated spectra, acquisition metadata, and processing history were not available, these values are not interpreted as dominant absorption peaks or as evidence of a specific interaction. The figures are therefore presented only as supplied descriptive spectral records.

Table 2. Experimentally labelled FTIR bands from the supplied Bruker Alpha II spectra

Spectral region / interpretation	**Elaeis guineensis, dr-P (cm^{-1})**	**Centella asiatica, dr-KS (cm^{-1})**
O-H stretching region	3352.50	3364.95
Aliphatic C-H stretching	2923.08; 2853.16	2922.50; 2852.36
Carbonyl / unsaturated region	1711.36; 1650.95	1608.44; 1516.17
CH bending / aromatic region	1455.31; 1387.61	1445.42; 1357.70
C-O / fingerprint region	1261.12; 1200.40; 1160.69; 1105.03; 1066.35; 1038.63	1247.83; 1159.56; 1067.78
Lower fingerprint region	915.98; 721.85; 664.44; 515.26	823.63; 768.17; 721.04; 661.32; 583.44; 515.48

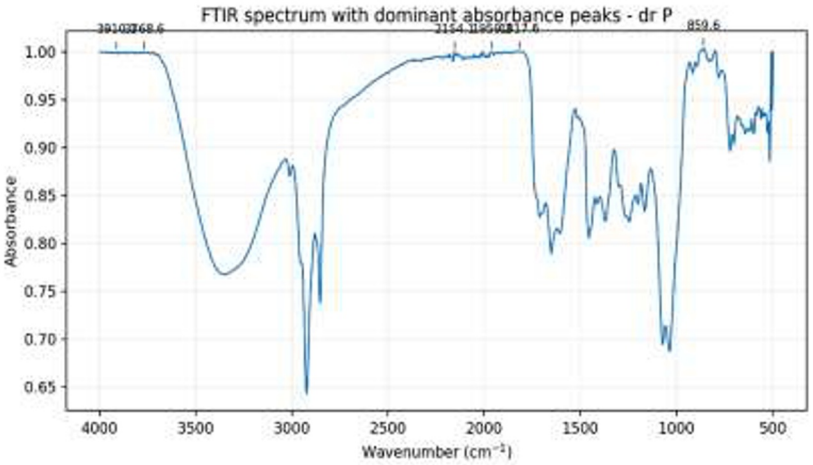


Fig. 1. Supplied processed FTIR spectrum for dr-P (E. guineensis). The original instrument-generated spectrum and complete acquisition/processing metadata were not available for verification.

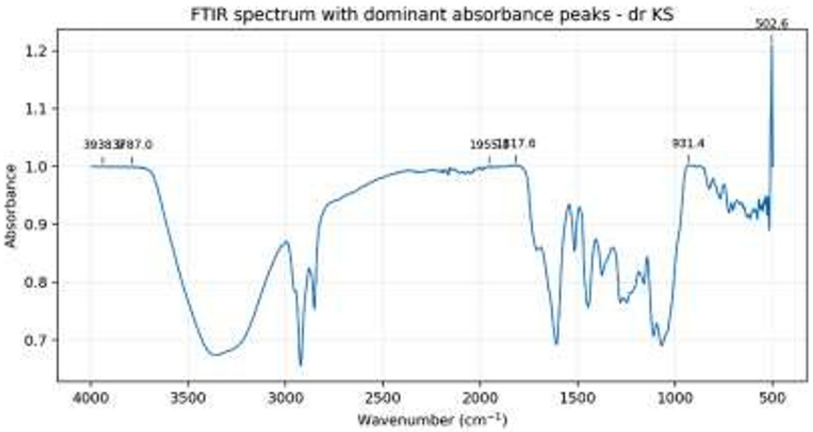


Fig. 2. Supplied processed FTIR spectrum for dr-KS (C. asiatica). The original instrument-generated spectrum and complete acquisition/processing metadata were not available for verification.

The two spectra provide descriptive fingerprints of the individual extracts. Similarities or differences between spectra obtained from separate botanical materials cannot demonstrate interactions that may occur after mixing. A direct compatibility assessment would require spectra of each extract, relevant excipients, the physical mixture, and the final gel under identical analytical conditions, together with predefined criteria for meaningful peak shifts, disappearance, or emergence. It also confirmed the presence of

quercetin in the leaf extract at a concentration of 125.430 ppm, with a retention time of 12.543 min matching the quercetin reference standard, indicating accurate and specific identification of the target compound in the extract.

3.3 Spreadability

The observed spread diameters were approximately 5.0-5.6 cm. The arithmetic mean of D1 and D2 was 5.02 cm for variation 0.10, 5.57 cm for variation 0.05, and 5.28 cm for variation 0.025. These values are descriptive only because D1 and D2 are perpendicular dimensions from a single spread event and independent replication and variability estimates were not available. Accordingly, the largest observed diameter should not be interpreted as evidence that one formulation is superior or optimized. The FTIR spectrum of FCS closely resembled that of the chitosan standard, with a spectral correlation of 99.48%. Absorption bands at 3000–3500 cm^{-1} corresponded to O–H and N–H stretching, bands at 1500–1600 cm^{-1} corresponded to nitrogen-containing functional groups, and the 1000–1300 cm^{-1} region matched the characteristic chitosan fingerprint region, confirming that FCS retained the core structural features of chitosan after fluorocarbon modification.

Table 3. Spreadability results from the formulation worksheet.

Variation	D1 (mm)	D2 (mm)	Mean spread (cm)
0.10	48.015	52.30	5.01575
0.05	53.25	58.20	5.57250
0.025	51.35	54.20	5.27750

4 Discussion

Qualitative screening detected the same broad metabolite classes in both extracts, but this finding requires cautious interpretation. Presence/absence tests do not identify individual constituents or quantify their concentrations; therefore, they cannot demonstrate strong compositional overlap, chemical complementarity, synergism, or compatibility. Compound-specific and quantitative analyses would be required to support such interpretations. Future phytochemical screening should also report reagent concentrations, positive and negative controls, observation criteria, and independent repetitions.

The FTIR results are best regarded as baseline descriptive fingerprints of the individual E. guineensis and C. asiatica samples. They do not experimentally test interactions produced by combining the extracts because no spectrum of the physical mixture, excipients, or final gel was available. Although FTIR is widely used in preformulation studies [5,6], a valid compatibility assessment in this context should analyze each extract, relevant excipients, the physical mixture, and the final formulation under identical acquisition and processing conditions. Original instrument-generated spectra should

also be retained and reported so that signal orientation, peak assignment, and potential processing artefacts can be evaluated.

Compatibility and stability are distinct experimental questions, and neither can be established from the present individual-extract FTIR dataset. A stability study would require predefined storage conditions, duration and time points, packaging, acceptance criteria, and longitudinal evaluation of appearance, homogeneity, pH, viscosity or rheology, syneresis, marker or extract content, and microbial quality [12]. No such longitudinal dataset was available in the present study; consequently, stability is not claimed.

Spreadability is relevant to topical application because it reflects how readily a semisolid preparation distributes over a surface [8]. Nevertheless, the present observations are insufficient for formulation ranking. The reported values were derived from perpendicular dimensions of single spread events rather than independent replicate experiments. Future studies should specify sample quantity, plate dimensions and material, applied load, duration, temperature, initial diameter, acceptance criteria, and independently repeated measurements, followed by reporting of n, mean with standard deviation or confidence intervals and appropriate statistical analysis. Spreadability should also be interpreted together with viscosity/rheology, adhesion, retention, pH, homogeneity, and physical stability.

The principal limitations arise from incomplete experimental metadata and the descriptive nature of the available dataset. Botanical authentication and extraction details were not supplied; formulation composition and preparation were incompletely defined; FTIR acquisition and processing parameters were unavailable; no physical-mixture, excipient, or final-gel FTIR spectra were provided; and spreadability lacked independent replication. These limitations preclude conclusions regarding compatibility, stability, formulation optimization, synergism, or therapeutic usefulness. Nevertheless, the dataset provides preliminary records of qualitative phytochemical classes, individual-extract FTIR features, and initial spreadability observations that can guide a more rigorous confirmatory study.

5 Conclusion

This study provides descriptive baseline information for E. guineensis and C. asiatica leaf extracts. Qualitative screening detected alkaloids, flavonoids, saponins, tannins, and steroids in both extracts, while terpenoids were not detected under the applied conditions. Individual FTIR spectra documented functional-group and fingerprint-region features of each botanical sample, but they do not establish compatibility because the physical mixture, relevant excipients, and final gel were not analyzed under identical conditions. The reported spreadability values are preliminary observations from single spread events and cannot support formulation ranking or optimization. Further work should fully document botanical authentication and extraction, define formulation composition and preparation, repeat spreadability independently, and analyze the individual components, physical mixture, excipients, and final gel using reproducible FTIR methods. Longitudinal physicochemical and microbiological testing would additionally be required before any claim of formulation stability or therapeutic usefulness.

Disclosure of Interests. The authors declare no conflicts of interest.

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