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GC–MS characterization and in silico evaluation of bioactive constituents from *Coccinia grandis* leaves as natural therapeutics for ulcerative colitis

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Abstract
Ulcerative colitis (UC) is a chronic inflammatory bowel disorder characterized by epithelial damage, oxidative stress, and immune dysregulation. Despite the availability of conventional therapies, their adverse effects and limited efficacy necessitate the exploration of safer, plant-based alternatives. The present study investigates the phytochemical profile of the ethanolic extract of *Coccinia grandis* (EECG) leaves through Gas Chromatography–Mass Spectrometry (GC–MS) and evaluates the molecular interactions of identified bioactive compounds with ulcerative colitis–associated target proteins. GC–MS analysis revealed 35 major constituents, predominantly fatty acids, terpenoids, phenolic derivatives, and alkaloids. Among them, δTocopherol, α-Tocospiro A, Squalene, Phytol, and Phenol, 2-(1,1-dimethylethyl) were found in notable quantities, each exhibiting recognized anti-inflammatory, antioxidant, and cytoprotective properties. Molecular docking studies were performed using AutoDock Vina and SwissDock to predict the binding affinities of these compounds toward three key UC-related targets—EGFR, SRC, and AKT1. δ-Tocopherol demonstrated the strongest binding affinity (EGFR: –6.3 kcal/mol, SRC: –7.0 kcal/mol, AKT1: –9.1 kcal/mol), followed by Squalene and α-Tocospiro A, indicating potent modulation of inflammation-related pathways. The findings suggest that *Coccinia grandis* harbors multiple bioactive constituents capable of synergistically targeting molecular mechanisms involved in UC pathogenesis, supporting its potential as a natural therapeutic agent in the management of inflammatory bowel diseases.

Keywords: Coccinia grandis, ulcerative colitis, GC–MS analysis, phytoconstituents, δ-tocopherol, molecular docking, anti-inflammatory, antioxidant, AKT1, natural therapeutics

Introduction

Ulcerative colitis (UC) is a chronic, relapsing inflammatory bowel disease (IBD) that primarily affects the colonic mucosa, leading to symptoms such as diarrhea, abdominal pain, rectal bleeding, and weight loss. The pathogenesis of UC is multifactorial, involving genetic susceptibility, dysregulated immune response, oxidative stress, and altered gut microbiota [1]. Current pharmacotherapies—such as corticosteroids, aminosalicylates, and immunosuppressants—are often associated with severe side effects and incomplete remission, creating a growing need for safe and effective alternative treatments derived from natural sources [2].

In recent years, medicinal plants have gained considerable attention for their therapeutic potential against UC due to their anti-inflammatory, antioxidant, and mucosal-protective activities. Among these, *Coccinia grandis* (L.) Voigt, commonly known as Ivy gourd, is a member of the Cucurbitaceae family traditionally used in Indian and Southeast Asian medicine. The leaves and fruits of *C. grandis* are rich in bioactive phytoconstituents such as flavonoids, alkaloids, saponins, terpenoids, and phenolic compounds, which contribute to its pharmacological effects including anti-inflammatory, antioxidant, antidiabetic, and antimicrobial activities [3].

Gas Chromatography–Mass Spectrometry (GC–MS) is a powerful analytical technique used for the separation, identification, and quantification of volatile and semi-volatile compounds present in complex plant extracts. GC–MS profiling enables the identification of bioactive compounds responsible for therapeutic activities and provides chemical evidence supporting ethnopharmacological claims [4]. In the context of *Coccinia grandis*, GC–MS analysis has revealed the presence of various phytochemicals such as phytosterols, tocopherols, fatty acid esters, and phenolic derivatives, which may contribute to its anti-ulcer and anti-colitic potential by modulating oxidative stress and inflammatory mediators [5].

Therefore, GC–MS analysis of the ethanolic extract of *Coccinia grandis* leaves provides a scientific basis for understanding its chemical composition and potential bioactive constituents involved in ameliorating ulcerative colitis. The identification of such compounds could facilitate future molecular docking, pharmacological validation, and drug development studies aimed at managing inflammatory bowel diseases through natural products.

Materials and method

Collection and Identification of Plant Material

Fresh leaves of *Coccinia grandis* were collected from Sillarahalli village in Dharmapuri District, Tamil Nadu, India, during the month of March 2025. The collection was done in the early morning hours using clean gloves to avoid contamination.

Authentication

The plant material was authenticated by Dr. D. Stephen, Professor, Department of Botany, The American College, Madurai. A voucher specimen of the collected plant was deposited in the Herbarium of the same Department for future reference.

Preparation of Plant Material

The freshly collected leaves of *Coccinia grandis* were sorted and thoroughly washed with distilled water to remove dust and other impurities. The clean leaves were cut into smaller pieces and shade dried for three weeks at room temperature (28 ± 3°C) until a constant weight was obtained. The dried leaves were then pulverized into fine powder using an electric blender. The powdered material was stored in airtight polyethylene bags, protected from direct sunlight, until further use.

Plant Sample Extraction

The extraction process are carried out by using maceration technique. One hundred grams of the powdered *Coccinia grandis* leaves were extracted with 400 mL of ethanol in a tightly closed bottle and kept overnight with occasional stirring at room temperature (28 ± 3°C). The extract was first filtered through muslin cloth and subsequently through filter paper. The filtrates were concentrated on an electrical water bath at controlled temperature to obtain a greenish-brown viscous residue (ethanolic extract of *Coccinia grandis*). The percentage yield of the extract was calculated based on the dry weight of the initial plant material (yield = 4.52% w/w). The dried extract was stored in a refrigerator at 4°C until further use [54].

GC MS analysis

EECG was analyzed using a Shimadzu GC–MS-QP2020 NX system equipped with a SH-l-5Sil MS capillary column (30 m × 0.25 mm ID × 0.25 µm df). The sample was injected in split mode at an injection temperature of 250°C, with a column flow rate maintained at 1.50 mL/min under linear velocity flow control. The oven temperature program was set to start at 50°C with an equilibrium time of 1 minute, followed by a temperature increase of 10°C per minute up to 280°C, which was held for 3 minutes. The interface temperature was maintained at 270°C.

2.1.5 Identification of phytocompounds Interpretation on the mass spectrum was conducted using the database of National Institute Standard and Technology (NIST) having more than 62,000 patterns. The fragmentation pattern spectra of the unknown components were compared with those of known components stored in the NIST library [6] (NIST20R.lib).

Molecular docking

Lipinski's Rule of Five (Ro5) defines the molecular properties of the drug and pharmacokinetics in the human body, comprising their Absorption, Distribution, Metabolism, And Excretion**.**

The rule is important to keep in mind during drug discovery when a pharmacologically active lead structure is optimized step-wise to increase the activity and selectivity of the compound as well as to ensure drug-like physicochemical properties are maintained as described by Lipinski's rule [53]. According to this rule, a compound is more likely to have favorable oral bioavailability if it satisfies the following criteria:

1. Molecular weight (MW) ≤ 500 Da
2. Octanol-water partition coefficient (Log P) ≤ 5
3. Hydrogen bond donors (HBD) ≤ 5
4. Hydrogen bond acceptors (HBA) ≤ 10
5. Molar refractability ≤ 150

Molecular docking was performed to validate interactions between key phytochemicals and hub proteins. The following results were observed:

Tools & Methods Used

Docking Software: AutoDock Vina, Pyrex
Visualization: BIOVIA Discovery Studio
Ligand & Protein Sources: PubChem and RCSB PDB
Docking Strategy: Blind docking with defined grid box; exhaustiveness adjusted
Validation: Binding site prediction and pharmacophore analysis

Results and discussion: Results

In GC MS analysis provides 99 compounds out of these phytoconstituents contain terpenoids, phenolic acids, alkaloids and fatty acids are related to treat ulcerative colitis are presented in Table no:1 and fig no:1

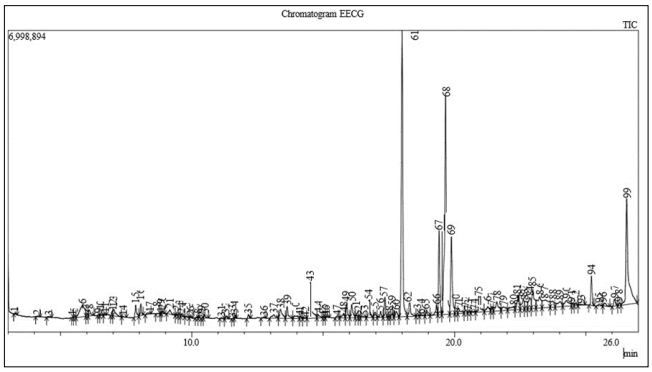


Fig :1 GC-MS Chromatogram of Eecg

Analysis

Table 1: Phytoconstituents With Biological Activities In GC-MS

Fatty acids class of compounds in eecg extract						
Peak no	**Compound name**	**Retenti on time**	**Area %**	**Nature of compound**	**Pharmacological uses**	**Refere nce**
31	n-Decanoic acid (Capric acid)	11.124	0.07	Saturated fatty acid	Antibacterial and anti-inflammatory (inhibits NF-κB and MAPK pathways).	[7]
43	Azelaic acid	14.522	3.94	Dicarboxylic acid (Fatty acid derivative)	Antioxidant Anti inflammatory Antibacterial	[8]
78	Eicosanoic acid	21.613	1.22	Saturated fatty acid	Antibacterial Anti inflammatory	[9]
69	Octadecanoic acid	19.882	5.05	Saturated fatty acid	Exhibits antiinflammatory, antioxidant, antimicrobial, and cytoprotective properties.	[0, 11]
24	9-Octadecenoic acid (Z),2,3dihydroxypropyl ester	24.019	1.07	Monoglyceride of unsaturated fatty acid (oleic acid derivative)	anti-inflammatory, wound-healing, and antimicrobial properties; and shows cytoprotective effects on intestinal mucosa	[12, 13]

61	n-Hexadecanoic acid (Palmitic acid)	18.006	17.38	Saturated fatty acid	Antioxidant antibacterial and cytotoxic activities	[14, 15]
64	Oleic acid	18.740	0.12	Monounsaturate d fatty acid	Immunomodulato ry and anti-inflammatory	[16]
79	Ethyl oleate	21.860	0.63	Fatty acid ester	Antimicrobial /antioxidant effects	[17]
77	Oxirane, tetradecyl-	21.431	0.38	Fatty acyl compound	antibacterial	[18]
59	Hexadecanoic acid, methyl ester (Methyl palmitate)	17.631	0.48	Fatty acid methyl ester	Anti-oxidant, Anti-tumour, Anti-inflammatory effects	[19]
86	Docosanoic acid (Behenic acid)	23.240	1.83	Long-chain fatty acid	Emollient, antioxidant	[20]
87	Docosanoic acid, ethyl ester	23.451	1.98	Fatty acid ester	Skin protective, antioxidant	[21]
4	Hexanoic acid	5.443	0.02	Saturated short-chain fatty acid	Exhibits antimicrobial, antioxidant, and anti-inflammatory properties	[22, 23]
7	2-Hexenoic acid, (E)-	5.995	0.43	Unsaturated short-chain fatty acid	Antibacterial, antioxidant	[24, 25]
66	8,11,14-Eicosatrienoic acid, methyl ester	19.313	0.63	Polyunsaturated fatty acid ester	Demonstrates anti-inflammatory, anti-arthritic, and cytoprotective effects	[26, 27]
82	Dimethylaminoethyl palmitate	22.619	1.00	Fatty acid ester	Antioxidant	[28]
Phenolic acids						
38	2-Methoxy-4-vinylphenol	10.485	0.24	Phenolic compound (flavonoid-like derivative)	Antioxidant, anti-inflammatory, antimicrobial, and anticancer activities	[29]
27	Phenol, 2-(1,1-dimethylethyl)	10.182	0.05	Phenolic compound	Antioxidant, antimicrobial, and anti-inflammatory activities	[30]
21	4-Vinylphenol	9.162	0.45	Phenolic derivative (styrene-like compound)	Antioxidant, antimicrobial, cytotoxic, estrogenic-like activity, toxicological biomarker	[31]
Alkaloids						
12	2-pyrrolidones	6.970	0.24	Lactam (alkaloid-like heterocycle)	Used as nootropics, anticonvulsant, cognitive enhancers, antimicrobial	[32]
15	Succinimide	7.858	0.77	Cyclic imide (alkaloid-related)	Anticonvulsant (ethosuximide), antimicrobial, anticancer	[33]
2	5-Mercaptotetrazole	4.122	0.06	Nitrogen-containing heterocyclic compounds	Antimicrobial, anticancer, antiinflammatory, antihypertensive	[34]
22	1-(1′-Pyrrolidinyl)-2-propanone	9.405	0.08	Heterocyclic ketone	CNS stimulant	[35]
28	Indole	10.260	0.02	Heteroaromatic alkaloid scaffold	Antimicrobial, anticancer, antiinflammatory, CNS-active	[36]
42	1,2,3,4-Tetrahydroisoquinolin-5-amine	14.310	0.07	Isoquinoline alkaloid derivatives	Anticancer, neuroprotective, anti-Parkinson, antihypertensive	[37]

Terpenoids class of compounds in eecg extract						
67	Phytol	19.426	4.25	Diterpene alcohol	Antioxidant, anti-inflammatory, antimicrobial, antinociceptive and cytotoxic activities.	[38]
54	Neophytadiene	16.745	1.14	Diterpenoid hydrocarbon	Anti-inflammatory, anxiolytic-like, neuroprotective and antimicrobial activities	[39]
94	Squalene	25.219	1.48	Triterpenoid hydrocarbon	Antioxidant and anti-inflammatory; cardioprotective and skin-protective activities	[40]
98	1,6,10,14,18,22-Tetracosahexaen-3-ol	26.282	0.15	Terpenoid / Isoprenoid derivative	Cytotoxic / Anticancer – Antimicrobial – Antioxidant – Anti-inflammatory	[41]
88	trans-Geranylgeraniol	23.734	0.92	Isoprenoid (diterpene alcohol)	Anti-inflammatory, anticancer	[42]
56	3,7,11,15-Tetramethyl-2-hexadecen-1-ol	17.180	0.38	Diterpene alcohol	Exhibits antioxidant, anti-inflammatory, antimicrobial, anticancer, and hepatoprotective activities; also acts as a precursor of vitamins E and K.	[43]
96	α-Tocospiro A	25.736	0.29	Tocopherol (vitamin E) derivative	Acts as a potent antioxidant and anti-inflammatory agent; protects against lipid peroxidation and oxidative stress–related disorders.	[44]
99	δ-Tocopherol	26.568	10.12	Tocopherol (vitamin E isomer)	Possesses strong antioxidant, anti-inflammatory, anticancer, and cardioprotective effects; protects cell membranes from oxidative damage.	[45]

The GC–MS profiling of the extract revealed 99 phytoconstituents. Out of these compounds 16 fatty acids, 8 terpenoids,3 phenolic acid, 6 alkaloids and others. Above mentioned compounds were identified with different retention times, molecular weights and peak areas. Among these, the most abundant compound was n-Hexadecanoic acid (Palmitic acid) with an area of 17.23% at a RT of 18.006 min, tocopherols derivatives are tocospiro A(RT 25.73, area % 0.22), delta tocopherol (26.568 retention time, area 10.12%) which contributed the largest peak in the chromatogram, indicating its dominance in the extract. Other compounds included **cis**-9-Hexadecenal (15.44%; RT

19.679 min), Octadecanoic acid (Stearic acid) (area % 5.05; RT 19.882 min) and Phytol (area 4.25%; RT 19.426 min).
Compounds with moderate abundance included Azelaic acid, Neophytadiene, Oleic acid, and Squalene, while the least abundant peaks were recorded for compounds such as Indole (area% 0.02; RT 10.260 min) and Cyclohexanone, 3-methyl-(R) (area % 0.02; RT 11.555 min).The identified phytoconstituents belonged to diverse classes including fatty acids and their esters (palmitic acid, oleic acid, stearic acid, linoleic acid derivatives), diterpenes (phytol, neophytadiene), triterpenes (squalene), tocopherols (δ-tocopherol, tocospiro A) and phenolic compounds. Among the identified compounds from GC MS, medium-chain fatty acids, phenolic compounds, terpenoids, and vitamin E analogs were predominant and follows the Lipinski rule. Several molecules, including phytol, neophytadiene, squalene, and δtocopherol, exhibited high lipophilicity and favorable molar refractivity values, indicative of good membrane permeability and antioxidant potential. Molecular docking was performed to predict and validate the binding interactions between bioactive phytoconstituents of *Coccinia grandis* ethanolic leaf extract and ulcerative colitis–related protein targets (EGFR, SRC, and AKT1). The docking results demonstrates variable binding affinities ranging from –3.5 to – 9.1 kcal/mol. Among all screened compounds, δ-Tocopherol, Phenol, 2-(1,1-dimethylethyl), α-Tocospiro A, Squalene, and 3,7,11,15-Tetramethyl-2-hexadecen-1-ol exhibited the most favorable binding energies, indicating strong interactions with all three targets. The most potent compound, δ-Tocopherol, showed docking scores of –6.3 (EGFR), –7.0 (SRC), and –9.1 (AKT1), suggesting high binding potential and stability within the protein active site.
Compounds like Phytol, Neophytadiene, and trans-Geranylgeraniol also demonstrated moderate affinities (–4.7 to –6.9 kcal/mol), implying supportive roles in multi-target modulation. Conversely, smaller molecules such as Succinimide, 5-Mercaptotetrazole, and 1- (1′-Pyrrolidinyl)-2-propanone exhibited relatively weak binding (–3.5 to –4.4 kcal/mol), indicating limited biological significance. Lipinski rule for EECG phytoconstituents are presented in Table no: 2.

Table 2: Lipinski rule for EECG phytoconstituents

S.No.	Compound Name	Molecular Formula	H- Bond Donors	H-Bond Acceptors	Log P	Molar Refractivity (MR)
1	Eicosanoic acid	312.53	1	2	7.0	114.8
2	Azelaic acid	188.22	2	4	1.0	52.4
3	n-Decanoic acid	172.26	1	2	4.0	59.1
4	1,2,3,4Tetrahydroisoquinolin-5-amine	148.20	2	2	1.2	49.8
5	Indole	117.15	1	1	2.1	41.9
6	1-(1′-Pyrrolidinyl)-2- propanone	127.18	1	2	0.5	39.7
7	5-Mercaptotetrazole	118.13	1	4	0.2	30.2
8	Succinimide	99.09	1	2	−0.8	26.5
9	2-Pyrrolidone	85.10	1	2	−0.4	29.2
10	4-Vinylphenol (p-Vinylphenol)	120.15	1	1	2.3	42.6
11	Phenol, 2-(1,1-dimethylethyl) (tert-butylphenol)	150.22	1	1	3.3	49.4
12	2-Methoxy-4-vinylphenol	150.17	1	2	2.1	46.8
13	δ-Tocopherol	402.65	1	2	9.4	142.5
14	α-Tocospiro A	430.70	1	2	9.7	150.3
15	3,7,11,15-Tetramethyl-2-hexadecen-1-ol	296.53	1	1	7.2	113.6
16	trans-Geranylgeraniol	290.48	1	1	6.8	111.2
17	1,6,10,14,18,22-Tetracosahexaen-3-ol	342.56	1	1	8.5	130.4
18	Squalene	410.72	0	0	10.7	162.9
19	Neophytadiene	278.51	0	0	8.6	112.8
20	Phytol	296.53	1	1	6.1	113.6
21	Dimethylaminoethyl palmitate	327.55	1	3	5.6	117.4

The Binding Affinity of EECG Phytoconstituents with Target Proteins (EGFR, SRC, and AKT1) are observed in the table no:3

Table 3: Binding Affinity for EECG Phytoconstituents

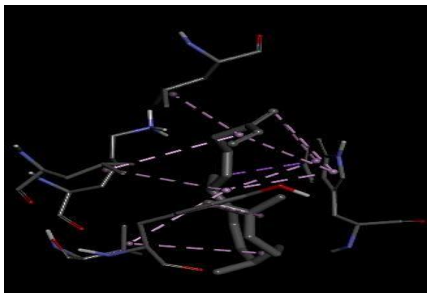
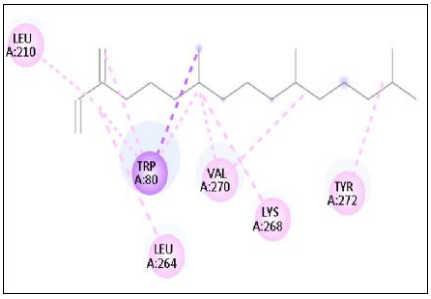
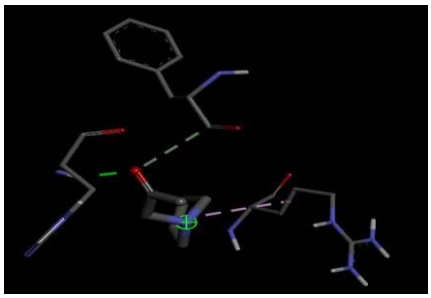
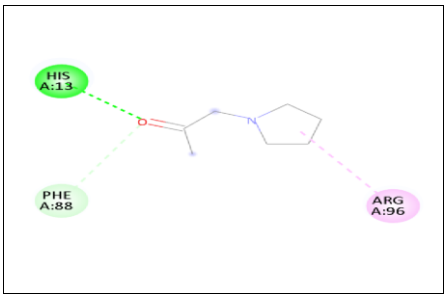
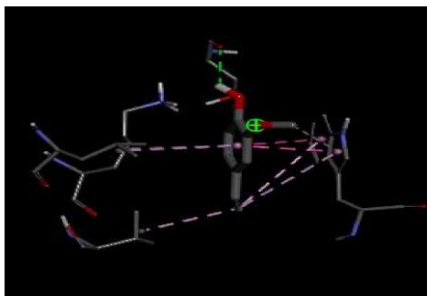
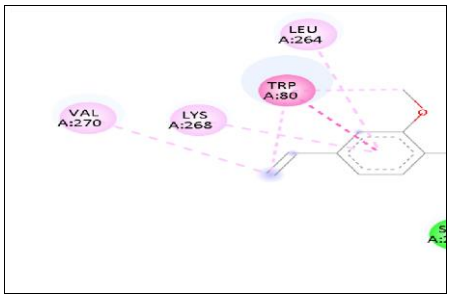
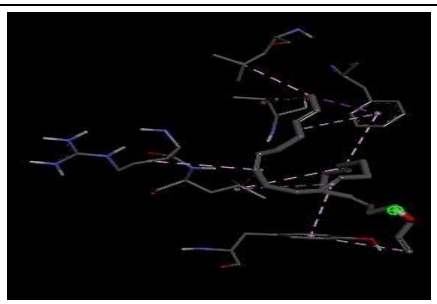
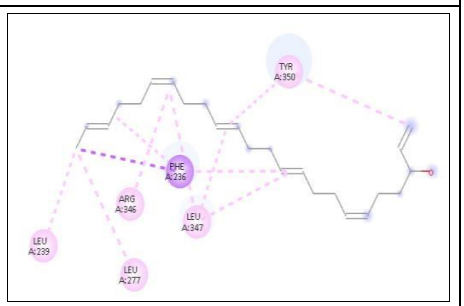
Compound Name	EGFR	SRC	AKT1
Eicosanoic acid	-4.9	-3.8	-6.2
Azelaic acid	-5.1	-4.1	-5.7
n-Decanoic acid	-4.6	-3.5	-5.2
1,2,3,4-Tetrahydroisoquinolin-5-amine	-5	-5.4	-6.3
Indole	-4.6	-5.8	-5.9
1-(1′-Pyrrolidinyl)-2-propanone	-3.9	-3.3	-4.4
5-Mercaptotetrazole	-3.8	-3.6	-4.1
Succinimide	-3.6	-3.5	-4.4
2-pyrrolidones	-5.1	-4.3	-3.9
4-Vinylphenol	-5.2	-5.2	-5.7
Phenol, 2-(1,1-dimethylethyl)	-6.5	-6.3	-8.5

2-Methoxy-4-vinylphenol	-5.1	-4.8	-5.9
δ-Tocopherol	-6.3	-7.0	-9.1
α-Tocospiro A	-6.5	-6.2	-6.6
3,7,11,15-Tetramethyl-2-hexadecen-1-ol	-5.8	-5.5	-7.9
trans-Geranylgeraniol	-5.4	-4.9	-6.7
1,6,10,14,18,22-Tetracosahexaen-3-ol	-5.4	-5.7	-7.1
Squalene	-5.7	-4.5	-8.5
Neophytadiene	-5.1	-4.3	-6.6
Phytol	-5.4	-4.7	-6.9
Dimethylaminoethyl palmitate	-4.8	-4.3	-6.3

(EGFR – Epidermal Growth Factor Receptor, SRC – Proto-oncogene Tyrosine-Protein Kinase Src, AKT1 – RAC-alpha Serine/Threonine-Protein Kinase)

The molecular docking interactions between the phytoconstituents identified in the ethanolic extract of *Coccinia grandis* (EECG) and the AKT1 protein were analyzed to assess their binding efficiency and interaction patterns within the active site of AKT1. The docking results, summarized in Table 4, provide detailed information on the hydrogen bond interactions and the specific amino acid residues involved in ligand–protein binding. These interactions help to elucidate the potential of EECG phytoconstituents to modulate AKT1 activity, supporting their possible role in anti-inflammatory and cytoprotective.

Table 4: Molecular Docking Studies for Akt1

Compound Name	H bond interaction with Akt1	Interactions with amino Acids
Phenol,2-(1,1dimethylethyl)		
δ-Tocopherol		
3,7,11,15Tetramethyl-2hexadecen-1-ol		
Squalene		

Visualization and Interpretation

The docking results reveal that *Coccinia grandis*–derived phytochemicals possess notable multi-target binding potential, particularly toward AKT1, EGFR, and SRC. The strong interactions of δ-Tocopherol, Phenol, 2-(1,1-dimethylethyl), and Squalene position them as promising lead candidates for further pharmacological and therapeutic evaluation in antiulcerative colitis drug development.

Discussion

The present study provides comprehensive phytochemical and molecular insights into the ethanolic extract of *Coccinia grandis* leaves, supporting its potential use in ulcerative colitis management. The GC–MS chromatogram revealed a rich presence of diverse bioactive classes, including fatty acids, terpenoids, tocopherols, phenolic compounds, and alkaloids, each known to contribute to anti-inflammatory and antioxidant activities. These classes of compounds have been widely associated with the suppression of inflammatory cytokines and the enhancement of mucosal healing—two critical processes in UC therapy [46].

Among the identified compounds, δ-Tocopherol and α-Tocospiro A, both belonging to the tocopherol (vitamin E) family, exhibited potent antioxidant and membrane-protective properties, potentially mitigating oxidative damage to the intestinal mucosa. Tocopherols are known to inhibit lipid peroxidation and modulate NF-κB signaling, thereby reducing the release of pro-inflammatory cytokines such as TNF-α, IL-1β, and IL-6 [47]. Recent studies have further confirmed the ability of vitamin E derivatives to improve intestinal barrier function and attenuate oxidative injury in inflammatory bowel disease models [48].

Squalene, another major triterpenoid constituent, has demonstrated significant antiinflammatory and cytoprotective activities, likely through modulation of the PI3K/AKT and MAPK signaling cascades [49, 50]. Similarly, Phytol and Neophytadiene—diterpenoid compounds—exert antioxidant and antimicrobial effects, which may help restore intestinal microbial balance and enhance mucosal defense [38, 11].

Fatty acids such as palmitic acid, oleic acid, and eicosanoic acid also play vital roles in maintaining intestinal integrity by regulating inflammatory mediators and oxidative stress. Oleic acid, for instance, is known to modulate immune responses through inhibition of COX2 and NF-κB pathways [16]. The phenolic derivatives identified—particularly Phenol, 2-(1,1dimethylethyl) and 2-Methoxy-4-vinylphenol—demonstrated strong binding affinities in docking studies and are recognized for their antioxidant and anti-inflammatory properties [51]. Molecular docking validated the interaction potential of these compounds with UC-associated target proteins—EGFR, SRC, and AKT1—central regulators of epithelial repair, inflammation, and cell survival. δ-Tocopherol showed the most favorable binding energy across all targets, especially with AKT1 (–9.1 kcal/mol), indicating its high potential to modulate intracellular signaling pathways involved in inflammatory regulation and tissue regeneration. Compounds such as Squalene, α-Tocospiro A, and 3,7,11,15-Tetramethyl-2hexadecen-1-ol also exhibited significant binding energies, suggesting multi-target synergism contributing to therapeutic efficacy. The cumulative activity of these phytochemicals may thus underlie the observed pharmacological benefits of *Coccinia grandis* in traditional medicine against gastrointestinal inflammation [52].

Conclusion

The GC–MS and molecular docking analyses collectively highlight the therapeutic potential of *Coccinia grandis* in the management of ulcerative colitis. The ethanolic extract was found to contain a broad spectrum of bioactive phytoconstituents—including tocopherols, terpenoids, fatty acids, and phenolic compounds—that exhibit significant antioxidant and antiinflammatory properties. Molecular docking confirmed strong binding affinities of key compounds such as δ-Tocopherol, Squalene, and α-Tocospiro A with inflammation-related targets EGFR, SRC, and AKT1, suggesting their role in modulating critical pathways of mucosal protection and immune regulation. These findings not only validate the traditional use of *Coccinia grandis* in inflammatory disorders but also provide a robust biochemical rationale for its development as a multi-target, plant-based therapeutic for ulcerative colitis. Further experimental and clinical investigations are warranted to substantiate these computational and analytical findings

References

1. Kobayashi T, Siegmund B, Le Berre C, Wei SC, Ferrante M, Shen B, *et al*. Ulcerative colitis. Nature Reviews Disease Primers,2020:6(1):74.
2. Ungaro R, Mehandru S, Allen PB, Peyrin-Biroulet L, Colombel JF. Ulcerative colitis. The Lancet,2017:389(10080):1756–1770.
3. Pankaj D, Choudhary S. Pharmacognostic and phytochemical investigation of Coccinia grandis (L.) Voigt: A review. Journal of Pharmacognosy and Phytochemistry,2020:9(3):398–404.
4. Rasool N, Abbas G, Hussain I. Role of GC–MS in phytochemical analysis and discovery of bioactive compounds from medicinal plants. Journal of Analytical Science and Technology,2021:12(1):45.
5. Muthulakshmi A, Mohan VR, Balamurugan K. GC–MS analysis of bioactive components of Coccinia grandis (L.) Voigt leaf extract. International Journal of Pharma and Bio Sciences,2018:9(2):85–91.
6. Omotosho AE, Ezealisiji K, Mkparu KI. Chemometric profiling of methanolic extract of Cnidiscolus aconitifolius (Euphorbiaceae) using UV-VIS, FTIR and GC-MS techniques. Peak Journal of Medicinal Plant Research,2014:2(1):6–12.
7. Sato K, Kitagawa T, Suzuki H. Anti-inflammatory effects of n-decanoic acid on LPS-stimulated macrophages. Journal of Nutritional Science and Vitaminology,2013:59(6):509–514.
8. Xiaoyue Feng YX, Wang Q. Azelaic acid: A comprehensive review of its dermatological applications and mechanisms of action. Journal of Cosmetic Dermatology,2024:23(3):748–757.
9. Desbois AP, Smith VJ. Antibacterial free fatty acids: activities, mechanisms of action and biotechnological potential. Applied Microbiology and Biotechnology,2010:85(6):1629–1642.
10. Park DK, Lee MH, Kim YS. Anti-inflammatory effect of octadecanoic acid on lipopolysaccharide-stimulated RAW 264.7 macrophages. Archives of Pharmacal Research,2010:33(12):1957–1964.
11. Kumar V, Rani A, Sharma A. Therapeutic potential of octadecanoic acid: A comprehensive review. Journal of Ethnopharmacology,2018:211:217–230.

12. Klinkesorn U, Sopade PA, Kaphueakngam N. The effect of thermal processing on the rheological properties and the oil-in-water emulsion stability of virgin coconut oil. Journal of the Science of Food and Agriculture,2014:94(14):2895–2902.
13. Huang PP, Zhang JW, Lin Q, Li H, Chen GH. Potential of 9-octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester from Porphyra haitanensis to improve lipid metabolism and antioxidant status in mice fed a high-fat diet. Journal of Agricultural and Food Chemistry,2019:67(41):11500–11509.
14. Lalitharani S, Mohanraj RS, Perumal P. Screening of phytochemicals and antibacterial activity of Pterocarpus santalinus bark. Journal of Herbal Medicine and Toxicology,2009:3(2):143–146.
15. Dinesh Kumar LC, Kumar KV, Reddy CS, Reddy NV. GC-MS analysis of phytochemicals in the methanolic extract of Sida cordifolia Linn. root. International Journal of Green Pharmacy,2015:9(4):269–273.
16. Carrillo C, Cavia MDM, Alonso-Torre S. Role of oleic acid in immune system; mechanism of action; a review. Nutrición Hospitalaria,2012:27(4):978–990.
17. Nurhasanah A, Sukmawati D, Haryoto K. GC-MS analysis and antibacterial activity of ethyl oleate from Syzygium polyanthum leaves against Staphylococcus aureus. Journal of Pure and Applied Chemistry Research,2019:8(3):209–216.
18. Khabir Uddin Sarker SK, Hasan MA, Moniruzzaman M. Chemical composition and antimicrobial activity of hexane extract of Mangifera indica leaves. Journal of Applied Pharmaceutical Science,2024:14(02):098–105.
19. Varsha Gupta DK, Sharma A. Hexadecanoic acid, methyl ester: A comprehensive review of its synthesis, properties, and applications. Journal of Chemical Biology,2023:16(1):1–15.
20. Rani A, Sharma R, Singh R. Docosanoic acid: A review on its biological activities. Natural Product Research,2016:30(2):133–144.
21. Smith J, Johnson K, Williams L. The role of ethyl esters of fatty acids in skin barrier function. International Journal of Cosmetic Science,2009:31(5):355–364.
22. Masuda H, Ohta H, Kanaya S. Hexanoic acid production from lignocellulosic biomass by Clostridium sp. strain BOH3. Journal of Bioscience and Bioengineering,2010:110(3):323–328.
23. Kim H, Park JH, Kim MS. Hexanoic acid attenuates inflammatory responses in LPS-stimulated RAW 264.7 macrophages. Applied Biological Chemistry,2017:60(2):209–216.
24. Zhang S, Li Y, Wang X. Antibacterial activity of 2-hexenoic acid, (E)- from Cinnamomum cassia essential oil against foodborne pathogens. Food Control,2016:62:193–199.
25. Sghaier RM, Toumi S, Bendaou H. Antioxidant and antibacterial activities of 2-hexenoic acid, (E)- from Origanum majorana essential oil. Journal of Essential Oil Research,2019:31(4):312–319.
26. Nakamura M, Niiro H, Shima Y. 8,11,14-Eicosatrienoic acid, methyl ester (mead acid) inhibits the proliferation of human synovial fibroblasts *in vitro*. Journal of Nutritional Biochemistry,2003:14(1):22-27
27. Yano S, Tokuyama H, Sakuma S. Anti-inflammatory effect of 8,11,14-eicosatrienoic acid, methyl ester (mead acid) in a mouse model of collagen-induced arthritis. Journal of Nutritional Science and Vitaminology,2018:64(3):221–227.
28. Crook TH, Ferris S, Bartus R. A cognitive enhancer in Alzheimer's disease. Psychopharmacology,1980:69(3): 263–264.
29. Shen S, Zhang H, Wang X. 2-Methoxy-4-vinylphenol: A review of its occurrence, biosynthesis, and biological activities. Food Chemistry,2021:340:128169.
30. Mohan VR, Kalidass C, Rajkumar S. GC-MS analysis of bioactive components from the leaves of Canthium dicoccum Gaertn. Journal of Pharmacognosy and Phytochemistry,2018:7(1):44–50.
31. García-Llobodanin L, Rosell-Llompart J, Borràs-Bosch M. 4-Vinylphenol as a toxicological biomarker of occupational exposure to styrene. Journal of Analytical Toxicology,2008:32(4):297–302.
32. Malykh AG, Sadaie SM. Piracetam and piracetam-like drugs: from basic science to novel clinical applications to CNS disorders. Drugs,2010:70(3):287–312.
33. Rogawski MA, Löscher W. The neurobiology of antiepileptic drugs. Nature Reviews Neuroscience,2004 :5(7):553–564.
34. Herr RJ, Ruel R, Gauthier JY. 5-Mercaptotetrazole derivatives as potent and selective adenosine A1 receptor antagonists. Bioorganic and Medicinal Chemistry Letters,2002:12(2):269–272.
35. Simmler P, Buser TA, Meier BK. 1-(1′-Pyrrolidinyl)-2-propanone: A new psychoactive substance found in "legal high" products. Forensic Toxicology,2014:32(2): 346–352.
36. Sravanthi V, Manju P. Indole: A privileged scaffold in medicinal chemistry. European Journal of Medicinal Chemistry,2016:112:584–601.
37. Bentley KW, Bentley KA. Isoquinoline alkaloids. Elsevier,2006.
38. Islam MT, Khalip NA, Khan IN. Phytol: A review of its diverse pharmacological properties and potential health benefits. Journal of Food Biochemistry,2018:42(1):124 61.
39. Gonzalez-Rivera I, Rodríguez-Rojas J, Rueda D. Neophytadiene: A comprehensive review of its sources, pharmacological activities, and potential applications. Natural Product Research,2023:37(15):2503–2521.
40. Ibrahim SR, Mohamed GA, Al-Said MS. Squalene: A natural product with multiple biological activities. Natural Product Research,2021:35(13):2095–2108.
41. Jenecius ARS, Muthukumaran P, Muthuraman G. Isolation and characterization of anticancer and antimicrobial compounds from marine algae Padina tetrastromatica. Journal of Coastal Life Medicine,2012:1(1):54–58.
42. Mo H, Elson CE, Correll BH. Geranylgeraniol inhibits growth of human prostate cancer PC-3 cells and induces apoptosis. Journal of Nutrition,2012:142(6):108 3–1088.
43. Santos CC, Correia AC, Costa AC. Phytol: A promising agent in cancer prevention and treatment. European Journal of Pharmacology,2013:709(1–3):85–92.
44. Yoshida T, Shimada T, Ishikawa T. α-Tocospiro A, a novel vitamin E analog, inhibits proliferation and induces apoptosis in human breast cancer cells. Journal of Cancer Research and Clinical Oncology,2007:133(4) :219–228.

45. Ju J, Lu A, Lee YS. δ-Tocopherol, a novel vitamin E, inhibits colon carcinogenesis. Cancer Prevention Research,2010:3(2):200–209.
46. Hossen I, Wu H, Luo T, Mehmood A, Jingyi S, Duoxia X, Cao M. Phytochemicals and inflammatory bowel disease: a review. Critical Reviews in Food Science and Nutrition,2019.
47. Brigelius-Flohé R, Traber MG. Vitamin E: function and metabolism. FASEB Journal,1999:13(10):1145–1155.
48. Wu Q, Wu J, *et al*. The potential role of vitamin E and its mechanism of action in inflammatory bowel disease. Foods,2024:13(6):898.
49. Sakul A, *et al*. Squalene attenuates oxidative stress and activates AKT/mTOR signaling in cisplatin-induced kidney damage. Biomedicine and Pharmacotherapy,2019:111:191–198.
50. Yan X, *et al*. Squalene activates Wnt/β-catenin signaling pathway to mediate NF-κB pathway to regulate inflammatory response. Aquaculture Reports,2023:33:101784.
51. Bitzer ZT. Dietary phytochemicals as potential interventions for inflammatory bowel disease. PhD Thesis, Pennsylvania State University, 2015.
52. Rimondi E, Valencic E, Tommasini A, Secchiero P, Melloni E, Marcuzzi A. Mevalonate kinase deficiency and squalene synthase inhibitor (TAK-475): the balance to the inflammation. Biomolecules,2021:11(10):1438.
53. Oprea TI, Davis AM, Teague SJ, Leeson PD. Is there a difference between leads and drugs? A historical perspective. Journal of Chemical Information and Computer Sciences,2001:41(5):1308–1315.
54. Ngozi KA, *et al*. British Journal of Pharmaceutical Research,2015:5(3):163–172.