INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: https://www.ijpsjournal.com

OPEN ACCESS

Research Article

Exploring the Antimicrobial Mechanism of *Morinda citrifolia*: An Integrated Phytochemical and Molecular Docking Approach

Dr. Suresh V.*, Dr. Senthilkumar S. K., Jayaseelan K., Aruna devi L., Blessy Bavina V., Chandramouli S., Charumathi E., Deepa R.

Arunai College of Pharmacy, Tiruvannamalai, Tamilnadu, India.

ARTICLE INFO

Published: 30 Aug 2025
Keywords:
Morinda citrifolia; antimicrobial mechanisms; molecular docking; phytoconstituents; bacterial target proteins
DOI:
10.5281/zenodo.17008835

ABSTRACT

The present study investigates the antimicrobial potential of *Morinda citrifolia* through in vitro evaluation and molecular docking. Antimicrobial assays revealed significant inhibitory activity against selected pathogenic microorganisms, indicating the presence of active phytoconstituents. Identified bioactive compounds were subjected to molecular docking against key bacterial target proteins, demonstrating strong binding affinities and potential inhibitory mechanisms. The combined results highlight M.citrifolia as a promising candidate for developing novel antimicrobial agents.

INTRODUCTION

An antimicrobial is an agent that kills microorganisms (microbicide) or stops their growth (bacteriostatic agent). Antimicrobial medicines can be grouped according to the microorganisms they are used to treat.

For example, antibiotics are used against bacteria, and antifungals are used against fungi. They can also be classified according to their function.

Antimicrobial medicines to treat infection are known as antimicrobial chemotherapy, while antimicrobial drugs are used to prevent infection, which known as antimicrobial prophylaxis.

The main classes of antimicrobial agents are disinfectants (non-selective agents, such as bleach), which kill a wide range of microbes on surfaces to prevent the spread of illness, antiseptics which are applied to living tissue and help reduce infection during surgery, and antibiotics which destroy microorganisms within the body.

***Corresponding Author:** Dr. Suresh V.
Address: *Arunai College of Pharmacy, Tiruvannamalai, Tamilnadu, India*
Email : vsureshsph@gmail.com

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

ANTIFUNGALS

Antifungals are used to kill or prevent further growth of fungi. In medicine, they are used as a treatment for infections such as athlete's foot, ringworm and thrush and work by exploiting differences between mammalian and fungal cells. Unlike bacteria, both fungi and humans are eukaryotes.

ANTIVIRAL

Antiviral drugs are a class of medication used specifically for treating viral infections. Like antibiotics, specific antivirals are used for specific viruses. They should be distinguished from vermicides, which actively deactivate virus particles outside the body.

ANTIPARASITIC:

Antiparasitic are a class of medications which are indicated for the treatment of parasitic diseases, such as those caused by helminthes, amoeba, ectoparasites, parasitic fungi, and protozoa, among others. Antiparasitic target the parasitic agents of the infections by destroying them or inhibiting their growth; they are usually effective against a limited number of parasites within a Particular class.

MECHANISM OF ACTION OF ANTI MICROBIALS:

1. Inhibition of Cell Wall Synthesis

- **Target:** Peptidoglycan layer in bacterial cell walls
- **Effect:** Weakens the cell wall, leading to cell lysis and death
- **Mainly active against:** Gram-positive bacteria
- **Examples:**
  - **β-lactams:** Penicillins, Cephalosporins
  - **Glycopeptides:** Vancomycin

2. Disruption of Cell Membrane Function

- **Target:** Cell membrane (phospholipid or sterol components)
- **Effect:** Destroys membrane integrity→leakage of vital molecules→cell death
- **Examples:**
  - **Polymyxins** (bacteria)
  - **Amphotericin B**, **Nystatin** (fungi - target ergosterol)

3. Inhibition of Protein Synthesis

- **Target:** Bacterial ribosomes (30S or 50S subunits)
- **Effect:** Blocks protein production → inhibits growth or kills cell
- **Examples:**
  - **Tetracyclines**, **Aminoglycosides** (30S)
  - **Macrolides**, **Chloramphenicol** (50S)

4. Inhibition of Nucleic Acid Synthesis

- **Target:** Enzymes for DNA or RNA replication
- **Effect:** Prevents DNA replication or transcription → halts cell division
- **Examples:**

- **Fluoroquinolones** (inhibit DNA gyrase)
- **Rifampin** (inhibits RNA polymerase)

5. Inhibition of Essential Metabolic Pathways

- **Target:** Enzymes in folic acid synthesis (used for DNA/RNA synthesis)
- **Effect:** Starves the cell of critical nutrients
- **Examples:**
- **Sulfonamide**
- **Trimethoprim**

PLANT PROFILE

NONI

Common name: Indian Mulberry, Great Morinda, Cheesefruit,

Scientific name: *Morinda citrifolia*

Family: Rubiaceae

Geographical Source : Kerala, Karnataka and Tamil Nadu

Scientific classification:

- Kingdom : Plantae
- Order : Gentianales
- Family : Rubiaceae
- Subfamily : Rubioideae
- Genus : Morinda
- Species : *Morinda citrifolia*

Vernacular names:

- English : Indian Mulberry
- Tamil : Nuna
- Hindi : Bartundi
- Telugu : Mogali
- Kannada : Tagase maddi

Description:

Morinda citrifolia is a shrub or small tree up to 6 m tall, with grey-brown bark. The twigs are more or less square in cross-section and often fleshy. Stipules are present, very broad and obtuse at the apex, measuring up to 2 cm wide and long. The large glabrous leaves are elliptic to ovate in shape and have 6–9 pairs of lateral veins. The flowers are white and tubular with five lobes, measuring about 15 cm long and across.

The fruits are initially green, transitioning through pale yellow to white or grey, and when ripe they emit a pungent odour. They are irregularly ellipsoid or ovoid.

Chemical Constituent:

Morinda citrifolia fruit powder contains carbohydrates and dietary fibre in moderate amounts. These macronutrients reside in the fruit pulp, as M. citrifolia juice has sparse nutrient content. *Morinda citrifolia* fruit contains diverse phytochemicals, including anthraquinones, lignans, oligo- and polysaccharides, flavonoids, iridoids, such as deacetylasperulosidic acid, scopoletin , fatty acids, catechin, beta-sitosterol, damnacanthal, and alkaloids.

Pharmacological profile:

- Antibacterial
- Antiviral
- Antifungal

- Anthelminthic
- Antitumor
- Analgesic
- Hypotensive
- Anti-inflammatory
- Immune-enhancing effect.

MOLECULAR DESIGN

Molecular design is the process of finding new medicines based on the knowledge of a biological target, it enabled the chemist to predict the structure and then it also allows the medicinal chemist to evaluate the interaction between a compound and its target site before synthesizing a compound so as to increase the ability by reducing the side effects. Various software used :

- Chem Sketch
- Mol inspiration
- Swiss ADME
- Pro Tox 3.0

MOL INSPIRATION

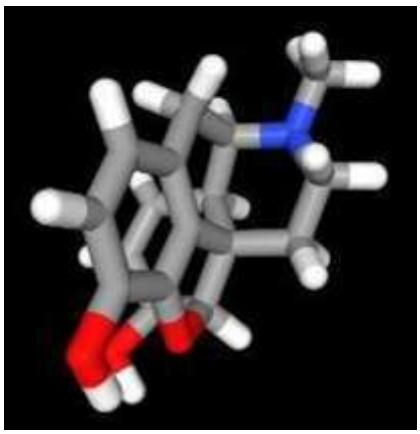
This software is used to calculate the following properties

- Log P
- Molecular weight
- Number of H-bond donor
- Number of H-bond acceptor
- Number of rotatable bonds

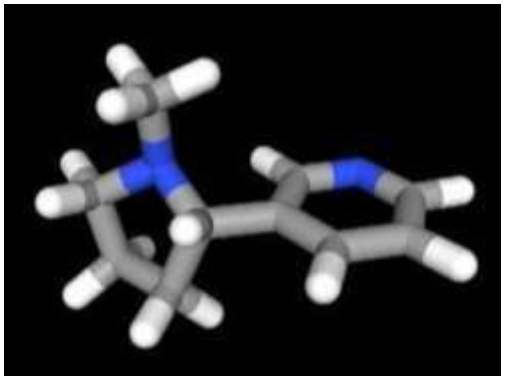
In addition to "LIPINSKI'S RULE" another rule was proposed VEBER he states that the number of rotatable bonds should be less than 10. This rule is more appropriate for oral drug only. According to the veber's rule

1. The Log P value should not be more than 5
2. The molecular weight of the compound should not more than 500
3. No. of H-bond donor not more than 5
4. No. of rotatable bonds should not be more than 10

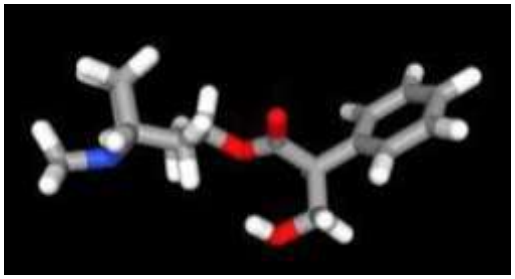
3D STRUCTURAL VIEW OF COMPOUNDS



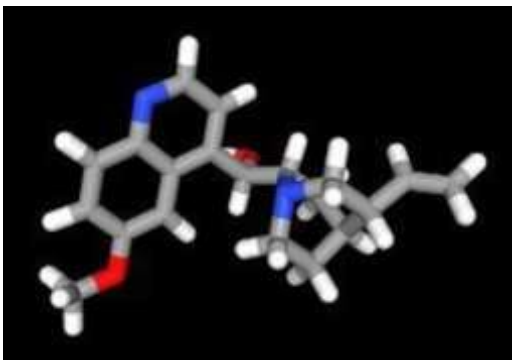
Morphine



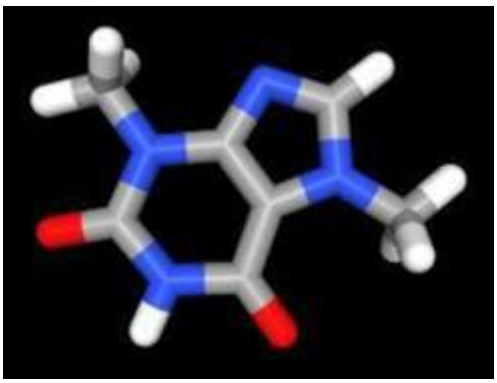
Nicotine



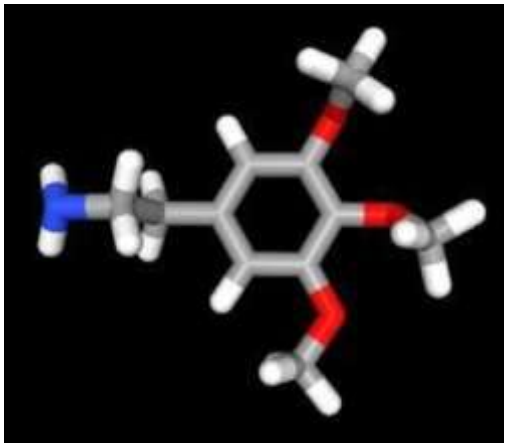
Atropine



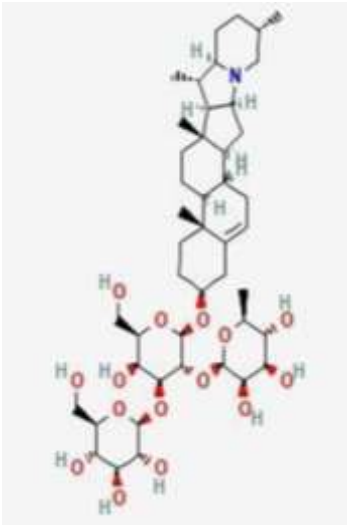
Quinine



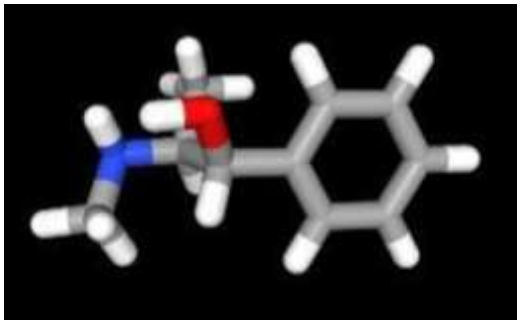
Theobromine



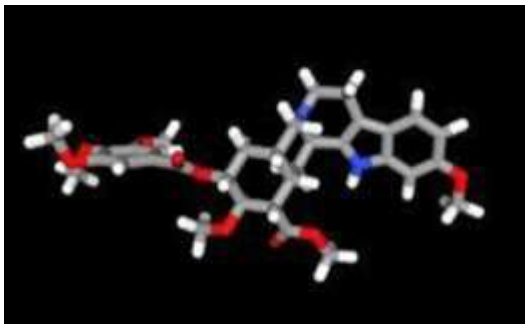
Mescaline



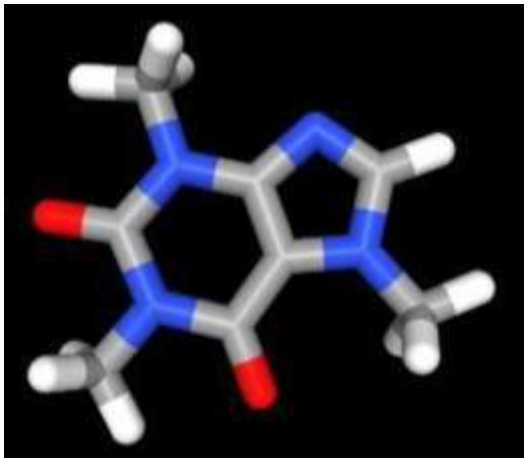
Solanine



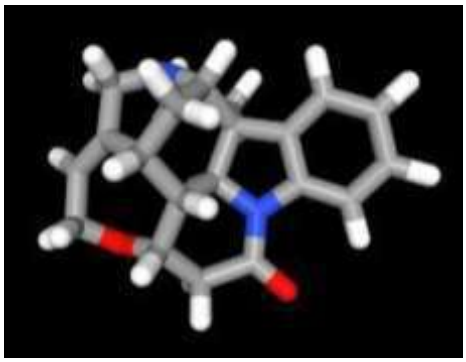
Ephedrine



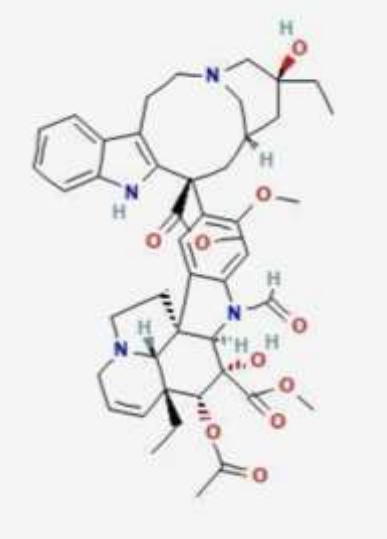
Reserpine



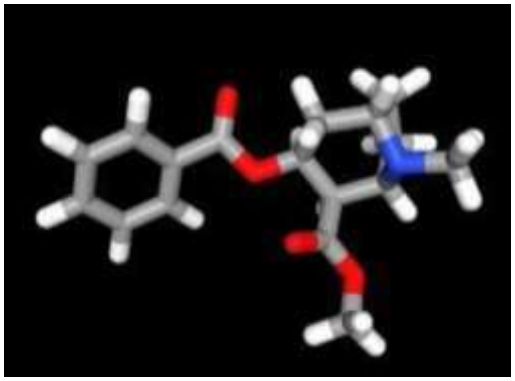
Caffeine



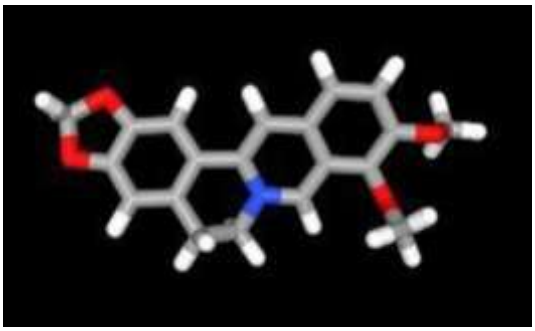
Strychnine



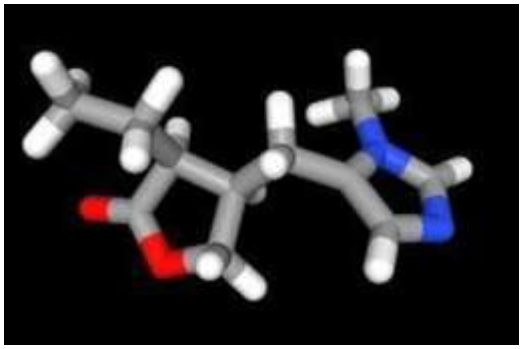
Vincristine



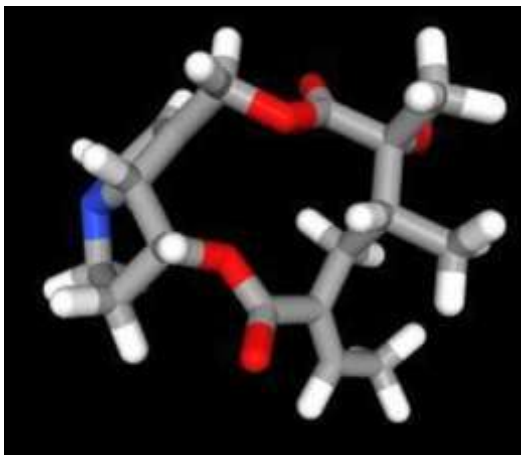
Cocaine



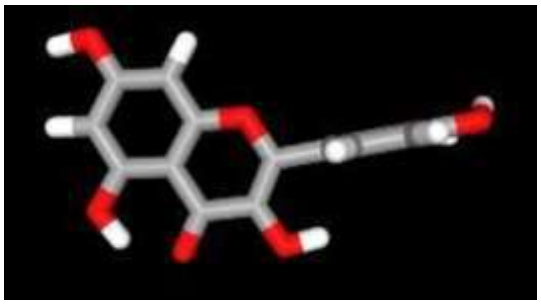
Berberine



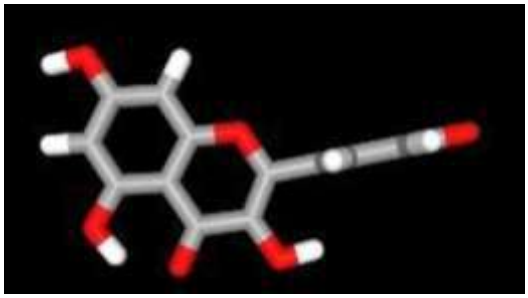
Pilocarpine



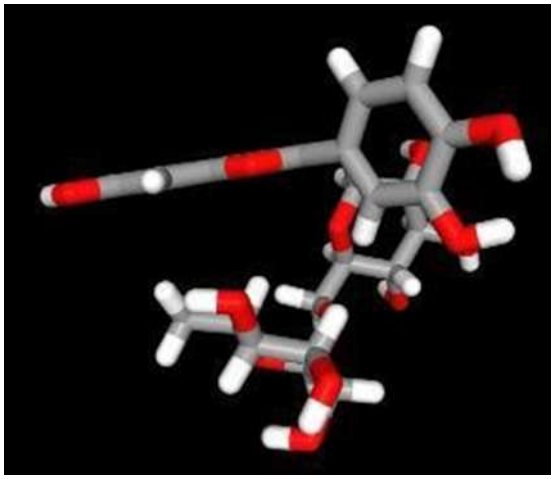
Senecionine



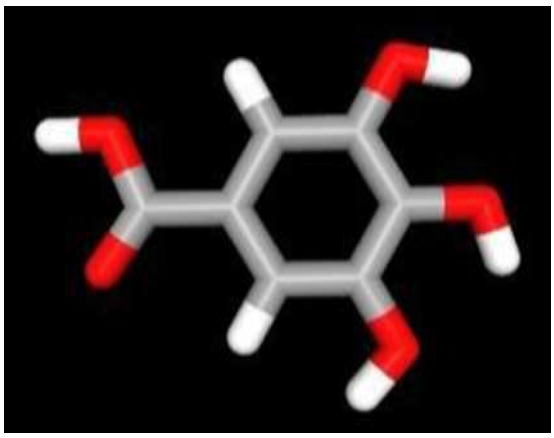
Quercetine



Kaempferol

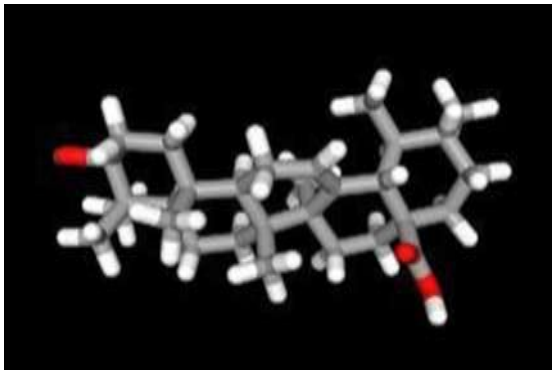


Rutin

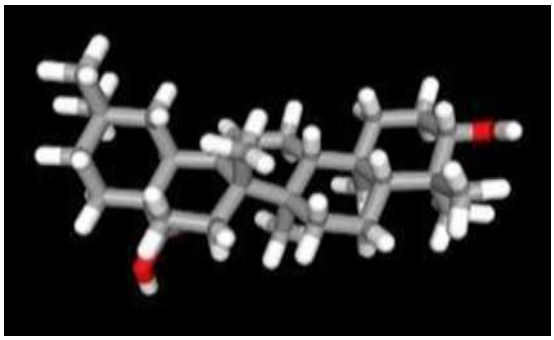


Gallic acid

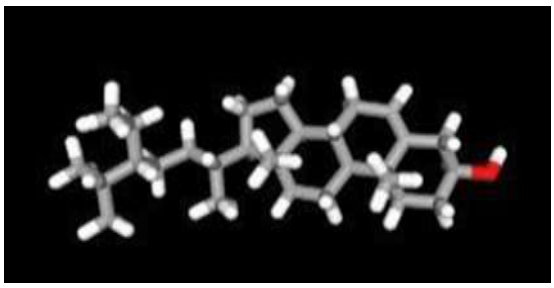
Caffeic acid



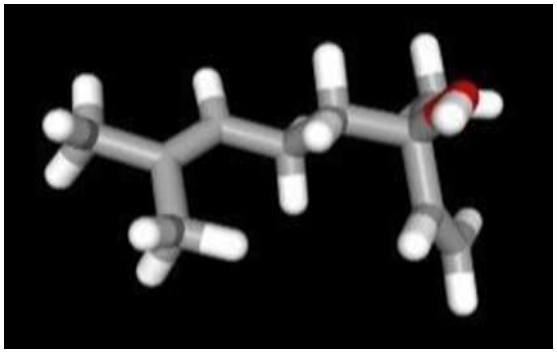
Ursolic acid



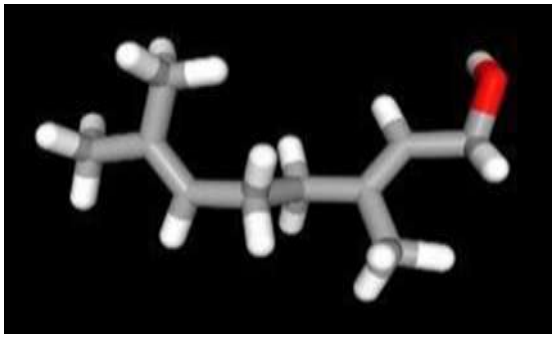
Oleanolic acid



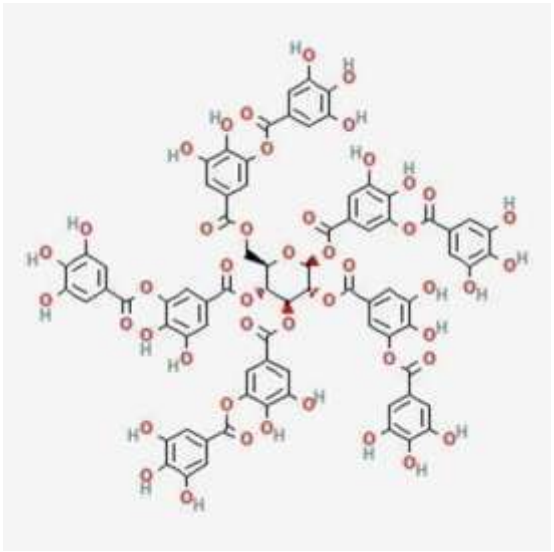
β-Sitosterol



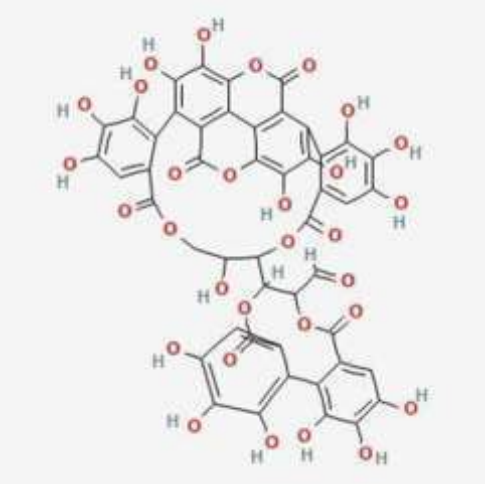
Linalool



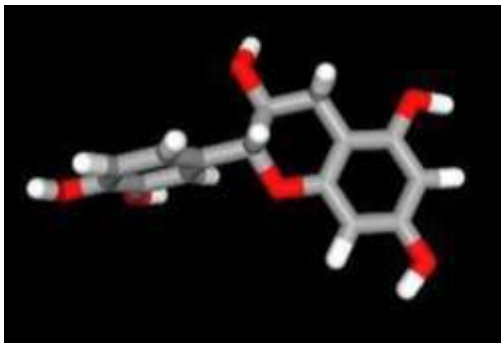
Geraniol



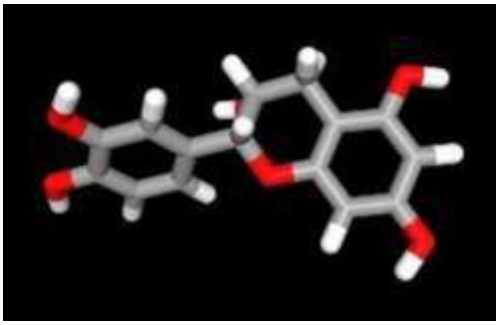
Tannic acid



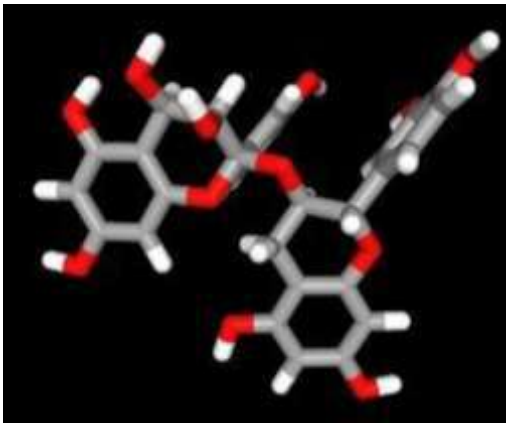
Punicalaginn



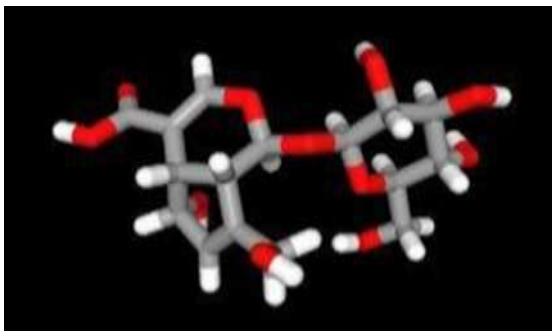
Catechin



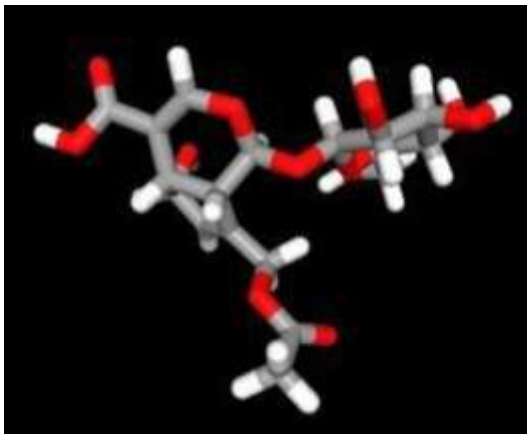
Epicatechin



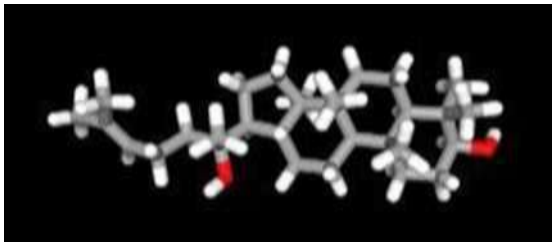
Procyanidin



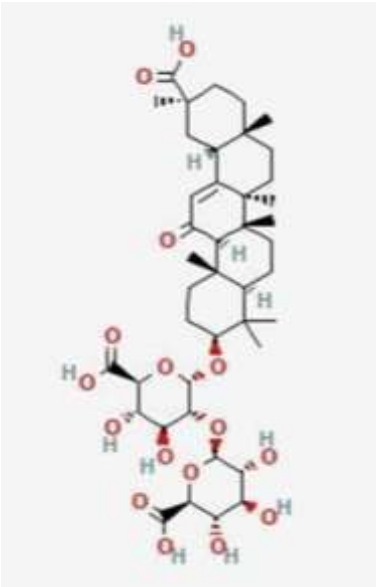
Deacetylsperulosidic acid



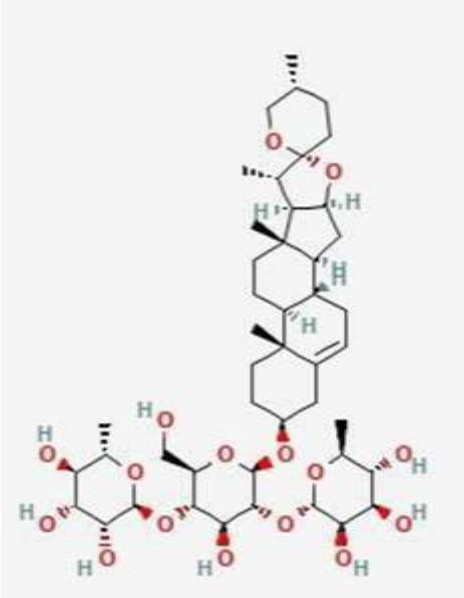
Asperulosidic acid



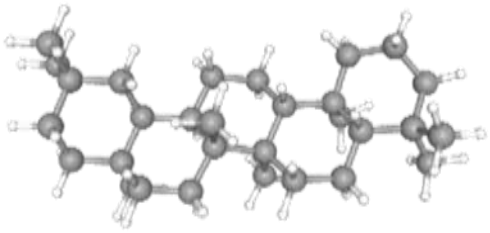
Ginsenosides



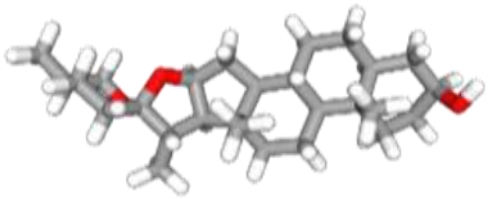
Glycyrrhizin



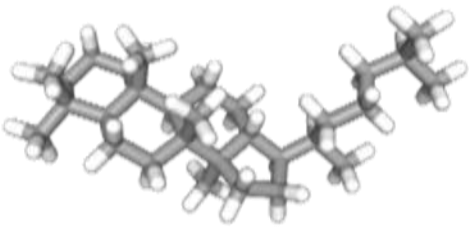
Dioscin



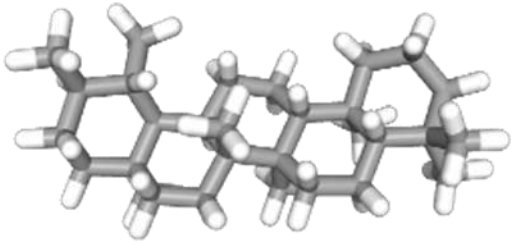
Oleanane



Ursane



Tigogenin



Dammarane

TABLE-1:PROPERTIES OF PHYTOCONSTITUENTS

Sr. No	PHYTOCONSIUENTS	PUBCHEM ID	MOLECULAR WEIGHT	MOLECULAR FORMULA
1	MORPHINE	5288826	285.34 g/mol	$C_{17}H_{19}NO_3$
2	NICOTINE	89594	162.34 g/mol	$C_{10}H_{14}N_2$
3	ATROPINE	174174	289.4 g/mol	$C_{17}H_{23}NO_3$
4	QUININE	6999115	325.4 g/mol	$C_{20}H_{25}N_2O_2$
5	MESCALINE	4075	153.14 g/mol	$C_7H_{7N}NO_3$
6	EPHEDRINE	9457	165.23 g/mol	$C_{10}H_{15}NO$
7	CAFFINE	2519	194.19 g/mol	$C_8H_{10}N_40_2$
8	THEOBROMINE	5429	180.16 g/mol	$C_7H_8N_4O_2$
9	SOLANINE	30185	868.1 g/mol	$C_{45}H_{73}NO_{15}$
10	RESERPINE	5770	608.7 g/mol	$C_{33}H_{40}N_20_9$
11	STRYCHNINE	441071	334.4 g/mol	$C_{21}H_{22}N_2O_2$
12	VINCRISTINE	5978	825.0 g/mol	$C_{45}H_{56}N_4O_{10}$
13	COCAINE	446220	303.34 g/mol	$C_{17}H_{21}NO_4$
14	BERBERINE	2353	336.4 g/mol	$C_{20}H_{18}NO_4^+$
15	PILOCARPINE	5910	208.26 g/mol	$C_{11}H_{16}N_2O_2$
16	SENECIONINE	5280906	335.4 g/mol	$C_{18}H_{25}NO_5$
17	QUERCETINE	5280343	302.23 g/mol	$C_{15}H_{10}O_7$
18	KAEMPFEROL	5280863	286.24 g/mol	$C_{15}H_{10}O_6$
19	RUTIN	6728944	610.5 g/mol	$C_{27}H_{30}O_{16}$

20	GALLIC ACID	370	170.12g/mol	$C_7H_6O_5$
21	CAFFEIC ACID	689043	180.16g/mol	$C_9H_8O_4$
22	URSOLIC ACID	64945	456.7g/mol	$C_{30}H_{48}O_3$
23	OLEANOLIC ACID	10494	456.7g/mol	$C_{30}H_{48}O_3$
24	β-SITOSTEROL	222284	414.7g/mol	$C_{29}H_{50}O$
25	LINALOOL	6549	154.25g/mol	$C_{10}H_{18}O$
26	GERANIOL	637566	0.25g/mol	$C_{10}H_{18}O$
27	TANNIC ACID	16129778	1701.2g/mol	$C_{76}H_{52}O_{46}$
28	PUNICALAGIN	16129719	1084.7g/mol	$C_{48}H_{28}O_{30}$
29	CATECHIN	9064	290.27g/mol	$C_{15}H_{14}O_6$
30	EPICATECHIN	72276	290.27g/mol	$C_{15}H_{14}O_6$
31	PROCYANIDIN	107876	594.5g/mol	$C_{30}H_{26}O_{13}$
32	DEACETYLASPERULOSIDIC ACID(DAA)	12315350	390.34g/mol	$C_{16}H_{22}O_{11}$
33	ASPERULOSIDIC ACID (AA)	119688	432.4g/mol	$C_{18}H_{24}O_{12}$
34	GINSENOSIDES	3086007	444.7g/mol	$C_{18}H_{52}O_2$
35	GLYCYRRHIZIN	14982	822.9 g/mol	$C_{42}H_{62}O_{16}$
36	DIOSCIN	119245	869.0 g/mol	$C_{45}H_{72}O_6$
37	TIGOGENIN	99516	416.6 g/mol	$C_{27}H_{44}O_3$
38	OLEANANE	9548717	412.27 g/mol	$C_{56}H_{92}O_{29}$
39	URSANE	9548870	412.7 g/mol	$C_{30}H_{52}$
40	DAMMARANE	9548714	414.7 g/mol	$C_{30}H_{54}$

TABLE-2: ADME PROPERTIES OF PHYTOCONSTITUENTS:

Sr. No.	Phytoconsttiuents	Number Of Rota-Table Bonds	Number Of Bond Acceptor	Number Of Bond Donor	Lpgpc/ W9 (Liogl)	Molar Refractive	Solu-Bility	Gastro-Intestinal Absorption
1	MORPHINE	0	4	2	2.55	32.27	SOLUBLE	HIGH
2	NICOTINE	1	2	0	2.04	53.13	SOLUBLE	HIGH
3	ATROPINE	5	4	1	2.79	84.51	SOLUBLE	HIGH
4	QUININE	4	4	1	3.36	99.73	SOLUBLE	HIGH
5	MESCALINE	5	4	1	2.37	53.40	SOLUBLE	HIGH
6	EPHEDRINE	3	2	2	2.16	49.79	SOLUBLE	HIGH
7	CAFFINE	0	3	0	1.79	52.04	SOLUBLE	HIGH
8	THEOBROMINE	0	3	1	1.22	47.14	SOLUBLE	HIGH
9	SOLANINE	6	12	7	2.90	190.96	SOLUBLE	LOW
10	RESERPINE	10	10	1	5.21	165.52	SOLUBLE	HIGH
11	STRYCHNINE	0	3	0	2.78	101.05	SOLUBLE	HIGH
12	VINCRISTINE	11	12	3	4.70	233.11	SOLUBLE	LOW
13	COCAINE	5	5	0	3.22	54.85	SOLUBLE	HIGH
14	BERBERINE	2	4	0	0.00	94.87	SOLUBLE	HIGH
15	PILOCARPINE	3	3	0	1.81	56.47	SOLUBLE	HIGH
16	SENECIONINE	0	6	1	2.43	91.93	SOLUBLE	HIGH
17	QUERCETINE	1	7	5	1.63	78.03	SOLUBLE	HIGH
18	KAEMPFEROL	1	6	4	1.70	76.01	SOLUBLE	HIGH
19	RUTIN	6	16	10	0.46	141.38	SOLUBLE	LOW
20	GALLIC ACID	1	5	4	0.21	39.47	SOLUBLE	HIGH
21	CAFFEIC ACID	2	4	3	0.97	47.16	SOLUBLE	HIGH
22	URSOLIC ACID	1	3	2	3.95	136.91	SOLUBLE	LOW
23	OLEANOLIC ACID	1	3	2	3.94	136.65	SOLUBLE	LOW
24	B-SITOSTEROL	6	1	1	5.05	133.23	SOLUBLE	LOW
25	LINALOOL	4	1	1	2.70	50.44	SOLUBLE	HIGH
26	GERANIOL	4	1	1	2.52	50.40	SOLUBLE	HIGH
27	TANNIC ACID	10	19	11	0.36	142.56	SOLUBLE	LOW

28	PUNICALAGIN	2	30	17	0.42	252.09	SOLUBLE	LOW
29	CATECHIN	1	6	5	1.33	74.33	SOLUBLE	HIGH
30	EPICATECHIN	1	6	5	1.47	74.33	SOLUBLE	HIGH
31	PROCYANIDIN	4	13	10	2.17	147.52	SOLUBLE	LOW
32	DEACETYLASPERULOSIDIC ACID(DAA)	5	11	7	0.58	83.73	SOLUBLE	LOW
33	ASPERULOSIDIC ACID (AA)	7	12	6	1.13	93.47	SOLUBLE	LOW
34	GINSENOSIDES	4	2	2	5.01	138.72	SOLUBLE	LOW
35	GLYCYRRHIZIN	7	16	8	1.89	202.84	SOLUBLE	LOW
36	DIOSCIN	0	3	0	2.37	00.40	SOLUBLE	HIGH
37	TIGOGENIN	7	13	1	4.53	122.07	SOLUBLE	HIGH
38	OLEANANE	0	0	0	5.05	134.19	SOLUBLE	LOW
39	URSANE	0	0	0	5.02	134.45	SOLUBLE	LOW
40	DAMMARANE	5	0	0	5.61	136.83	SOLUBLE	LOW

TABLE-3: TOXICITY STUDY OF PHYTOCONSTITUENTS

Sr. No	Phyto Constituents	Nephro Toxicity	Carcino Toxicity	Cardio Toxicity	Muta Genecity	Cyto Toxicity	Bbb-Barrier	Nutritional Toxicity	Aryl Hydrocarbon Receptor	Androgen Receptor
1	**Morphine**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
2	**Nicotine**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
3	**Atropine**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
4	**Quinine**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
5	**Mescaline**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
6	**Ephedrine**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
7	**Caffeine**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
8	**Theo-Bromine**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
9	**Solanine**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
10	**Reserpine**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
11	**Strychinine**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
12	**VinCristine**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
13	**Cocaine**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
14	**Berberine**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
15	**Pilocarpine**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
16	**Senecionine**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
17	**Quercetin**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
18	**Kaempferol**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
19	**Rutin**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
20	**Gallic Acid**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
21	**Caffeic Acid**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
22	**Ursolic Acid**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
23	**Oleanolic Acid**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
24	**B-sitosterol**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
25	**Linalool**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
26	**Geraniol**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
27	**Tannic Acid**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
28	**Punicalagin**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
29	**Catechin**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
30	**Epicatechin**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
31	**Procyanidin**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
32	**Deacetyl Asperuloidic Acid**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
33	**Asperulo Sidic Acid**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
34	**Ginseno Sides**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
35	**Glycyrrhzin**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
36	**Dioscin**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive

37	**Tigogenin**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
38	**Oleanane**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
39	**Ursane**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
40	**Dammarane**	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive

ANTI MICROBIAL ACTIVITY

PREPARATION OF PROTEIN:

The protein target, obtained from the RCSB protein data bank with the PDB accession. Code 1ULK function as docking receptor. The active site of the receptor was cleared of all sound ligands and water molecules.

CRYSTAL STRUCTURE OF 1ULK

PDB DOI: https://doi.org/10.2210/pdb1ULK/pdb

Classification: SUGAR BINDING PROTEIN

Organism(s): Phytolacca americana

Mutation(s): No

Experimental Data Snapshot

- **Method:** X-RAY DIFFRACTION
- **Resolution:** 1.80 Å
- **R-Value Free:** 0.203 (Depositor)
- **R-Value Work:** 0.176 (Depositor)
- **R-Value Observed:** 0.176 (Depositor)

PREPARATION OF PROTEIN:

The protein target, obtained from the RCSB protein data bank with the PDB accession. Code 6YIS function as docking receptor. The active site of the receptor was cleared of all sound ligands and water molecules.

CRYSTAL STRUCTURE OF 6YIS

PDB DOI: https://doi.org/10.2210/pdb6YIS/pdb

Classification: HYDROLASE

Organism(s): Bos taurus

Mutation(s): No

Experimental Data Snapshot

- **Method:** X-RAY DIFFRACTION
- **Resolution:** 1.19 Å
- **R-Value Free:** 0.173 (Depositor), 0.170 (DCC)
- **R-Value Work:**0.150 (Depositor), 0.150 (DCC)
- **R-Value Observed:** 0.151 (Depositor)

TABLE-4: BINDING AFFINITY OF PHYTOCONSTITUENTS USING

Sr. No.	Phytoconsiuents	Binding Affinity

1	Morphine	-7.0219
2	Nicotine	-5.9739
3	Atropine	-7.3454
4	Quinine	-7.1117
5	Mescaline	-6.3483
6	Ephedrine	-6.3880
7	Caffine	-6.5242
8	Theobromine	-7.8453
9	Solanine	-8.7729
10	Reserpine	-8.7729
11	Strychnine	-6.7014
12	Vincristine	-8.6114
13	Cocaine	-7.3386
14	Berberine	-6.7822
15	Pilocarpine	-6.8946
16	Senecionine	-6.5852
17	Quercetine	-6.6996
18	Kaempferol	-7.6110
19	Rutin	-8.4362
20	Gallic Acid	-5.9175
21	Caffeic Acid	-6.6113
22	Ursolic Acid	-7.1021
23	Oleanolic Acid	-7.0433
24	B-Sitosterol	-7.2657
25	Linalool	-6.1516
26	Geraniol	-6.4432
27	Tannic Acid	-8.9826
28	Punicalagin	-7.9427
29	Catechin	-6.4530
30	Epicatechin	-7.1191
31	Procyanidin	-8.1106
32	Deacetylasperulosidic Acid(Daa)	-7.2467
33	Asperulosidic Acid (Aa)	-7.4013
34	Ginsenosides	-7.3768
35	Glycyrrhizin	-8.0319
36	Dioscin	-9.2254
37	Tigogenin	-7.2500
38	Oleanane	-6.9805
39	Ursane	-7.1507
40	Dammarane	-7.2525

RESULTS AND CONCLUSION

The present investigation focused on the antimicrobial potential of *Morinda citrifolia*, combining antimicrobial evaluation with in-silico molecular docking studies. The study systematically screened phytoconstituents, assessed their ADME properties, binding affinities with selected microbial target proteins, and evaluated their toxicity profiles.

Results

Antimicrobial assays of M. citrifolia revealed significant inhibitory effects against a range of pathogenic microorganisms, suggesting the presence of bioactive secondary metabolites. Phytochemical analysis confirmed the occurrence of diverse compounds including alkaloids, flavonoids, iridoids, phenolics, terpenoids, and sterols, many of which are well-documented for antimicrobial and pharmacological effects.

A total of 40 phytoconstituents were subjected to computational screening. ADME analysis highlighted that most compounds exhibited favorable physicochemical properties under Lipinski's Rule of Five and Veber's Rule, confirming their potential oral bioavailability. However, some larger molecules (such as tannic acid, punicalagin, and glycyrrhizin) showed reduced gastrointestinal absorption, indicating possible limitations in systemic bioavailability.

Molecular docking studies were performed using 1ULK (sugar-binding protein) and 6YIS (hydrolase protein) as bacterial target proteins. Binding affinity scores demonstrated strong interactions of several phytochemicals. Notably, Dioscin (-9.2254 kcal/mol), Tannic acid (-8.9826 kcal/mol), Solanine (-8.7729 kcal/mol), Reserpine (-8.7729 kcal/mol), and Vincristine (-8.6114 kcal/mol) exhibited the most favorable docking energies, surpassing several standard antimicrobial agents. Flavonoids such as quercetin, kaempferol, and rutin also displayed promising affinities, reinforcing their role as natural antimicrobial scaffolds.

Toxicity prediction studies indicated that all tested compounds were non-toxic across nephrotoxicity, cardiotoxicity, genotoxicity, and mutagenicity assays. Importantly, none showed significant nutritional or blood–brain barrier toxicity risks, which enhances their therapeutic relevance. This combination of potent binding affinity, favorable ADME properties, and low predicted toxicity suggests that multiple phytoconstituents from M. citrifolia could act as promising antimicrobial drug leads.

CONCLUSION

This study highlights the strong antimicrobial efficacy of *Morinda citrifolia*, supported by both experimental assays and molecular docking simulations. Key bioactive compounds, including Dioscin, Tannic acid, Solanine, Reserpine, and Rutin, exhibited notable binding affinities with bacterial proteins, indicating their potential as natural inhibitors of microbial growth. Computational ADME and toxicity assessments further confirmed that several of these phytoconstituents possess favorable drug-like properties with minimal safety concerns.

The results establish M. citrifolia as a valuable source of antimicrobial phytochemicals with the potential to serve as lead molecules in developing new therapeutic agents. In the context of rising antimicrobial resistance, such naturally derived compounds represent sustainable and safer alternatives to conventional antibiotics. The integration of in vitro assays with in silico modeling provides deeper insight into mechanisms of action, while also streamlining the identification of promising candidates.

Future directions should focus on in vivo validation of these compounds, structural optimization to enhance bioactivity, and studies on synergistic effects with existing antibiotics to improve clinical outcomes. Collectively, the findings reinforce the medicinal value of M. citrifolia and its promise in next-generation antimicrobial drug discovery.

REFERENCES

1. Merriam-Webster Online Dictionary. Archived from the original on 24 April 2009. Retrieved 2009-05-02.
2. Leekha, Surbhi; Terrell, Christine L.; Edson, Randall S. (February 2011). "General Principles of Antimicrobial Therapy". Mayo Clinic Proceedings. 86 (2): 156–167. doi:10.4065/mcp.2010.0639. PMC 3031442. PMID 21282489.
3. "Antimicrobial Porous Media | Microbicidal Technology | Porex Barrier Technology". www.porex.com. Archived from the original on 2017-03-03. Retrieved 2017-02-16.
4. Houšť, Jiří; Spížek, Jaroslav; Havlíček, Vladimír (2020-03-12). "Antifungal Drugs". Metabolites. 10 (3): 106. doi:10.3390/metabo10030106. ISSN 2218-1989. PMC 7143493. PMID 32178468
5. Arakawa, Tsutomu; Yamasaki, Hisashi; Ikeda, Keiko; Ejima, Daisuke; Naito, Takeshi; Koyama, A. Hajime (2009). "Antiviral and Virucidal Activities of Natural Products". Current Medicinal Chemistry. 16 (20): 2485–2497. doi:10.2174/092986709788682065. PMID 19601794
6. Kappagoda, Shanthi; Singh, Upinder; Blackburn, Brian G. (2011). "Antiparasitic Therapy". Mayo Clin. Proc. 86 (6): 561-583. doi:10.4065/mcp.2011.0203. PMC 3104918. PMID 21628620.
7. Kusrini E, Hashim F, Azmi WN, Amin NM, Estuningtyas A (2016). "A novel antiamoebic agent against Acanthamoeba sp. – A causative agent for eye keratitis infection". Spectrochimica Acta Part A: Molecular

Spectroscopy. 153: 714–21. Bibcode:2016AcSpA.153..714K. doi:10.1016/j.saa.2015.09.021. PMID 26474244.
8. Molina JM, Tourneur M, Sarfati C, et al. (June 2002). "Fumagillin treatment of intestinal microsporidiosis". N. Engl. J. Med. 346 (25): 1963–9. doi:10.1056/NEJMoa012924. PMID 12075057.
9. "ANTIPARASITICS". Purdue University Cytology Laboratories. Purdue Research Foundation. Retrieved 2015-08-30.
10. F.A.Zich; B.P.M.Hyland; T.Whiffen; R.A.Kerrigan (2020). "*Morinda citrifolia*". Australian Tropical Rainforest Plants Edition 8 (RFK8). Centre for Australian National Biodiversity Research (CANBR), Australian Government. Retrieved 12 May 2024.
11. "*Morinda citrifolia* L." Flora of China (eFloras). Missouri Botanical Garden, St. Louis, MO & Harvard University Herbaria, Cambridge, MA. Retrieved 12 May 2024.
12. "*Morinda citrifolia* - Indian Mulberry". Cook Islands Biodiversity. The Cook Islands Natural Heritage Trust. Retrieved 12 May 2024.
13. "RUBIACEAE (Wong et al.)". Flora of Singapore. Singapore Botanic Gardens. p. 182. Retrieved 12 May 2024.
14. T.P.T. Cushnie et al. Recent advances in understanding the antibacterial properties of flavonoids International Journal of Antimicrobial Agents
15. T.P.T. Cushnie et al. Antimicrobial activity of flavonoids. International Journal of Antimicrobial Agents(2005)
16. Nita T, Arai T, Takamatsu H et al. Antibacterial activity of extracts prepared from tropical and subtropical plants on methicillin-resistant Staphylococcus aureus. J Health Sci 48: 273-6, 2002.
17. Atefl DA, Erdo¤rul ÖT. Antimicrobial activities of various medicinal and commercial plant extracts. Turk J Biol 27: 157-62, 2003.
18. Abdulrahman et al., 2010 M.S. Abdulrahman, S. Thangaraj, S.M. Salique, K.F. Khan, S.E. Natheer Antimicrobial and biochemical analysis of some spices extracts against food spoilage pathogens Int. J. Food Safety, 12 (2010), pp. 71-75.
19. Akinpelu et al., 2015 D.A. Akinpelu, O.A. Aiyegoro, O.F. Akinpelu, A.I. Okah Stem bark extract and fraction of Persea americana (Mill) exhibits bactericidal activities against strains of Bacillus cereus associated with food poisoning Molecules, 20 (2015),pp. 416-429
20. Marasini B. P., Baral P., Aryal P. et al., Evaluation of antibacterial activity of some traditionally used medicinal plants against human pathogenic bacteria, BioMed Research International.(2015) 2015, 6, 265425.
21. Romero C. D., Chopin S. F., Buck G., Martinez E., Garcia M., and Bixby L., Antibacterial properties of common herbal remedies of the southwest, Journal of Ethnopharmacology.(2005) 99, no. 2, 253–257 https://doi.org/10.1016/j.jep.2005.02.028, 2-s2.0-19444364037.
22. Awadh Ali NA, Julich WD, Kusnick C, Lindequist U (2001): Screening of Yemeni medicinal plants for antibacterial and cytotoxic activities. J Ethnopharmacol 74:173–179.
23. Garcia VMN, Gonzalez A, Fuentes M, Aviles M, Rios MY, Zepeda G, Rojas MG (2003): Antifungal activities of nine traditional Mexican medicinal plants. J.Ethnopharmacol 87: 85–88.
24. Garcia VMN, Gonzalez A, Fuentes M, Aviles , Rios MY, Zepeda G, Rojas MG (2003): Antifungal activities of nine traditional

Mexican medicinal plants.J.Ethnopharmacol 87: 85–88.
25. Dülger B., Yılmaz F., Gücin B. (1998) Antimicrobial activity of the macrofungi Macrolepiota procera (Scop. ex Fr.) Sing. Kükem Dergisi, 21 (1): 7-12.
26. S.S. Chang et al. Natural antioxidants from rosemary and sage Journal of Food Science(1977)
27. H. Kikuzaki et al. Antioxidant Effects of Some Ginger Constituents Journal of Food Science (1993)
28. Lourdu Jafrin A, Shanti M, Meher Ali R. Anxiolytic effect of ondansetron, a 5-HT3 antagonist on male albino mice in the elevated plus maze. Res J Pharm Biol Chem Sci. 2013;4:1665–75. [Google Scholar]
29. Vaseghi G, Andalib S, Rabbani M, Sajjadi SE, Jafarian A. Hypnotic Effect of Salvia reuterana Boiss for Treatment of Insomnia. J Med Plants. 2013;12:7–13. [Google Scholar]
30. DeFronzo, R. A., Ferrannini, E., Groop, L., Henry, R. R., Herman, W. H., Holst, J. J., Hu, F. B., Kahn, C. R., Raz, I., Shulman, G. I., Simonson, D. C., Testa, M. A., & Weiss, R. (2015). Type 2 diabetes mellitus. Nature Reviews Disease Primers, 1(July), 1–23. https://doi.org/10.1038/nrdp.2015.19
31. Cilla, A., Alegrí a, A., De Ancos, B., Sa nchez-Moreno, C., Cano, M. P., Plaza, L., Clemente, G., Lagarda, M. J., & Barbera , R. (2012). Bioaccessibility of tocopherols, carotenoids, and ascorbic acid from milk- and soy-based fruit beverages: Influence of food matrix and processing. Journal of Agricultural and Food Chemistry, 60(29), 7282–7290. https://doi.org/10.1021/jf301165r
32. Hirazumi, A.Y. 1997. Antitumor Studies of a Traditional Hawaiian Medical Plant, *Morinda citrifolia* (Noni), in Vitro and in Vivo. University of Hawaii, Ph.D. Thesis, Dec.
33. Hirazumi, A., E. Furusawa, S.C. Chow & Y. Hokama. 1994. Anticancer activity of *Morinda citrifolia* (noni) in intraperitoneally implanted Lewis lung carcinoma in syngeneic mice. Proc. West. Pharmacol. Soc. 37: 145–146.

HOW TO CITE: Dr. Suresh V., Dr. Senthilkumar S. K., Jayaseelan K., Aruna devi L., Blessy Bavina V., Chandramouli S., Charumathi E., Deepa R., Exploring the Antimicrobial Mechanism of Morinda citrifolia: An Integrated Phytochemical and Molecular Docking Approach, Int. J. of Pharm. Sci., 2025, Vol 3, Issue 8, 3178-3193. https://doi.org/10.5281/zenodo.17008835