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GC-MS Analysis and Molecular Docking Studies of *Lavandula dentata* Leaves Extract of Taif Region, Saudi Arabia

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ABSTRACT

Background: *Lavandula dentata* is recognized for its therapeutic properties and has been traditionally used in various medicinal applications. Monoamine oxidases (MAOs) are critical for neurotransmitters breaking down; therefore, their inhibitors treat neurodegenerative disorders such as Alzheimer, Parkinson and amyotrophic lateral sclerosis diseases.

Methods: The current study was done to analyze the bioactive compounds present in the methanolic extract of *Lavandula dentata* of Taif region, Saudi Arabia using Gas Chromatography-Mass Spectrometry (GC-MS) analysis. In addition, computational analysis using SwissADME and ProTox-II was used to predict the physicochemical and biological activities and predicted toxicity of four selected components from lavender extract. Moreover, linalool and 7-Methoxy-2-oxo-2H-chromene-3-carboxylic acid were selected for the molecular docking of Monoamine Oxidase A.

Result: GC-MS analysis revealed a diverse array of bioactive compounds, including but not limited to linalool, retinal, chromene-2-one and 7-Methoxy-2-oxo-2H-chromene-3-carboxylic acid, which are known for their pharmacological activities such as antimicrobial, anti-inflammatory and anxiolytic effects. *In silico* analysis has assumed that linalool is safe with a predicted toxicity LD50 2200 mg/kg (Class: 5). The docking affinity score of linalool to Monoamine Oxidase A is -24.4 and appears more stable in the docking site box due to the presence of nine hydrophobic interactions. Collectively this study contributes to the understanding of the chemical profile of *Lavandula dentata* and highlights its suitability for pharmaceutical and therapeutic applications along with exploring the specific bioactivities and potential synergistic effects of these compounds. In particular, linalool emerges as a promising bioactive compound in neurodegenerative disorders therapy through Monoamine oxidase A inhibition.

Key words: GC-MS analysis, *In silico*, *Lavandula dentata*, Linalool, Monoamine oxidase A, Taif.

INTRODUCTION

Lavandula spp. is one of the most cultivated plants worldwide due to its essential oil properties. Several studies have demonstrated its antimicrobial and biological activities (Carrasco *et al*., 2016; de Rapper *et al*., 2016). This genus consists of 39 species, along with approximately 400 registered cultivars and several hybrids (Benabdelkader *et al*., 2011). The major compounds of *Lavandula* and its essential oil are linalool, linalyl acetate and alpha-terpineol (Speranza *et al*., 2023). However, the chemical composition of essential oils from the same plant species varies qualitatively and quantitatively depending on environmental conditions and their processing method (Asekun *et al*., 2007; Singh *et al*., 2008). *Lavandula dentata* L., belonging to the family *Lamiaceae*, is a widespread wild herb that grows in Saudi Arabia as well as in many other countries worldwide (Al-Sarar *et al*., 2014).

Lavandula dentata L. is a medicinal plant commonly used in traditional medicine to treat different diseases (Bouyahya *et al*., 2023). It was reported that *L. dentata* extracts and essential oils can be used as an antioxidant, anticancer, antiparasitic, antidiarrheal, antispasmodic, antihypertensive, antibacterial, antilithiasic, antifungal, anti-inflammatory and in treatment of neurological, gastrointestinal, urinary, genital, musculoskeletal and dermatological diseases (Belhaj *et al*., 2021; Djaballah and Bellaka, 2020; Fouad and Lahcen, 2020; Imen *et al*., 2021; Justus *et al*., 2019a, 2019b; Mohammed *et al*., 2020; Mrabti *et al*., 2019). These biological activities of *L. dentata* could be assigned to their bioactive compounds of flavonoids, tannins, terpenoids and anthracene derivatives (Imen *et al*., 2021).

Spectrometric and chromatographic methods to screen medicinal plants provide fundamental information on their chemical and pharmacological activities. This information is crucial in identifying plants with biological activity (Juszczak *et al*., 2019). Recently, gas chromatography-mass spectrometry (GC-MS) and Fourier-transform infrared (FTIR) have commonly been used for functional groups detection and identification of different bioactive therapeutic

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compounds that are present in medicinal plants (Fan *et al*., 2018; Satapute *et al*., 2019). However, GC-MS analysis represents one of the best, fastest and most accurate techniques for various compounds detection such as alkaloids, nitro compounds, alcohols, long-chain hydrocarbons, steroids, esters, organic acids and amino acids (Razack *et al*., 2015).

Monoamine oxidases (MAOs) are mitochondrial enzymes with two isotypes A and B. Their function is the breakdown of monoamine neurotransmitters including dopamine, adrenaline, serotonin, noradrenaline, β-phenylethylamine, norepinephrine and tyramine. MAO-A has a greater affinity for serotonin and noradrenaline as hydroxylated amines. MAOs overexpression can lead to mitochondrial damage that in turn could lead to a neurotoxic nature, depression, Alzheimer's disease and Parkinson's disease. Blocking MAOs with small molecules has advanced treatment for neuropsychiatric disorders and neurodegenerative diseases. Many MAO inhibitors have been developed since the 1960s, however, MAO inhibitors usage is linked to health improvement, mental/neurological diseases, off-target effects, safety concerns, dietary restrictions and low tyramine intake (Aljanabi *et al*., 2021; Kumar *et al*., 2024; Özdemir *et al*., 2021).

In the present study, we used the GC-MS technique to detect and identify the phytochemical compounds present in lavender leaves methanolic extract that is cultivated in the Taif region of Saudi Arabia. In Silico computational analysis was done using SwissADME and ProTox-II to predict the physicochemical, biological activities and predicted toxicity (lethal dose, LD50) of four select components from the extract of *Lavadula* methanolic extract. In addition, molecular docking was done using linalool and 7-Methoxy-2-oxo-2H-chromene-3-carboxylic acid to Monoamine Oxidase A enzyme.

MATERIALS AND METHODS

The experiment was conducted at Taif University in the summer season of 2023. *Lavandula dentata* L. were freshly collected from Taif region, Saudi Arabia (21°16′30.34″N 40°24′22.16″E). Before use, leaves were rinsed in water, dried away from the sun, collected and ground in an electric grinder to obtain fine powder. The powder was mixed with methanol (200 mL), macerated overnight and then filtered. The marc was macerated in methanol for 1 h and then filtered, this step was repeated twice. Finally, we obtained 600 ml of the collected methanol that was evaporated under vacuum at 40°C to yield 1.289 g of lavender leaves methanolic extract (LE) (Labarbe *et al*., 1999).

Gas chromatography-mass spectroscopy (GC-MS) is an ideal technique for phytoconstituents characterization to predict their structure, name, formula and retention time. RTX-5 MS capillary column (Restek) was used to chemically characterize the 95% methanolic LE with the help of GC-MS-QP2010 Plus system (Shimadzu, Japan) (Siddiqui *et al*., 2015). GC separates the various constituents into their components with their variable retention times and a mass spectrophotometer identifies the components. A chromatogram of relative abundance against retention time was produced by the software, coupled to the mass spectrophotometer.

We have selected the most abundant compounds from the extract to be used further in molecular docking analysis. The 3D conformations of selected compounds (ligands) were downloaded from the PubChem database. The 3D crystal structure of human Amine Oxidase A (receptor protein) with Harmine (actual co-crystallized ligand) (PDB ID: 2z5x with resolution 2.20 Å) was retrieved from RCSB PDB (http://www.rcsb.org/pdb/home/home.do). All water molecules, cofactor (FAD) and ligand (Harmine) were removed from the receptor protein by using PyMOL software.

The free online service SwissADME was used to predict their physicochemical properties, pharmacokinetics, drug-likeness and medicinal chemistry (http://www.swissadme.ch/) (Daina *et al*., 2014; 2017; Daina and Zoete, 2016). The best-docked compounds were selected according to Lipinski's rule of five. Compounds that obey the Lipinski rule are considered ideal drug candidates. Lipinski stated that a compound could display drug-like behaviour if it does not fail more than one of the criteria: molecular weight not more than 500; hydrogen bond donors ≤5 and acceptors ≤10; lipophilicity less than 5 and molar refractivity between 40 and 130 (Lipinski *et al*., 2012).

Predicted toxicities and the Lethal Dose (LD50) predictions of the studied compounds were obtained using a ProTox-II web server (https://tox-new.charite.de/protox_II/) (Banerjee *et al*., 2018). SMINA/Anaconda was used in the molecular docking of selected compounds into the binding pockets of the receptor protein. The re-docking procedure was also applied to validate the accuracy of the docking protocol (Boström *et al*., 2003). Docking validation was done by redocking the co-crystallized ligand (Harmine) to the active site by using the ad4_scoring function. The best-docked conformations have been chosen by comparing the root mean squared deviation (RMSD) values with the actual co-crystallized ligand against the protein (Hevener *et al*., 2009). After docking, all the complex images were analyzed by using the Protein Ligand Interaction Profiler (PLIP, https://plip-tool.biotec.tu-dresden.de/plip-web/plip/index) to identify non-covalent interactions between protein and their ligands and their 2D images (Adasme *et al*., 2021).

RESULTS AND DISCUSSION

Gas Chromatography-Mass Spectrometry (GC-MS) analysis has become a pivotal technique in the identification and characterization of bioactive compounds in various botanical extracts (Adams, 2007). In the current study, *Lavandula dentata* leaves methanolic extract underwent GC-MS analysis to elucidate its chemical composition.

The GC-MS analysis revealed a complex mixture of more than one hundred compounds with different retention time within the methanolic extract of *Lavandula dentata* leaves as displayed in Fig 1 and Table 1-3. One of the

Table 1: GC-MS identified compounds in the methanolic extract of *Lavandula dentate*

RT	Compound Name	Area %	MF	Molecular Formula	Molecular Weight	Cas #	Library
7.75	Cyclopropanetetradecanoic acid, 2-octyl-, methyl ester	1.40	723	C26H50O2	394	52355-42-7	mainlib
7.75	CYCLOPROPANETETRADECANOIC ACID, 2-OCTYL-, METHYL ESTER	1.40	722	C26H50O2	394	52355-42-7	Wiley Registry8e
7.75	l-Gala-l-ido-octose	1.40	721	C8H16O8	240	NA	mainlib
7.75	Oleic Acid	1.40	689	C18H34O2	282	112-80-1	replib
7.75	9-OCTADECENOIC ACID	1.40	689	C18H34O2	282	NA	Wiley Registry8e
12.75	1,6-Pentalenedione, hexahydro-6a-(2-propynyl)-, cis-	1.58	716	C11H12O2	176	92485-87-5	mainlib
12.75	1,6-PENTALENEDIONE, HEXAHYDRO-6A-(2-PROPYNYL)-, CIS-	1.58	716	C11H12O2	176	92485-87-5	Wiley Registry8e
12.75	(5-Oxo-1,3a,4,5,6,6a-hexahydropentalen-1-yl)-acetaldehyde	1.58	695	C10H12O2	164	NA	mainlib
12.75	(5-OXO-1,3A,4,5,6,6A-HEXAHYDRO-1-PENTALENYL)ACETALDEHYDE	1.58	695	C10H12O2	164	NA	Wiley Registry8e
12.75	Tetracyclo[3.3.1.0.1(3,9)]decan-10-one	1.58	724	C10H12O	148	16492-06-1	mainlib
12.86	1,6-Pentalenedione, hexahydro-6a-(2-propynyl)-, cis-	0.46	714	C11H12O2	176	92485-87-5	mainlib
12.86	1,6-PENTALENEDIONE, HEXAHYDRO-6A-(2-PROPYNYL)-, CIS-	0.46	714	C11H12O2	176	92485-87-5	Wiley Registry8e
12.86	Tetracyclo[3.3.1.0.1(3,9)]decan-10-one	0.46	716	C10H12O	148	16492-06-1	mainlib
12.86	TETRACYCLO[3.3.1.0.1(3,9)]DECAN-10-ONE	0.46	716	C10H12O	148	16492-06-1	Wiley Registry8e
12.86	(6-Hydroxymethyl-2,3-dimethylphenyl)methanol	0.46	700	C10H14O2	166	NA	mainlib
14.11	2H-1-BENZOPYRAN-2-ONE	10.64	926	C9H6O2	146	91-64-5	Wiley Registry8e
14.11	2H-1-BENZOPYRAN-2-ONE	10.64	924	C9H6O2	146	91-64-5	Wiley Registry8e
14.11	CHROMEN-2-ONE	10.64	884	C9H6O2	146	NA	Wiley Registry8e
14.11	CHROMEN-2-ONE	10.64	882	C9H6O2	146	91-64-5	Wiley Registry8e
14.11	2H-1-BENZOPYRAN-2-ONE	10.64	907	C9H6O2	146	91-64-5	Wiley Registry8e
18.85	Cyclopenta[1,3]cyclopropa[1,2]cyclohepten-3(3aH)-one, 1,2,3b,6,7,8-hexahydro-6,6-dimethyl-	1.03	755	C13H18O	190	91531-58-7	mainlib
18.85	CYCLOPENTA[1,3]CYCLOPROPA[1,2]CYCLOHEPTEN-3(3AH)-ONE, 1,2,3B,6,7,8-HEXAHYDRO-6,6-DIMETHYL-	1.03	755	C13H18O	190	91531-58-7	Wiley Registry8e
18.85	8-Isopropenyl-1,3,3,7-tetramethyl-bicyclo[5.1.0]oct-5-en-2-one	1.03	744	C15H22O	218	NA	mainlib
18.85	8-ISOPROPENYL-1,3,3,7-TETRAMETHYL-BICYCLO[5.1.0]OCT-5-EN-2-ONE	1.03	744	C15H22O	218	NA	Wiley Registry8e
18.85	Cedran-diol, 8S,13-	1.03	732	C15H26O2	238	88588-48-1	mainlib
18.99	Retinal	0.84	802	C20H28O	284	116-31-4	mainlib
18.99	RETINAL	0.84	802	C20H28O	284	116-31-4	Wiley Registry8e
18.99	Ppropiolic acid, 3-(1-hydroxy-2-isopropyl-5-methylcyclohexyl)-	0.84	741	C13H20O3	224	NA	mainlib
18.99	3-(1-HYDROXY-2-ISOPROPYL-5-METHYLCYCLOHEXYL)-2-PROPYNOIC ACID	0.84	741	C13H20O3	224	NA	Wiley Registry8e
18.99	Spiro[4.5]dec-6-en-8-one, 1,7-dimethyl-4-(1-methylethyl)-	0.84	719	C15H24O	220	39510-36-6	mainlib
19.64	2-Naphthalenemethanol, decahydro-à,à,4a-trimethyl-8-methylene-, [2R-(2à,4aà,8aà)]-	1.67	878	C15H26O	222	473-15-4	replib
19.64	2-NAPHTHALENEMETHANOL, DECAHYDRO-à,à,4A,8-TETRAMETHYL-, DIDEHYDRO DERIV., [2R-(2à,4Aà,8Aà)]-	1.67	802	C15H26O	222	51317-08-9	Wiley Registry8e
19.64	2-NAPHTHALENEMETHANOL, DECAHYDRO-à,à,4A-TRIMETHYL-8-METHYLENE-, [2R-(2à,4Aà,8Aà)]-	1.67	802	C15H26O	222	473-15-4	Wiley Registry8e
19.64	2-NAPHTHALENEMETHANOL, DECAHYDRO-à,à,4A-TRIMETHYL-8-METHYLENE-, [2R-(2à,4Aà,8Aà)]-	1.67	867	C15H26O	222	473-15-4	Wiley Registry8e
19.64	2-Naphthalenemethanol, decahydro-à,à,4a-trimethyl-8-methylene-, [2R-(2à,4aà,8aà)]-	1.67	810	C15H26O	222	473-15-4	mainlib
20.16	2-CYCLOHEXEN-1-ONE, 2,4,4-TRIMETHYL-3-(3-OXO-1-BUTENYL)-	1.20	821	C13H18O2	206	27185-77-9	Wiley Registry8e
20.16	4-(2-ACETYL-5,5-DIMETHYL-2-CYCLOPENTEN-1-YLIDENE)-2-BUTANONE	1.20	742	C13H18O2	206	NA	Wiley Registry8e
20.16	4-(2-ACETYL-5,5-DIMETHYL-2-CYCLOPENTEN-1-YLIDENE)-2-BUTANONE	1.20	742	C13H18O2	206	NA	Wiley Registry8e
20.16	4-(2-Acetyl-5,5-dimethylcyclopent-2-enylidene)butan-2-one	1.20	740	C13H18O2	206	NA	mainlib
20.16	ETHYL 3-(1-HYDROXY-2-ISOPROPYL-5-METHYLCYCLOHEXYL)-2-PROPYN	1.20	732	C15H24O3	252	NA	Wiley Registry8e
20.79	1-Methyl-1-(o-methylphenyl)-1-silacyclobutane	1.37	797	C11H16Si	176	NA	mainlib
20.79	1,6-Pentalenedione, hexahydro-6a-(2-propynyl)-, cis-	1.37	694	C11H12O2	176	92485-87-5	mainlib
20.79	1,6-PENTALENEDIONE, HEXAHYDRO-6A-(2-PROPYNYL)-, CIS-	1.37	694	C11H12O2	176	92485-87-5	Wiley Registry8e
20.79	1-HEXENE, 2-(O-ANISYL)-4-METHYL-	1.37	694	C14H20O	204	NA	Wiley Registry8e
20.79	2H-1-Benzopyran-2-one, 7-methoxy-	1.37	881	C10H8O3	176	531-59-9	replib
20.86	1-Methyl-1-(o-methylphenyl)-1-silacyclobutane	0.47	791	C11H16Si	176	NA	mainlib
20.86	2H-1-Benzopyran-2-one, 8-methoxy-	0.47	740	C10H8O3	176	2445-8-3	mainlib
20.86	2H-1-BENZOPYRAN-2-ONE, 8-METHOXY-	0.47	740	C10H8O3	176	2445-81-0	Wiley Registry8e
20.86	Cumarin-3-carboxylic acid, 7-methoxy-	0.47	713	C11H8O5	220	20300-59-8	mainlib

Table 2: GC-MS identified compounds in the methanolic extract of *Lavandula dentate*

RT	Compound Name	Area %	MF	Molecular Formula	Molecular Weight	Cas #	Library
20.98	2H-1-Benzopyran-2-one, 8-methoxy-	0.77	738	C10H8O3	176	2445-81-0	mainlib
20.98	2H-1-BENZOPYRAN-2-ONE, 8-METHOXY-	0.77	738	C10H8O3	176	2445-81-0	Wiley Registry8e
20.98	1,6-Pentalenedione, hexahydro-6a-(2-propynyl)-, cis-	0.77	689	C11H12O2	176	92485-87-5	mainlib
20.98	1,6-PENTALENEDIONE, HEXAHYDRO-6A-(2-PROPYNYL)-, CIS-	0.77	689	C11H12O2	176	92485-87-5	Wiley Registry8e
20.98	N'-(2-HYDROXY-3-ALLYLBENZYLIDENE)-2-BENZAMIDOPROPANHYDRAZIDE	0.77	685	C20H21N3O3	351	NA	Wiley Registry8e
21.15	5-BENZOFURANACETIC ACID, 6-ETHENYL-2,4,5,6,7,7A-HEXAHYDRO-3,6-DIMETHYL-à-METHYLENE-2-OXO-, METHYL ESTER	0.78	730	C16H20O4	276	19892-19-4	Wiley Registry8e
21.15	1H-INDOL-5-OL, 3-(2-AMINOETHYL)-	0.78	741	C10H12N2O	176	50-67-9	Wiley Registry8e
21.15	Aromadendrene oxide-(2)	0.78	728	C15H24O	220	NA	mainlib
21.15	AROMADENDRENOXID-(2)	0.78	728	C15H24O	220	NA	Wiley Registry8e
21.15	ALLOAROMADENDRENOXID-(1)	0.78	722	C15H24O	220	85710-39-0	Wiley Registry8e
22.64	3à,4à,9à,11-Diepoxymuurolan-10-ol	0.65	739	C15H24O3	252	NA	mainlib
22.64	ALLOAROMADENDRENOXID-(1)	0.65	727	C15H24O	220	NA	Wiley Registry8e
22.64	Alloaromadendrene oxide-(1)	0.65	726	C15H24O	220	NA	mainlib
22.64	2,3-Dehydro-4-oxo-à-ionol	0.65	745	C13H18O2	206	NA	mainlib
22.64	Curcumenol	0.65	674	C15H22O2	234	19431-84-6	mainlib
23.37	ETHANOL, 2-(9-OCTADECENYLOXY)-, (Z)-	3.51	800	C20H40O2	312	5353-25-3	Wiley Registry8e
23.37	Ethanol, 2-(9-octadecenyloxy)-, (Z)-	3.51	798	C20H40O2	312	5353-25-3	mainlib
23.37	13-Heptadecyn-1-ol	3.51	784	C17H32O	252	56554-77-9	mainlib
23.37	13-HEPTADECYN-1-OL	3.51	784	C17H32O	252	56554-77-9	Wiley Registry8e
23.37	Octadecanal	3.51	880	C18H36O	268	638-66-4	mainlib
24.03	1-Heptatriacotanol	0.44	795	C37H76O	536	105794-58-9	mainlib
24.03	Spiro[4.5]decan-7-one, 1,8-dimethyl-8,9-epoxy-4-isopropyl-	0.44	774	C15H24O2	236	61050-91-7	mainlib
24.03	SPIRO[4.5]DECAN7-ONE, 1,8-DIMETHYL-8,9-EPOXY-4-ISOPROPYL-	0.44	774	C15H24O2	236	NA	Wiley Registry8e
24.03	SPIRO[7H-CYCLOHEPTA[B]FURAN-7,2'(5'H)-FURAN]-2,5'(3H)-DIONE, OCTAHYDRO-8-HYDROXY-6,8-DIMETHYL-3-METHYLENE-, [3AS-(3Aà,6à,7à,8à,8Aà)]-	0.44	767	C15H20O5	280	3533-47-9	Wiley Registry8e
24.03	2-[5-(2,2-Dimethyl-6-methylene-cyclohexyl)-3-methyl-pent-2-enyl]-[1,4]benzoquinone	0.44	734	C21H28O2	312	NA	mainlib
24.18	Cholestan-3-ol, 2-methylene-, (3à,5à)-	2.42	821	C28H48O	400	22599-96-8	mainlib
24.18	CHOLESTAN-3-OL, 2-METHYLENE-, (3à,5à)-	2.42	820	C28H48O	400	22599-96-8	Wiley Registry8e
24.18	Ethanol, 2-(9-octadecenyloxy)-, (Z)-	2.42	781	C20H40O2	312	5353-25-3	mainlib
24.18	ETHANOL, 2-(9-OCTADECENYLOXY)-, (Z)-	2.42	781	C20H40O2	312	5353-25-3	Wiley Registry8e
24.18	17-Octadecynoic acid	2.42	782	C18H32O2	280	34450-18-5	mainlib
24.35	Picrotoxin	0.50	780	C15H16O6	292	124-87-8	mainlib
24.35	[1,1'-BICYCLOPROPYL]-2-OCTANOIC ACID, 2'-HEXYL-, METHYL ESTER	0.50	789	C21H38O2	322	56687-68-4	Wiley Registry8e
24.35	[1,1'-Bicyclopropyl]-2-octanoic acid, 2'-hexyl-, methyl ester	0.50	790	C21H38O2	322	56687-68-4	mainlib
24.35	E,E,Z-1,3,12-Nonadecatriene-5,14-diol	0.50	727	C19H34O2	294	NA	mainlib
24.35	cis-Z-à-Bisabolene epoxide	0.50	744	C15H24O	220	NA	mainlib
24.66	13-Heptadecyn-1-ol	0.59	771	C17H32O	252	56554-77-9	mainlib
24.66	13-HEPTADECYN-1-OL	0.59	771	C17H32O	252	56554-77-9	Wiley Registry8e
24.66	Tricyclo[20.8.0.0(7,16)]triacontane, 1(22),7(16)-diepoxy-	0.59	756	C30H52O2	444	NA	mainlib
24.66	TRICYCLO[20.8.0.0E7,16]TRIACONTAN, 1(22),7(16)-DIEPOXY-	0.59	756	C30H52O2	444	NA	Wiley Registry8e
24.66	E,E,Z-1,3,12-Nonadecatriene-5,14-diol	0.59	736	C19H34O2	294	NA	mainlib
25.01	1-Heptatriacotanol	0.71	792	C37H76O	536	105794-58-9	mainlib
25.01	Cholestan-3-ol, 2-methylene-, (3à,5à)-	0.71	830	C28H48O	400	22599-96-8	mainlib
25.01	CHOLESTAN-3-OL, 2-METHYLENE-, (3à,5à)-	0.71	829	C28H48O	400	22599-96-8	Wiley Registry8e
25.01	13-Heptadecyn-1-ol	0.71	772	C17H32O	252	56554-77-9	mainlib
25.01	13-HEPTADECYN-1-OL	0.71	770	C17H32O	252	56554-77-9	Wiley Registry8e
25.10	1,25-Dihydroxyvitamin D3, TMS derivative	0.47	782	C30H52O3Si	488	55759-94-9	mainlib
25.10	9,10-SECOCHOLESTA-5,7,10(19)-TRIENE-1,3-DIOL, 25-[(TRIMETHYLSILYL)OXY]-, (3à,5Z,7E)-	0.47	782	C30H52O3Si	488	55759-94-9	Wiley Registry8e
25.10	2-ACETYL-3-(2-CINNAMIDO)ETHYL-7-METHOXYINDOLE	0.47	768	C22H22N2O3	362	NA	Wiley Registry8e
25.10	TRIDEUTERIOMETHYL 10-EPOXY-7-ETHYL-3,11-DIMETHYLTRIDECA-2,6-DIENOATE	0.47	759	C18H27D3O3	297	56805-11-9	Wiley Registry8e
25.10	9-OCTADECENOIC ACID (Z)-	0.47	734	C18H34O2	282	112-80-1	Wiley Registry8e
25.64	PENTADECANOIC ACID, 14-METHYL-, METHYL ESTER	1.38	730	C17H34O2	270	5129-60-2	Wiley Registry8e
25.64	Oxiraneundecanoic acid, 3-pentyl-, methyl ester, cis-	1.38	725	C19H36O3	312	38520-30-8	mainlib
25.64	OXIRANEUNDECANOIC ACID, 3-PENTYL-, METHYL ESTER, CIS-	1.38	725	C19H36O3	312	38520-30-8	Wiley Registry8e
25.64	OXIRANEUNDECANOIC ACID, 3-PENTYL-, METHYL ESTER, TRANS-	1.38	723	C19H36O3	312	38520-31-9	Wiley Registry8e
25.64	Oxiraneundecanoic acid, 3-pentyl-, methyl ester, trans-	1.38	723	C19H36O3	312	38520-31-9	mainlib
26.50	HEXADECANOIC ACID, 2,3-DIHYDROXYPROPYL ESTER	3.34	784	C19H38O4	330	542-44-9	Wiley Registry8e
26.50	PENTADECANOIC ACID	3.34	778	C15H30O2	242	1002-84-2	Wiley Registry8e

Table 3: GC-MS identified compounds in the methanolic extract of *Lavandula dentate*

RT	Compound Name	Area %	MF	Molecular Formula	Molecular Weight	Cas #	Library
26.50	Oleic Acid	3.34	810	C18H34O2	282	112-80-1	replib
26.50	9-OCTADECENOIC ACID	3.34	810	C18H34O2	282	NA	Wiley Registry 8e
26.50	HEXADECANOIC ACID	3.34	798	C16H32O2	256	57-10-3	Wiley Registry 8e
27.37	Z-(13,14-Epoxy)tetradec-11-en-1-ol acetate	1.04	784	C16H28O3	268	NA	mainlib
27.37	01297107001 TETRANEURIN - A - DIOL	1.04	765	C15H20O5	280	NA	Wiley Registry 8e
27.37	13-HEPTADECYN-1-OL	1.04	774	C17H32O	252	56554-77-9	Wiley Registry 8e
27.37	13-Heptadecyn-1-ol	1.04	774	C17H32O	252	56554-77-9	mainlib
27.37	1-Heptatriacotanol	1.04	764	C37H76O	536	105794-58-9	mainlib
28.65	7,10-Octadecadienoic acid, methyl ester	2.48	859	C19H34O2	294	56554-24-6	mainlib
28.65	7,10-OCTADECADIENOIC ACID, METHYL ESTER	2.48	858	C19H34O2	294	56554-24-6	Wiley Registry 8e
28.65	9,12-OCTADECADIENOIC ACID, METHYL ESTER, (E,E)-	2.48	836	C19H34O2	294	2566-97-4	Wiley Registry 8e
28.65	9,12-Octadecadienoic acid, methyl ester, (E,E)-	2.48	835	C19H34O2	294	2566-97-4	mainlib
28.65	9,12-OCTADECADIENOIC ACID (Z,Z)-, METHYL ESTER	2.48	830	C19H34O2	294	112-63-0	Wiley Registry 8e
28.83	11-Octadecenoic acid, methyl ester	3.25	849	C19H36O2	296	52380-33-3	replib
28.83	9-Octadecenoic acid, methyl ester, (E)-	3.25	846	C19H36O2	296	1937-62-8	replib
28.83	METHYL 9,9-DIDEUTERO-OCTADECANOATE	3.25	838	C19H36D2O2	300	19905-64-7	Wiley Registry 8e
28.95	Oleic Acid	1.03	794	C18H34O2	282	112-80-1	replib
28.95	2-HYDROXY-3-[(9E)-9-OCTADECENOYLOXY]PROPYL (9E)-9-OCTADECENOATE #	1.03	779	C39H72O5	620	2465-32-9	Wiley Registry 8e
28.95	trans-13-Octadecenoic acid	1.03	791	C18H34O2	282	693-71-0	mainlib
28.95	cis-Vaccenic acid	1.03	785	C18H34O2	282	506-17-2	mainlib
28.95	Linoleic acid ethyl ester	1.03	768	C20H36O2	308	544-35-4	replib
29.17	Cholestan-3-ol, 2-methylene-, (3à,5à)-	1.18	849	C28H48O	400	22599-96-8	mainlib
29.17	CHOLESTAN-3-OL, 2-METHYLENE-, (3à,5à)-	1.18	848	C28H48O	400	22599-96-8	Wiley Registry 8e
29.17	E,E,Z-1,3,12-Nonadecatriene-5,14-diol	1.18	768	C19H34O2	294	NA	mainlib
29.17	Ethanol, 2-(9-octadecenyloxy)-, (Z)-	1.18	756	C20H40O2	312	5353-25-3	mainlib
29.17	Linoleic acid ethyl ester	1.18	754	C20H36O2	308	544-35-4	replib
29.62	9-OCTADECENOIC ACID (Z)-	11.17	860	C18H34O2	282	112-80-1	Wiley Registry 8e
29.62	9,12-Octadecadienoyl chloride, (Z,Z)-	11.17	857	C18H31ClO	298	7459-33-8	replib
29.62	(9E,12E)-9,12-OCTADECADIENOYL CHLORIDE #	11.17	857	C18H31ClO	298	7459-33-8	Wiley Registry 8e
29.62	9,12-Octadecadienoic acid (Z,Z)-	11.17	848	C18H32O2	280	60-33-3	replib
29.62	9,12-OCTADECADIENOIC ACID (Z,Z)-	11.17	848	C18H32O2	280	60-33-3	Wiley Registry 8e
32.86	[1,1'-Bicyclopropyl]-2-octanoic acid, 2'-hexyl-, methyl ester	0.76	840	C21H38O2	322	56687-68-4	mainlib
32.86	[1,1'-BICYCLOPROPYL]-2-OCTANOIC ACID, 2'-HEXYL-, METHYL ESTER	0.76	836	C21H38O2	322	56687-68-4	Wiley Registry 8e
32.86	Cholestan-3-ol, 2-methylene-, (3à,5à)-	0.76	830	C28H48O	400	22599-96-8	mainlib
32.86	CHOLESTAN-3-OL, 2-METHYLENE-, (3à,5à)-	0.76	829	C28H48O	400	22599-96-8	Wiley Registry 8e
32.86	Z-(13,14-Epoxy)tetradec-11-en-1-ol acetate	0.76	774	C16H28O3	268	NA	mainlib
33.13	Linoleic acid ethyl ester	0.39	783	C20H36O2	308	544-35-4	replib
33.13	E,E,Z-1,3,12-Nonadecatriene-5,14-diol	0.39	790	C19H34O2	294	NA	mainlib
33.13	Z,Z-3,15-Octadecadien-1-ol acetate	0.39	791	C20H36O2	308	NA	mainlib
33.13	Tricyclo[20.8.0.0(7,16)]triacontane, 1(22),7(16)-diepoxy-	0.39	810	C30H52O2	444	NA	mainlib
33.13	TRICYCLO[20.8.0.0E7,16]TRIACONTAN, 1(22),7(16)-DIEPOXY-	0.39	810	C30H52O2	444	NA	Wiley Registry 8e
33.28	9-Octadecenoic acid (Z)-, 2-hydroxy-1-(hydroxymethyl)ethyl ester	0.59	823	C21H40O4	356	3443-84-3	mainlib
33.28	9-OCTADECENOIC ACID (Z)-, 2-HYDROXY-1-(HYDROXYMETHYL)ETHYL ESTER	0.59	820	C21H40O4	356	3443-84-3	Wiley Registry 8e
33.28	Oleic Acid	0.59	789	C18H34O2	282	112-80-1	replib
33.28	trans-9-Octadecenoic acid, pentyl ester	0.59	802	C23H44O2	352	NA	mainlib
33.28	9-Octadecenoic acid, 1,2,3-propanetriyl ester, (E,E,E)-	0.59	778	C57H104O6	884	537-39-3	mainlib
35.83	ISOCHIAPIN B	2.31	736	C19H22O6	346	NA	Wiley Registry 8e
35.83	ISOCHIAPIN B %2<	2.31	736	C19H26O6	350	NA	Wiley Registry 8e
35.83	3',8,8'-Trimethoxy-3-piperidyl-2,2'-binaphthalene-1,1',4,4'-tetrone	2.31	759	C28H25NO7	487	127611-84-1	mainlib
35.83	4H-1-BENZOPYRAN-4-ONE, 2-(3,4-DIHYDROXYPHENYL)-6,8-DI-à-D-GLUCOPYRANOSYL-5,7-DIHYDROXY-	2.31	716	C27H30O16	610	29428-58-8	Wiley Registry 8e
35.83	1,2-BENZENEDICARBOXYLIC ACID	2.31	757	C24H38O4	390	117-81-7	Wiley Registry 8e
38.80	ISOCHIAPIN B	0.82	782	C19H22O6	346	NA	Wiley Registry 8e
38.80	ISOCHIAPIN B %2<	0.82	782	C19H26O6	350	NA	Wiley Registry 8e
38.80	DOTRIACONTANE	0.82	790	C32H66	450	544-85-4	Wiley Registry 8e
38.80	4H-1-BENZOPYRAN-4-ONE, 2-(3,4-DIMETHOXYPHENYL)-3,5-DIHYDROXY-7-METHOXY-	0.82	758	C18H16O7	344	6068-80-0	Wiley Registry 8e
38.80	1,25-Dihydroxyvitamin D3, TMS derivative	0.82	804	C30H52O3Si	488	55759-94-9	mainlib
39.83	ISOCHIAPIN B	1.08	799	C19H22O6	346	NA	Wiley Registry 8e
39.83	ISOCHIAPIN B %2<	1.08	799	C19H26O6	350	NA	Wiley Registry 8e
39.83	DOTRIACONTANE	1.08	800	C32H66	450	544-85-4	Wiley Registry 8e
39.83	4H-1-BENZOPYRAN-4-ONE, 2-(3,4-DIHYDROXYPHENYL)-6,8-DI-à-D-GLUCOPYRANOSYL-5,7-DIHYDROXY-	1.08	760	C27H30O16	610	29428-58-8	Wiley Registry 8e
40.50	ETHYL ISO-ALLOCHOLATE	0.87	767	C26H44O5	436	NA	Wiley Registry 8e
40.50	Ethyl iso-allocholate	0.87	769	C26H44O5	436	NA	mainlib
40.50	1-Heptatriacotanol	0.87	799	C37H76O	536	105794-58-9	mainlib
40.50	01297107001 TETRANEURIN - A - DIOL	0.87	794	C15H20O5	280	NA	Wiley Registry 8e
40.50	2-HYDROXY-3-[(9E)-9-OCTADECENOYLOXY]PROPYL (9E)-9-OCTADECENOATE #	0.87	733	C39H72O5	620	2465-32-9	Wiley Registry 8e
41.03	ISOCHIAPIN B	1.28	778	C19H22O6	346	NA	Wiley Registry 8e
41.03	ISOCHIAPIN B %2<	1.28	778	C19H26O6	350	NA	Wiley Registry 8e
41.03	Ethyl iso-allocholate	1.28	770	C26H44O5	436	NA	mainlib
41.03	ETHYL ISO-ALLOCHOLATE	1.28	770	C26H44O5	436	NA	Wiley Registry 8e
41.03	1-Heptatriacotanol	1.28	808	C37H76O	536	105794-58-9	mainlib
41.73	ISOCHIAPIN B	2.39	791	C19H22O6	346	NA	Wiley Registry 8e
41.73	ISOCHIAPIN B %2<	2.39	791	C19H26O6	350	NA	Wiley Registry 8e
41.73	DOTRIACONTANE	2.39	800	C32H66	450	544-85-4	Wiley Registry 8e
41.73	4H-1-BENZOPYRAN-4-ONE, 2-(3,4-DIMETHOXYPHENYL)-3,5-DIHYDROXY-7-METHOXY-	2.39	772	C18H16O7	344	6068-80-0	Wiley Registry 8e
41.73	4H-1-BENZOPYRAN-4-ONE, 2-(3,4-DIHYDROXYPHENYL)-6,8-DI-à-D-GLUCOPYRANOSYL-5,7-DIHYDROXY-	2.39	735	C27H30O16	610	29428-58-8	Wiley Registry 8e
42.19	1-Heptatriacotanol	0.85	805	C37H76O	536	105794-58-9	mainlib
42.19	Betulin	0.85	721	C30H50O2	442	473-98-3	replib
42.19	03027205002 FLAVONE 4'-OH,5-OH,7-DI-O-GLUCOSIDE	0.85	718	C27H30O15	594	NA	Wiley Registry 8e
42.19	LUP-20(29)-ENE-3,28-DIOL, (3à)-	0.85	776	C30H50O2	442	473-98-3	Wiley Registry 8e
42.19	7,10,13-Eicosatrienoic acid, methyl ester	0.85	733	C21H36O2	320	30223-51-9	replib
42.32	1-Heptatriacotanol	0.71	811	C37H76O	536	105794-58-9	mainlib
42.32	STIGMAST-5-EN-3-OL, (3à,24S)-	0.71	738	C29H50O	414	83-47-6	Wiley Registry 8e
42.32	Tricyclo[20.8.0.0(7,16)]triacontane, 1(22),7(16)-diepoxy-	0.71	792	C30H52O2	444	NA	mainlib
42.32	TRICYCLO[20.8.0.0E7,16]TRIACONTAN, 1(22),7(16)-DIEPOXY-	0.71	792	C30H52O2	444	NA	Wiley Registry 8e
42.32	7,10,13-Eicosatrienoic acid, methyl ester	0.71	732	C21H36O2	320	30223-51-9	replib
42.56	1-Heptatriacotanol	1.08	801	C37H76O	536	105794-58-9	mainlib
42.56	STIGMAST-5-EN-3-OL, (3à,24S)-	1.08	757	C29H50O	414	83-47-6	Wiley Registry 8e
42.56	9,12-OCTADECADIENOIC ACID (Z,Z)-, 2,3-BIS[(TRIMETHYLSILYL)OXY]PROPYL ESTER	1.08	757	C27H54O4Si2	498	54284-45-6	Wiley Registry 8e
42.56	Ursodeoxycholic acid	1.08	725	C24H40O4	392	128-13-2	mainlib
42.56	03027205002 FLAVONE 4'-OH,5-OH,7-DI-O-GLUCOSIDE	1.08	708	C27H30O15	594	NA	Wiley Registry 8e
42.97	Ethyl iso-allocholate	1.31	764	C26H44O5	436	NA	mainlib
42.97	ETHYL ISO-ALLOCHOLATE	1.31	764	C26H44O5	436	NA	Wiley Registry 8e
42.97	1-Heptatriacotanol	1.31	791	C37H76O	536	105794-58-9	mainlib
42.97	01297107001 TETRANEURIN - A - DIOL	1.31	782	C15H20O5	280	NA	Wiley Registry 8e
42.97	Tricyclo[20.8.0.0(7,16)]triacontane, 1(22),7(16)-diepoxy-	1.31	780	C30H52O2	444	NA	mainlib
43.07	Ethyl iso-allocholate	1.31	779	C26H44O5	436	NA	mainlib
43.07	ETHYL ISO-ALLOCHOLATE	1.31	779	C26H44O5	436	NA	Wiley Registry 8e
43.07	1-Heptatriacotanol	1.31	800	C37H76O	536	105794-58-9	mainlib
43.07	01297107001 TETRANEURIN - A - DIOL	1.31	790	C15H20O5	280	NA	Wiley Registry 8e
43.07	03027205002 FLAVONE 4'-OH,5-OH,7-DI-O-GLUCOSIDE	1.31	720	C27H30O15	594	NA	Wiley Registry 8e
45.05	Betulinaldehyde	15.13	808	C30H48O2	440	13159-28-9	mainlib
45.05	Betulin	15.13	783	C30H50O2	442	473-98-3	replib
45.05	Lupeol	15.13	804	C30H50O	426	545-47-1	replib
45.05	Propanoic acid, 2-methyl-, (dodecahydro-6a-hydroxy-9a-methyl-3-methylene-2,9-dioxoazuleno[4,5-b]furan-6-yl)methyl ester, [3aS-(3aà,6à,6aà,9aà,9bà)]-	15.13	757	C19H26O6	350	33649-17-1	mainlib
45.05	PROPANOIC ACID, 2-METHYL-, (DECAHYDRO-6A-HYDROXY-9	15.13	757	C19H26O6	350	33649-17-1	Wiley Registry 8e

major constituents identified was linalool, which is consistent with previous studies on *Lavandula* species (Bilia *et al*., 2014). Linalool has been extensively studied for its pharmacological properties, including its antimicrobial (Faleiro *et al*., 2003) and anxiolytic effects (Linck *et al*., 2009).

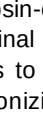
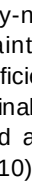
Moreover, the presence of Chromen-2-one was detected in the *Lavandula dentata* extract. Chromenes, also known as chromanones or chromones, represent an important class of heterocyclic compounds with diverse biological activities (Zhang *et al*., 2016). These compounds are characterized by their structural motif comprising a benzene ring fused to a cyclic ether ring. Chromenes exhibit a wide range of pharmacological properties, making them valuable targets for drug discovery and development. For instance, several studies have highlighted the anticancer potential of chromenes due to their ability to inhibit various cancer cell proliferation pathways (Zhou *et al*., 2019).

Additionally, chromenes have been reported to possess antioxidant properties, which can play a crucial role in combating oxidative stress-related diseases such as cardiovascular disorders and neurodegenerative conditions (Zhang *et al*., 2016). Furthermore, chromenes have attracted significant attention in the field of medicinal chemistry owing to their diverse biological activities. Research efforts have focused on synthesizing novel chromene derivatives with enhanced pharmacological profiles (Xu *et al*., 2020). These derivatives often undergo structural modifications to optimize their drug-like properties, such as improving solubility, bioavailability and target specificity.

Additionally, retinal was identified in the *Lavandula dentata* leaves extract. Retinal, a derivative of vitamin A, plays a crucial role in vision by serving as the light-absorbing chromophore in visual pigments (Palczewski, 2006). It is a vital component of the visual cycle, where it undergoes photoisomerization upon absorbing light to initiate signal transduction in photoreceptor cells. In addition to its role in vision, retinal also participates in non-visual processes, including the regulation of circadian rhythms (Buhr *et al*., 2015). Melanopsin-containing retinal ganglion cells in the retina utilize retinal as a chromophore to detect light and transmit signals to the brain's suprachiasmatic nucleus, thereby synchronizing the body's internal clock with the day-night cycle. Furthermore, retinal is essential for maintaining the health and integrity of retinal tissue. Deficiencies in retinal metabolism or transport can lead to retinal degenerative diseases such as retinitis pigmentosa and age-related macular degeneration (Sparrow *et al*., 2010). Understanding the biochemical pathways involving retinal metabolism is crucial for developing therapeutic interventions to treat these blinding disorders.

Furthermore, the GC-MS analysis detected the presence of Cumarin-3-carboxylic acid, 7-methoxy. Cumarin-3-carboxylic acid, 7-methoxy, also known as methoxycoumarin or 7-methoxycoumarin, is a derivative of

Table 4: Physicochemical properties of selected compounds of LE.

Molecule	Molecule 2D structure	Radar chart	MW	Number of heavy atoms	Number of aromatic heavy atoms	Fraction Csp3	Number of rotatable bonds	Number of H-bond acceptors	Number of H-bond donors	MR	TPSA (topological polar surface area)
Linalool			154.25	11	0	0.6	4	1	1	50.44	20.23
Retinal			284.44	21	0	0.45	5	1	0	93.71	17.07
chromene-2-one			146.14	11	10	0	0	2	0	42.48	30.21
7-Methoxy-2-oxo -2H-chromene-3-carboxylic acid			220.18	16	10	0.09	2	5	1	55.94	76.74

MW: Molecular weight; MR: Molecular refractivity.

coumarin with a methoxy substituent at the 7-position of the aromatic ring. This compound belongs to the broader class of coumarin derivatives and has garnered attention for its potential pharmacological activities and diverse applications in medicinal chemistry. Studies have indicated that Cumarin-3-carboxylic acid, 7-methoxy, possesses

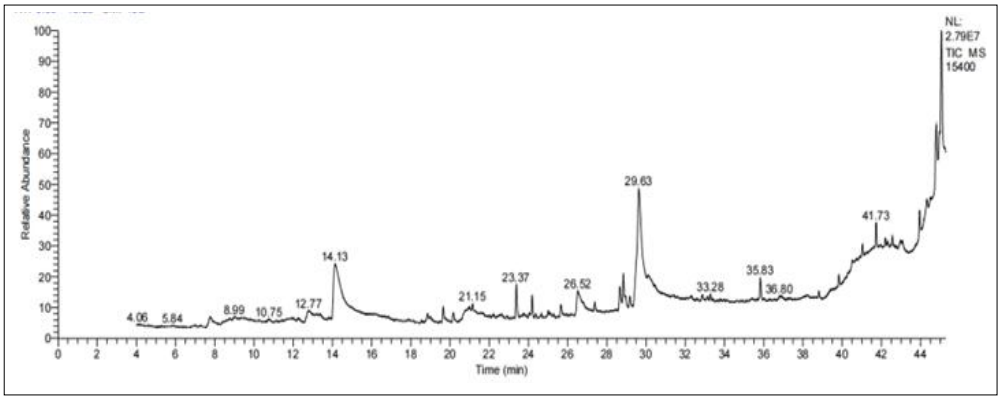


Fig 1: Chromatogram of methanolic extract of *Lavandula dentata.*

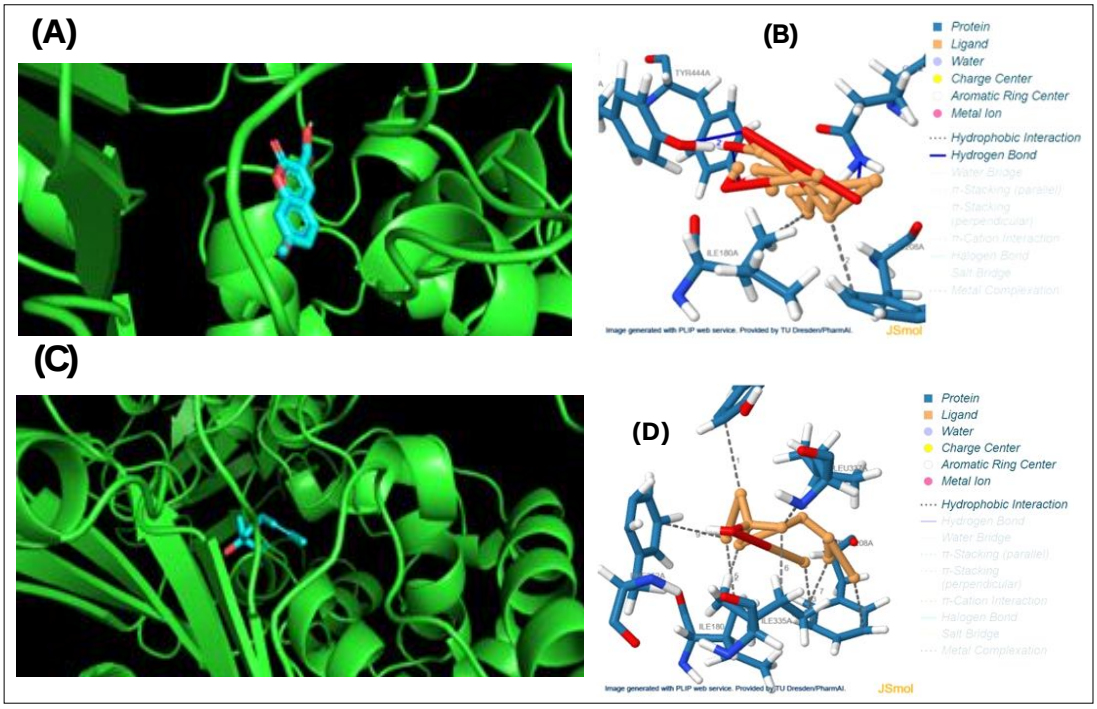


Fig 2: 7-Methoxy-2-oxo-2H-chromene-3-carboxylic acid (A, using PyMOL and B, using PLIP) and linalool (C, using PyMOL and D, using PLIP) docking Monoamine oxidase a showing the interactions.

Table 5: Lipophilicity of selected compounds of LE.

Molecule	Log *Po/w* (iLogP)	XLogP3	WLogP	MLogP	Silicos-IT Log P	Consensus Log P
Linalool	2.7	2.97	2.67	2.59	2.35	2.66
Retinal	-	-	5.72	-	-	-
chromene-2-one	1.75	1.39	1.79	1.65	2.5	1.82
7-Methoxy-2-oxo-2H-chromene -3-carboxylic acid	1.42	2.17	1.5	0.95	1.81	1.57

(-) means unknown data.

Table 6: Water Solubility of selected compounds of LE.

Molecule	Log S (ESOL)	Solubility (ESOL) (mg/ml)	Solubility (ESOL) (mol/l)	ESOL class	Log S (Ali)	Solubility (Ali) (mg/ml)	Solubility (Ali) (mol/l)	Ali class	Log S (Silicos-IT)	Solubility (Silicos-IT) (mg/ml)	Silicos-IT solubility (mol/l)	Silicos-IT class
Linalool	-2.4	6.09e-01	3.95e-03	Soluble	-3.06	1.35e-01	8.75e-04	Soluble	-1.84	2.20e+00	1.43e-02	Soluble
Retinal	-	-	-	-	-	-	-	-	-	-	-	-
chromene-2-one	-2.29	7.42E-01	5.08E-03	Soluble	-1.63	3.44E+00	2.35E-02	Very soluble	-3.59	3.77E-02	2.58E-04	Soluble
7-Methoxy-2-oxo-2H-chromene-3-carboxylic acid	-2.9	2.75E-01	1.25E-03	Soluble	-3.41	8.48E-02	3.85E-04	Soluble	-3.12	1.67E-01	7.59E-04	Soluble

(-) means unknown data.

Table 7: Pharmacokinetics, drug-likeness and medicinal chemistry of selected compounds of LE.

Molecule	Gastrointestinal (GI) absorption	Blood-brain barrier (BBB) permeant	Log Kp (cm/s)	Lipinski violations number	Bioavailability score	PAINS alerts	Brenk alerts	Leadlikeness violations	Synthetic accessibility
Linalool	High	Yes	-5.13	0	0.55	0	1	1	2.74
Retinal	-	Yes	-	-	-	0	0	-	-
chromene-2-one	High	Yes	-6.2	0	0.55	0	1	1	2.74
7-Methoxy-2-oxo-2H-chromene -3-carboxylic acid	High	No	-6.1	0	0.56	0	1	1	2.57

(-) means unknown data; PAINS, pan-assay interference compounds.

notable biological properties, including antioxidant and anti-inflammatory effects. These properties make it a promising candidate for the development of therapeutic agents targeting oxidative stress-related diseases and inflammatory conditions (Borges *et al*., 2016). The presence of the methoxy group at the 7-position may contribute to its antioxidant activity by enhancing its ability to scavenge free radicals and mitigate oxidative damage. Moreover, Cumarin-3-carboxylic acid, 7-methoxy has been investigated for its potential anticancer properties. Research suggests that certain methoxycoumarin derivatives exhibit cytotoxic effects against cancer cells and may hold promise as anticancer agents through mechanisms such as induction of apoptosis and inhibition of proliferation (Yang *et al*., 2015). The structural modification of coumarin to incorporate a methoxy group at the 7-position could influence its interactions with cellular targets involved in cancer progression, thereby enhancing its therapeutic efficacy. Furthermore, methoxycoumarin derivatives have been explored for their antimicrobial activities. Studies have demonstrated the antibacterial and antifungal properties of certain methoxycoumarin derivatives, indicating their potential as antimicrobial agents for combating infectious diseases (Lee *et al*., 2019). The presence of the methoxy group may contribute to the compound's ability to disrupt microbial cell membranes or interfere with essential metabolic processes, thereby exerting antimicrobial effects.

Four phytocompounds (linalool, retinal, chromene-2-one and 7-Methoxy-2-oxo-2H-chromene-3-carboxylic acid) were analyzed for Amine Oxidase A docking studies. Their physicochemical properties, pharmacokinetics, drug-likeness and medicinal chemistry are found in Tables 4-7. Retinal was excluded according to missing calculated parameters. Linalool, chromene-2-one and 7-Methoxy-2-oxo-2H-chromene-3-carboxylic acid met Lipinski's conditions, which is considered to predict optimal drug-like character. They reported no Lipinski's violations that suggested these are orally bioavailable drugs. It is reported that selected compounds have low lipophilicity, good gastrointestinal absorption and blood-brain barrier permeability (except for 7-Methoxy-2-oxo-2H-chromene-3-carboxylic acid) and bioavailability (Daina *et al*., 2014).

In ProTox-II, linalool and 7-Methoxy-2-oxo-2H-chromene-3-carboxylic acid are assumed to be non-toxic

Table 8: Interactions of 7-Methoxy-2-oxo-2H-chromene-3-carboxylic acid and amine oxidase A docking site.

Hydrophobic interactions									
Index	Residue	Amino acid	Distance	Ligand atom	Protein atom				
1	180A	ILE	3.41	8205	2717				
2	208A	PHE	3.26	8209	3167				
Hydrogen Bonds									
Index	Residue	Amino acid	Distance H-A	Distance D-A	Donor angle	Protein donor?	Side chain	Donor atom	Acceptor atom
1	215A	GLN (Glutamine)	3.00	3.79	123.77	√	√	3257 [Nam]	8217 [O3]
2	407A	TYR (Tyrosine)	2.05	3.10	145.56	√	√	6347 [O]	8214 [O2]
3	444A	TYR	2.92	3.55	113.03	√	√	6931 [O3]	8215 [O.co2]
4	444A	TYR	3.31	3.55	108.53	X	√	8215 [O.co2]	6931 [O3]

Table 9: Interactions of linalool and monoamine oxidase A docking site.

Hydrophobic interactions					
Index	Residue	Amino acid	Distance	Ligand atom	Protein atom
1	69A	TYR (Tyrosine)	3.61	8203	860
2	180A	ILE (Isoleucine)	3.57	8204	2717
3	208A	PHE (Phenylalanine)	3.65	8211	3170
4	208A	PHE	3.62	8210	5186
5	335A	ILE	3.70	8205	5185
6	335A	ILE	3.45	8206	5187
7	335A	ILE	3.57	8209	5218
8	337A	LEU (Leucine)	3.62	8206	5430
9	352A	PHE	3.87	8204	5430

with their predicted toxicity class and LD50 2200mg/kg (Class: 5) and 200 mg/kg (Class: 3), respectively. Linalool is assumed to be safer than 7-Methoxy-2-oxo-2H-chromene-3-carboxylic acid because it is inactive against hepato-, neuro-, nephro-, cardio-, cyto-, immuno-, respiratory toxicity, carcino- and mutagenicity.

For molecular docking: Linalool and 7-Methoxy-2-oxo-2H-chromene-3-carboxylic acid were docked, separately, with the receptor Amine Oxidase A. The docking scores of linalool and 7-Methoxy-2-oxo-2H-chromene-3-carboxylic acid are -24.4 and -33.7, respectively, with the receptor protein. Both are docked with nearly identical co-crystallized ligand Harmine binding site to receptor protein. However, linalool appears to be more stable in the docking site due to the presence of nine hydrophobic interactions with the receptor protein in comparison with only two hydrophobic interactions for 7-Methoxy-2-oxo-2H-chromene-3-carboxylic acid (Table 8 and 9, Fig 2). The *in silico* and docking computational results suggested that linalool could be a promise MAO-A inhibitor.

Computational analysis plays a critical role in the identification and development of new drugs with better therapeutic effects. Cheminformatics and molecular modeling have long been used to discover and develop better drug therapies (Noorjahan and Saranya, 2018). As part of standard drug discovery processes, in silico modeling is now an integral component. These methods aid in discovering new medications or improving the therapeutic efficacy of a chemical series in early drug development (Kumar *et al*., 2024; Stanzione *et al*., 2021). Linalool's potential activity in the central nervous system has been studied for its mechanism of antidepressant action through monoaminergic pathways. New studies have expanded knowledge about its interaction with different targets and pathways, making it a promising natural compound for treating depression (Dos Santos *et al*., 2022). According to the present results, linalool could have a crucial role in the treatment of different neurodegenerative disorders through its highly effective MAO-A inhibition. Therefore, further *in vitro* and *in vivo* studies are needed to verify our assumption and report its mechanism pathway.

CONCLUSION

In conclusion, the GC-MS analysis of the methanolic extract of *Lavandula dentata* leaves revealed the presence of various bioactive compounds including linalool, retinal, chromene-2-one and Cumarin-3-carboxylic acid, 7-methoxy. These compounds have been associated with diverse pharmacological properties, suggesting the therapeutic potential of *Lavandula dentata* extract in medicine and pharmaceutical applications. Linalool has an effective inhibitory action on MAO-A according to the present *in silico* and docking analysis that could be a promising safe therapeutic drug for various neurodegenerative diseases. More studies are thus recommended to shed more light on the pharmacological and medical properties of *Lavandula dentata*.

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Author contributions

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Conflict of interest

The authors declare no conflict of interest.

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