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Original Article

GCMS and LCMS/MS Based Analysis for the Identification and Characterization of Bioactive Metabolites of Seaweed *Kappaphycus striatus* as an Anti-hypertensive and Anti-hypercholesterolemic Agent

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ABSTRACT

Background: Over 50% of the population in Malaysia has hypercholesterolemia, which puts them at a high risk of cardiovascular disease. Both food sources and the ingredients in traditional medications are essential to the treatment of this ailment. Seaweeds are naturally occurring dietary bioresources that have garnered a lot of attention recently. The local seaweed *Kappaphycus striatus* (*K. striatus*) contains numerous beneficial phytoconstituents that have the potential to serve as new drug candidates due to their health benefits. Thus, the aim of the study was to analyze and characterize the phytoconstituents present in the *K. striatus*. **Materials and Methods:** Extraction was carried out by a simple maceration method. The analysis of phytoconstituents was carried out via GCMS, HPLC, and LCMS methods. The GCMS chromatogram of the components were compared with the database of known components from the GC-MS NIST (2008) library, whereas the LCMS chromatographic profiles were analyzed based on the accurate mass data identified, and the predicted compounds were annotated using the METLIN database. **Results:** HPLC analysis profiling shows the presence of most of the polar phytoconstituents. LCMS and GCMS analysis results identified and characterize different types of bioactive compounds in the methanolic extract of *K. striatus*. Some of the compounds have been identified as potential anti-hypertensive and anti-hypercholesterolemia agents, as reported in previous studies. **Conclusion:** We conclude that the precise identification is crucial for understanding the potential pharmacological activities of these compounds. The effectiveness of *K. striatus* phytoconstituents in treating hypercholesterolemia requires additional validation through *in vivo* research. These discoveries highlight the potential of *K. striatus* as a significant source of therapeutic agents and lay the foundation for the development of novel medications for treatment of hypertension and hypercholesterolemia.

Keywords: *Kappaphycus striatus*, Seaweed, LCMS, GCMS, HPLC, Hypercholesterolemia.

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INTRODUCTION

Seaweeds are considered natural dietary bio-resources.[1] Because of their great potential, seaweeds have drawn a lot of attention recently. Seaweeds are crucial food sources and components of traditional medicines.[2] By 2026, it is expected that the $4.7 billion global market for algal products will have grown by a compound annual growth rate of 6.3% to reach $6.4 billion. North America accounts for the biggest share of the global algae market.[3] Seaweeds (macroalgae) are primarily categorised into three groups based on pigmentation type and morphological traits. These groups are Phaeophyta (brown algae), Rhodophyta (red algae), and Chlorophyta (green algae).[4]

Seaweeds are commonly consumed as food in many countries, despite the fact that they are increasingly employed as raw materials in many industrial goods, including agar, algin, and carrageenan.[5] Due to its positive benefits in prolonging life expectancy and preventing CVDs, seaweed has recently risen to the top of many Western diets' lists of most popular foods. Seaweed has long been eaten as food in Southeast Asian nations like China, Japan, and South Korea.[6] Seaweed is also found

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to lower the risk of developing metabolic syndrome and its complications.[7]

K. striatus is a local seaweed found and cultivated mainly in the Saba region of Malaysia. This seaweed has been found to contain many valuable phytoconstituents. The bioactive substances found in seaweed, such as carotenoids, phenolics, chitosan, gelatin, polyunsaturated fatty acids, and different vitamins and minerals, are thought to have favorable health effects.[8] A study showed that a diet rich in seaweed, vegetables, and fruits reduces arteriosclerosis.[9] A diet rich in vegetables, seaweeds, soy products, and mushrooms has been associated with a lower risk of type 2 diabetes and cardiovascular disease.[10] Seaweeds have a number of compounds that may help prevent CVD, including carotenoids, phycocyanins, fatty acids, polysaccharides, vitamins, sterols, and tocopherols.[11] Additionally, peptides found in seaweed have been associated with blood pressure regulation.[12] Seaweed extract is also found to improve blood cholesterol, TGs, glucose, insulin, and inflammatory markers.[13]

Analysis of the bioactive constituents of seaweeds is important, as it would reveal the type of metabolites and their medicinal significance. In recent days, High-performance Liquid Chromatography and Electrospray Ionization-Quadrupole-Time of flight mass spectrometry (LC-ESI-QTOF-MS/MS) have been largely used to analyze and characterize the metabolites depending on their chemical composition.[14] High-Performance Liquid Chromatography Photodiode Arrays (HPLC-PDA) are also used for the characterization of metabolites present in seaweeds.[15] Gas Chromatography-Mass Spectroscopy (GC-MS), a combined analytical technique, is also commonly employed in industry and research labs to examine and identify the chemicals in plant samples.[16] GCMS is crucial for phytochemical analysis and chemotaxonomic research on medicinal plants with physiologically active constituents.[17] In this study, the phytochemicals of the *K. striatus* methanolic extract were analysed via LCMS and GCMS, and we also tried to find out the potential role of these metabolites in the treatment of hypertension and hypercholesterolemia.

GC-MS and LC-MS are essential tools in seaweed research, providing detailed insights into the chemical composition and bioactive potential of seaweed. Incorporating GC-MS and LC-MS in seaweed research ensures quality control and standardization of seaweed-based products. This is essential for ensuring the safety, efficacy, and consistency of products intended for pharmacological use. By identifying and quantifying bioactive compounds, these techniques play a critical role in understanding and harnessing the pharmacological activities of seaweed. This will facilitate the development of new therapeutic agents and ensures the quality and efficacy of seaweed-based products, especially from *K. striatus*.

MATERIALS AND METHODS

Chemicals

All chemicals and reagents used in this study were of analytical grade.

Sample collection

K. striatus was purchased from a local company called Gamai Sdn Bhd. Fresh *K. striatus* was thoroughly washed and cleaned with fresh water mixed with bleaching and then again with fresh water to remove all epiphytes, sand, and calcareous particles, including other adhering detritus materials. Subsequently, the seaweed was spread on blotting paper to remove excess water. It was then placed in an oven set at 45°C for further drying. The dried seaweed was ground into a fine powder using a grinder. This powder was then dissolved in water and subjected to freeze-drying. For analysis using GC-MS, HPLC, and LC-MS, the sample was dissolved in methanol to prepare the extract.

GC-MS analysis of *K. striatus* extract

Gas chromatography Mass spectroscopy analysis of methanolic extract was performed using Agilent equipped with Column - ELITE-5MS (30-meter length, 0.25 mm ID, and 0.25 µm thicknesses). Electron ionization system was used. The ionization energy of 70 eV was employed, and the helium gas (99.99%) was used as a carrier gas at a constant flow-rate of 1 mL/min. The temperature of the injector was set at 260°C. The oven temperature was programmed from 70°C to 200°C at 10°C increase/min for 5 min, and finally increased to 280°C at 5°C for 15 min. Then 1 µL of extract (1 mg/mL) was injected in splitless mode with a mass scan range of 50-500 Da. The total running time of the GC-MS analysis was 51 min. The spectra of the components were compared with the database of spectra of known components stored in the GC-MS NIST (2008) library.

HPLC analysis of methanolic *K. striatus* extract

HPLC was also carried out to see the pattern of metabolites in methanolic extract. For HPLC analysis, the methanolic extract (1 mg/mL) was filtered through 0.45 µm membrane filter. A 30 min gradient method was applied in separation of phytochemical compounds from the sample using HPLC (Agilent 1100) equipped with Diode-Array Detector (DAD) and autosampler chamber. A C-18 column (Agilent, 250 x 4.6 mm, 5 µm) was used for the separation of the phytochemicals present in the tested extract. Ultrapure water (A) and HPLC grade acetonitrile (B) were used as mobile phase, where B was 5-95% in 0-18 min, 95% in 18-23 min, decreased from 95 to 5% in 23-23.1 min, and 5% in 23.1-30 min. Injection volume was 20 µL while flow rate was 1 mL/min. The sample was screened against a wavelength of 210, 220 and 254 nm.

LCMS analysis of methanolic *K. striatus* extract

Instrument

The LC/MS-QTOF system used in this study consisted of an Agilent 1200 liquid chromatography system, equipped with a binary pump, a vacuum degasser unit, an auto sampler, and 6520 quadrupole time of flight mass spectrometers with an Electrospray Ionisation (ESI) source. The column used was Agilent ZORBAX Eclipse Plus C18 Rapid Resolution HT (2.1 x 100 mm) 1.8 µm.

Chromatography and mass spectrometry method

Chromatographic separation was performed at 40°C using Agilent ZORBAX Eclipse Plus C18 Rapid Resolution HT (2.1 x 100 mm) 1.8 µm with (A) 0.1% formic acid in dH20 and (B) 0.1% formic acid in acetonitrile for positive mode. The gradient elution program was 0.00-18.00 min, 5-95% (B); 18-23 min; 95% (B). 23.01 min; 5% (B). The total run time is 30 min. The LC condition was re-equilibrated for 2 min before starting the new injection. The sample injection volume was set at 2 µL and the flow rate of the mobile phase was set at 0.25 mL/min. The mass spectrometer was operated in positive Electrospray Ionization (ESI) mode with optimum gas temperature at 325°C, gas flow at 11 L/min and nebulizer at 35 psi, respectively.

Data Analysis

Agilent Mass Hunter Qualitative Analysis B.05.00 software (Agilent Technologies, Santa Clara, CA, USA) was used for the data analysis (MS data (.d)). The chromatographic profiles were analyzed based on the accurate mass data identified and the predicted compounds were annotated using METLIN database. The METLIN database contains over 240,000 compounds and is a repository for mass spectrometry metabolomics data intended to facilitate metabolite identification. The library contains naturally occurring metabolites from various organisms as well as exogenous compounds, including pharmaceutical drugs and other synthetic organic compounds could help the accurate compound prediction.

RESULTS

Extraction Yield

A fresh *K. striatus* sample of ten kilograms (10 kg) produced only 92 g of dry *K. striatus* powder (0.01% w/w). The yield was found to be very low, likely due to the high-water content characteristic of seaweed.

GCMS analysis of a methanolic extract of *K. striatus*

The methanolic extract shows the presence of many compounds, which are identified at different retention times. From all the identified compounds, 1,3-Di(4-bromophenyl) benzo[f]quinazoline is found to be present in the highest concentration (31%) at RT 31.68 min. Another compound, 4,5,6,7-Tetrahydroindoxazen-4-one is also found to be present in the second highest concentration (22%), at RT 16.24 min. β-Sitosterol trimethylsilyl ether is also reported as a secondary metabolite from the extract eluted at RT 16.73 min. Figure 1 shows GCMS chromatogram of compounds identified in the methanolic extract of *K. striatus*. Table 1 shows the list of compounds identified via GCMS analysis of *K. striatus* extract.

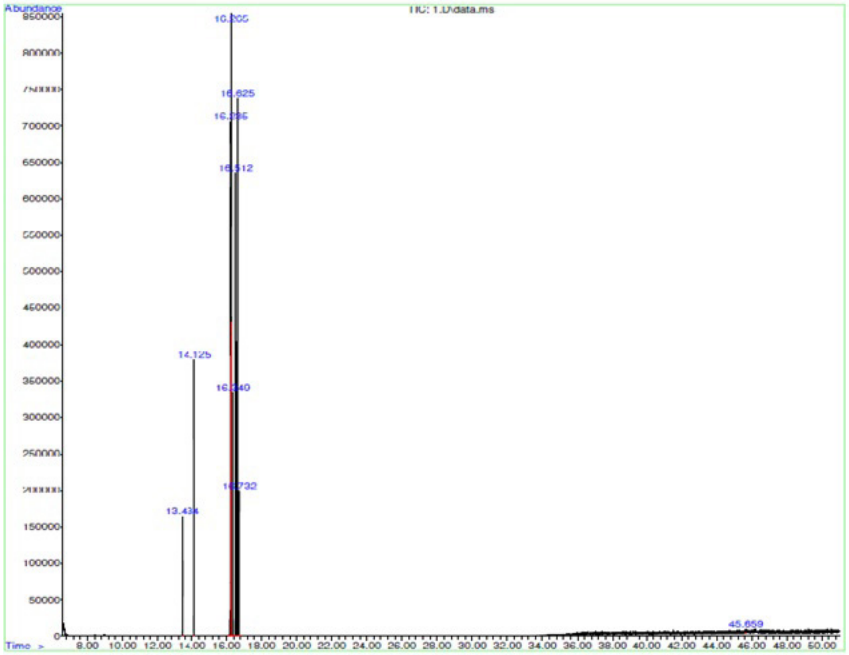

Figure 1: GCMS chromatogram of compounds identified in methanolic extract of *K. striatus*.

HPLC analysis of *K. striatus* extract

HPLC analysis is performed for screening of phytochemicals in *K. striatus* as it helps to profile the various compounds present, particularly highlighting the polarity and complexity of the extract, which can guide further bioactive compound isolation and potential pharmacological activity studies. A good separation of metabolites was seen at wavelength 210 nm. The peaks in the chromatogram indicate the presence of various compounds in the *K. striatus* methanolic extract, with each peak corresponding to a different compound (Figure 2). The retention time of each peak provides insight into the polarity of these compounds and their interaction with the stationary phase of the HPLC column. The early peaks suggest the presence of highly polar compounds. Generally, seaweed species containing such compounds could include polysaccharides, certain amino acids, and phenolic compounds, which are known to be highly polar due to their hydroxyl and carboxyl groups. This suggested that *K. striatus* contains significant amounts of polysaccharides like alginate, carrageenan, and fucoidan, which are highly hydrophilic and thus elute the early part of the analysis. The peaks that elute later indicate the presence of less polar or more hydrophobic compounds, such as fatty acids, sterols, and certain types of terpenes, therefore, have longer retention times, consistent with peaks observed in the 15-25 min range. This chromatographic behaviour aligns well with the known chemical diversity of seaweeds, which includes a variety of bioactive compounds across a wide polarity range. Further analysis and identification of these peaks using LCMS could provide deeper insights into the specific compounds present and their potential biological activities.

Table 1: List of compounds identified via GCMS analysis of *K. striatus* extract.

RT (min)	Compounds	Mol formula	Peak area (%)
13.436	2,6-Diphenyl-4-methyl-1,4-dihydropyridine-3,5-dicarbonitrile	$C_{10}H_{11}N_3$	1.95
14.126	Silane, [(dichlorostannylene) dimethylidyne]tetrakis[trimethyl	SiH_4	6.01
16.233	Dibromophenyl ether	$C_{12}H_6Br_4O$	21.29
16.264	4,5,6,7-Tetrahydroindoxazen-4-one, 3-[10-phendecyl]-6-[phenyl-dimethylsilyl]-	$C_31H_41NO_2Si$	22.64
16.347	2,2'-Bithienyl, 5,5'-bis(trimethylstannyl)-	$C_{14}H_{22}S_2Sn_2$	5.44
16.513	2,2'-Bithienyl, 5,5'-bis(trimethylstannyl)-	$C_{14}H_{22}S_2Sn_2$	9.02
16.627	1,3-Di(4-bromophenyl) benzo[f]quinazoline	$C_{24}H_{14}Br_2N_2$	31.68
16.731	β-Sitosterol trimethylsilyl ether	$C_{32}H_{58}OSi$	1.78
45.657	Hexahydropyridine, 1-methyl-4-[4,5-dihydroxyphenyl]-	$C_{12}H_{17}NO_2$	0.20

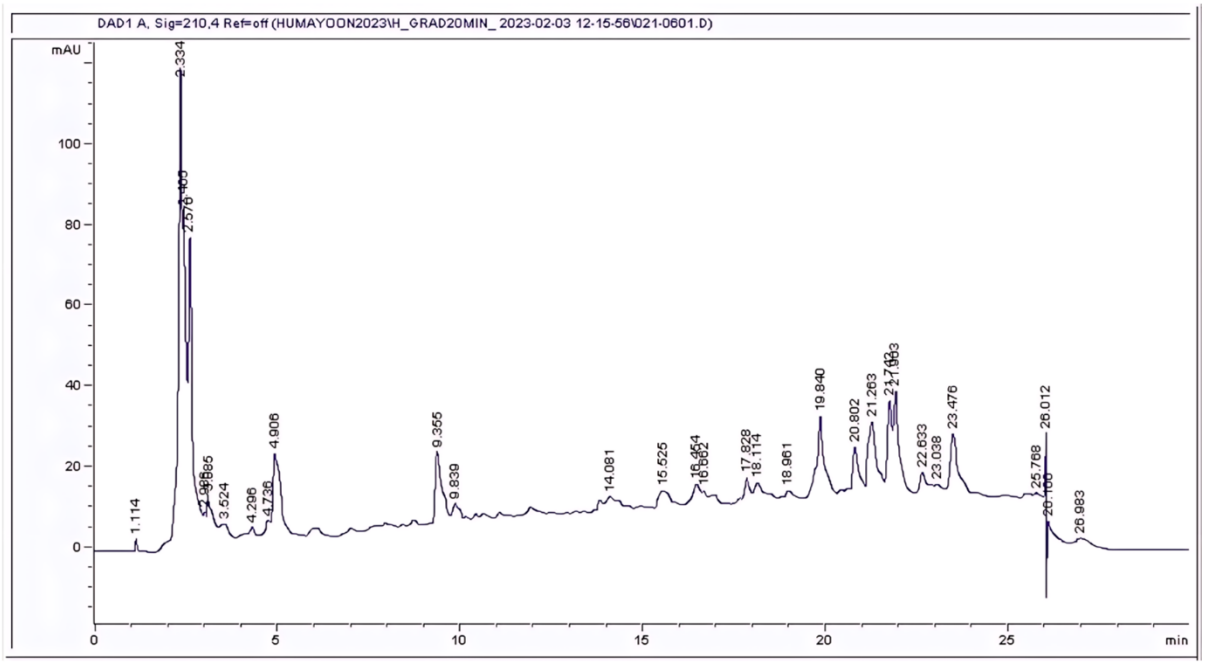

Figure 2: A HPLC chromatogram of *K. striatus* methanolic extract.

LCMS analysis of *K. striatus* extract

The LC/MS-QTOF analysis in positive electrospray ionization modes tentatively identified many compounds in *K. striatus* methanolic extract. The list of some important biologically active compounds is also mentioned in Table 2.

The analysis of the data revealed the existence of a terazosin-like compound within the extract, detected at a retention time of 16.79 min. A type of terpenophenolics compound known as cannabidiol dimethyl ether ($C_{23}H_{34}O_2$, m/z 342.255) was detected at 17.68 min. Enigmol, an amino alcohol with molecular formula $C_{18}H_{39}NO_2$ (m/z 302.305) is found to be eluted at 14.15 min. Kolanone ($C_{33}H_{42}O_4$), a monoterpenoid, was detected at 15.99 min, known to have a identified at retention time 25.04 min significant antimicrobial activity against both Gram-positive and Gram-negative bacteria.[18]

Additionally, camptothecin ($C_{20}H_{16}N_2O_4$, m/z 348.1105) has also been identified in the methanolic extract of *K. striatus*, which exhibited a retention time of 22.41 min. Another compound 24(S),25-epoxycholesterol (C_{27} H_{44} O_2, m/z 400.3339) has also been identified at retention time of 25.04 min in the methanolic extract of *K. striatus*. Total Ion Chromatogram (TIC) scan of the *K. striatus* methanolic extract from LCMS-ESI-QTOF analysis in positive Electrospray Ionization (ESI) mode is shown in Figure 3. The structure of some important biologically active compounds has also been depicted in Figure 4.

The list of compounds, molecular formula, retention time (RT), mass-to-charge ratio (m/z), matching score and the peak height of the compounds identified from K. striatus methanolic extract via LCMS-ESI-QTOF analysis in positive electrospray ionization (ESI) mode has been provided in Table 3.

DISCUSSION

GCMS analysis of *K. striatus* extract shows the presence of different compounds. 1,3-Di(4-bromophenyl) benzo[f]quinazoline, which is found in the highest percentage, could be used in the treatment of hyperlipidemia and hypertension.[18] An earlier study suggested that this could be used in the treatment of hypercholesterolemia.[19]

LCMS results show many different compounds. Terazosin, a selective, quinazoline-derived post-synaptic-1 antagonist, was used as a treatment for hypertension and for lower urinary tract symptoms related to benign prostatic hyperplasia. In addition, an earlier study by Luther[20] has justified the claim that terazosin tends to raise the levels of high-density lipoprotein cholesterol and lower the levels of serum triglycerides from their respective baselines. Other findings suggest that hypertensive patients who undergo long-term therapy with terazosin may experience an improvement in their glucose and lipid metabolism. Therefore, terazosin appears to be an antihypertensive medication that offers favourable effects for hypertensive patients who have either dyslipidemia or impaired glucose metabolism.[21] This evidence aligned with the previous studies on other seaweed species, which stated that the seaweed collected from Semporna, Sabah, Malaysia, could have the potential to function as an antihypertensive agent and reduce cholesterol levels.[22] Cannabidiol was studied as a potent MIC against clinically relevant Gram-positive bacteria, particularly due to its low toxicity profile and rapid bacterial killing.[23] This compound was previously reported to exhibit potential properties that can be used to combat cancer due to its capacity to cause DNA damage and induce apoptosis in cancerous cells. Enigmol has demonstrated potential in preclinical investigations to suppress the proliferation of various cancer cell types, such as lung cancer, breast cancer, and leukemia. Numerous clinical trials are presently underway to assess the safety and efficacy of enigmol as a treatment for various forms of cancer.[24,25] Additionally, kolanone demonstrates anti-oxidative and cytoprotective properties, making it a potential candidate for therapeutic applications in gastric ulcer treatment and wound healing.[26,27] This extract also showed the presence of Alverine ($C_{20}H_{27}N$, m/z 282.2219), a well-known muscle relaxant with anti-inflammatory properties that was previously discovered in porphyra, a type of edible algae.[28] Camptothecin is a quinoline alkaloid, was previously studied as a potent anticancer medication, and has demonstrated significant antitumor efficacy against a

Table 2: The list of some important biological active compounds reported in *K. striatus* extract.

No	Name	Formula	RT (min)	m/z	Activity
1	Enigmol	$C_{18}H_{39}NO_2$	14.15	302.3055	anticancer
2	Kolanone	$C_{33}H_{42}O_4$	15.99	520.3397	antimicrobe, antiulcer, wound healing
3	Terazosin	$C_{19}H_{25}N_5O_4$	16.79	405.2236	antihypertensive, reduce cholesterol
4	Cannabidiol dimethyl ether	$C_{23}H_{34}O_2$	17.68	360.2885	antibacterial
5	Alverine	$C_{20}H_{27}N$	22.21	282.2219	muscle relaxant, anti-inflammatory
6	Camptothecin	$C_{20}H_{16}N_2O_4$	22.41	371.1011	antitumor, anticancer
7	24,25-Epoxy-cholesterol	C_{27} H_{44} O_2	25.047	400.3339	antihypercholesterelemia

Table 3: The list of compounds, molecular formula, Retention Time (RT), mass-to-charge ratio (m/z), matching score and the peak height of the compounds identified from *K. striatus*. methanolic extract via LCMS-ESI-QTOF analysis in positive Electrospray Ionization (ESI) mode.

No	Name of compound	Formula	RT	m/z	Score	Height
1	Stearamide	$C_{18}H_{37}NO$	23.419	284.2945	99.62	107239
2	C16 Sphinganine	$C_{16}H_{35}NO_2$	12.764	274.2737	99.43	105651
3	N-Cyclohexanecarbonylpentadecylamine	$C_{22}H_{43}NO$	25.612	338.3414	99.34	43475
4	17-Hydroxy-5alpha,17alpha-pregn-1-en-3-one	$C_{21}H_{32}O_2$	16.986	334.274	99.21	35955
5	17-phenyl trinor-13,14-dihydro Prostaglandin A2	$C_{23}H_{30}O_4$	19.553	371.2214	99.2	32613
6	3-Acetoxypregn-16-En-12,20-Dione	$C_{23}H_{32}O_4$	20.376	373.2373	99.14	37287
7	alpha-Santalyl phenylacetate	$C_{23}H_{30}O_2$	20.145	339.2313	99.01	181719
8	1α,25-dihydroxy-11α-(2-hydroxyethyl)vitamin D3 / 1α,25-dihydroxy-11α-(2-hydroxyethyl)cholecalciferol	$C_{29}H_{48}O_4$	19.654	461.3617	97.89	16305
9	Latanoprost ethyl amide	$C_{25}H_{39}NO_4$	19.016	418.2944	97.66	30007
10	Phytosphingosine	$C_{18}H_{39}NO_3$	12.869	318.2997	97.46	43454
11	Norselic acid C	$C_{28}H_{40}O_3$	25.457	425.3052	96.83	10389
12	Sorbitan palmitate	$C_{22}H_{42}O_6$	21.881	420.3313	96.69	56355
13	1α,25-dihydroxy-24-oxo-23-azavitamin D2 / 1α,25-dihydroxy-24-oxo-23-azaergocalciferol	$C_{27}H_{43}NO_4$	19.015	446.3255	96.56	26121
14	CAY10429	$C_{21}H_{30}O_2$	19.016	337.2151	93.33	37706
15	DG (20:5(5Z,8Z,11Z,14Z,17Z)/14:1(9Z)/0:0)	$C_{37}H_{60}O_5$	25.997	585.4503	92.98	4561
16	Disopyramide	$C_{21}H_{29}N_3O$	20.378	340.2397	92.83	15198
17	25-Hydroxy[26,27-methyl]vitamin D3 3β-(1,2-epoxypropyl)ether	$C_{29}H_{46}O_3$	19.654	443.351	91.5	8914
18	MGDG(18:3(9Z,12Z,15Z)/16:3(7Z,10Z,13Z))	$C_{43}H_{70}O_{10}$	25.984	764.5306	88.92	10075
19	4-(2-hydroxypropoxy)-3,5-dimethyl-Phenol	$C_{11}H_{16}O_3$	9.227	197.1174	87.14	26647
20	2-ethyl-dodecanoic acid	$C_{14}H_{28}O_2$	11.305	246.2427	86.82	17395
21	4-propionyl butyric acid	$C_7H_{12}O_3$	1.07	162.1124	86.73	13763
22	1-(O-alpha-D-glucopyranosyl)-(1,3R,27S,29R)-triacontanetetraol	$C_{36}H_{72}O_9$	22.675	687.4822	86.62	3712
23	Decyl acetate	$C_{12}H_{24}O_2$	9.525	218.2115	86.2	8759
24	Bis (2-hydroxypropyl) amine	$C_6H_{15}NO_2$	0.996	134.1177	86.16	16621
25	Xestoaminol C	$C_{14}H_{31}NO$	13.538	230.2477	86.16	10377
26	(S)-4-(4-Methylphenyl)-2-pentanone	$C_{12}H_{16}O$	20.379	177.1273	86.06	10668
27	Fasciculic acid C	$C_{38}H_{63}NO_{11}$	22.774	727.4754	85.86	5096
28	Stearamide	$C_{18}H_{37}NO$	22.208	284.2952	85.28	3906
29	Emmotin A	$C_{16}H_{22}O_4$	18.643	279.1592	85.27	6034
30	C10:1n-7	$C_{10}H_{18}O_2$	21.882	171.1377	85	12991
31	Enigmol	$C_{18}H_{39}NO_2$	14.155	302.3055	84.88	15762
32	26-hydroxycholesterol 3-sulfate	$C_{27}H_{46}O_5S$	19.044	483.3159	84.75	25469
33	10-oxo-nonadecanoic acid	$C_{19}H_{36}O_3$	21.434	313.2737	84.71	6406
34	Eicosanedioic acid	$C_{20}H_{38}O_4$	15.466	360.3107	84.44	5880
35	Myxalamid A	$C_{26}H_{41}NO_3$	20.15	416.3153	84.3	9611
36	Hexadecyl Acetyl Glycerol	$C_{21}H_{42}O_4$	23.521	359.3153	84.12	6494
37	6Z,9Z-Eicosadien-11-ol	$C_{20}H_{38}O$	23.71	312.3255	84.11	4059

No	Name of compound	Formula	RT	m/z	Score	Height
38	Avocadynone Acetate	$C_{19}H_{32}O_4$	16.677	325.2373	83.98	14524
39	α-9(10)-EpODE	$C_{18}H_{30}O_3$	17.925	295.227	83.72	4330
40	Palmitic amide	$C_{16}H_{33}NO$	20.767	256.264	83.69	7789
41	5Z,8Z,11Z,14Z-octadecatetraenoic acid	$C_{18}H_{28}O_2$	16.404	277.2158	83.67	3301
42	Eucalyptol	$C_{10}H_{18}O$	21.305	177.1252	82.8	13898
43	(-)-Dilophol	$C_{20}H_{34}O$	22.51	308.2942	82.74	3025
44	α-9(10)-EpODE	$C_{18}H_{30}O_3$	17.688	295.2271	82.61	4135
45	N-isopropyl arachidonoyl amine	$C_{23}H_{39}NO$	23.56	346.3097	82.48	6402
46	N-stearoyl glutamic acid	$C_{23}H_{43}NO_5$	16.845	414.3215	82.42	10183
47	N,N-dimethyl-Safingol	$C_{20}H_{43}NO_2$	15.547	330.3359	82.41	3942
48	Calicogorgin A	$C_{23}H_{41}NO_3$	16.985	397.3419	82.04	6908
49	Carboprost	$C_{21}H_{36}O_5$	16.843	369.2632	81.96	7059
50	N-Hexadecanoylpyrrolidine	$C_{20}H_{39}NO$	24.355	310.3098	81.75	17975
51	MG (0:0/18:3(6Z,9Z,12Z)/0:0)	$C_{21}H_{36}O_4$	20.279	353.268	81.64	2777
52	Methyl farnesoate	$C_{16}H_{26}O_2$	18.681	251.1994	81.57	4100
53	MG (0:0/18:4(6Z,9Z,12Z,15Z)/0:0)	$C_{21}H_{34}O_4$	16.844	351.252	81.56	13064
54	Aspidospermatine	$C_{21}H_{26}N_2O_2$	20.378	356.2341	81.35	10333
55	1-Monopalmitin	$C_{19}H_{38}O_4$	21.436	331.2834	81.2	12592
56	1a,1b-dihomo-PGD2	$C_{22}H_{36}O_5$	15.555	381.2626	81.19	3542
57	N-Hexadecanoylpyrrolidine	$C_{20}H_{39}NO$	23.867	310.3101	81.12	10122
58	16-hydroxy hexadecanoic acid	$C_{16}H_{32}O_3$	11.442	290.2689	81.09	6815
59	C18-OH Sulfatide	$C_{42}H_{81}NO_{12}S$	24.375	841.5823	80.92	4263
60	Sorbitan stearate	$C_{24}H_{46}O_6$	21.88	448.3626	80.46	6357
61	N-Cyclohexanecarbonyltetradecylamine	$C_{21}H_{41}NO$	26.272	324.3255	80.42	3057
62	3α,12α-Dihydroxy-5β-chol-8(14)-en-24-oic Acid	$C_{24}H_{38}O_4$	25.676	391.2833	80.21	4842
63	Dioscoretine	$C_{13}H_{23}NO_3$	9.227	242.1751	80.1	6354
64	5-Androstene-3b,16b,17a-triol	$C_{19}H_{30}O_3$	16.675	307.2259	80.05	8789
65	6Z,9Z-Eicosadien-11-ol	$C_{20}H_{38}O$	24.458	312.3251	79.82	3177
66	3-hydroxy-sebacic acid	$C_{10}H_{18}O_5$	1.064	236.1482	79.73	8940
67	1-(O-alpha-D-glucopyranosyl)-(1,3R,27S,29R)-triacontanetetraol	$C_{36}H_{72}O_9$	22.507	687.4824	79.71	22905
68	Stearamide	$C_{18}H_{37}NO$	22.828	284.2939	79.66	4146
69	8-Methyl-3-hentriacontene	$C_{32}H_{64}$	22.127	466.5344	79.63	2721
70	cis-9,10-Epoxystearic acid	$C_{18}H_{34}O_3$	19.435	321.2407	79.57	3814
71	8,9-dihydroxy-5,11,14-eicosatrienoic acid	$C_{20}H_{34}O_4$	19.435	339.2518	78.75	4085
72	Cannabidiol dimethyl ether	$C_{23}H_{34}O_2$	17.68	360.2885	78.19	4441
73	Alverine	$C_{20}H_{27}N$	22.217	282.2219	78.07	3819
74	9Z,12Z,15E-octadecatrienoic acid	$C_{18}H_{30}O_2$	17.225	279.2315	78	8033
75	Levonorgestrel acetate	$C_{23}H_{30}O_3$	19.3	355.2259	77.92	5165
76	17-Hydroxy-5alpha,17alpha-pregn-1-en-3-one	$C_{21}H_{32}O_2$	17.255	334.2735	77.76	5800
77	N-Hexadecanoylpyrrolidine	$C_{20}H_{39}NO$	23.166	310.3098	77.24	3197
78	8E-Tetradecenyl acetate	$C_{16}H_{30}O_2$	21.069	255.2311	76.76	4100
79	6E,9E-octadecadienoic acid	$C_{18}H_{32}O_2$	21.57	281.2465	76.61	4879

No	Name of compound	Formula	RT	m/z	Score	Height
80	25-Hydroxy-24-epi-brassinolide	$C_{28}H_{48}O_7$	17.357	514.3737	76.21	6005
81	24-epi-brassinolide	$C_{28}H_{48}O_6$	16.941	498.3786	76.11	7342
82	3-Oxochola-1,4,6-trien-24-oic Acid	$C_{24}H_{32}O_3$	19.017	369.2409	75.88	8378
83	3,5,7-Trimethyl-2E,4E,6E,8E-undecatetraene	$C_{14}H_{22}$	15.474	191.1795	75.78	6215
84	Sarcostin	$C_{21}H_{34}O_6$	17.279	405.2253	75.43	5983
85	Eicosanedioic acid	$C_{20}H_{38}O_4$	15.342	360.3097	75.28	3332
86	10-Tridecynoic acid	$C_{13}H_{22}O_2$	12.953	228.1954	75.17	10398
87	Palmitic amide	$C_{16}H_{33}NO$	23.479	256.2638	74.65	2418
88	6alpha-hydroxycholestanol	$C_{27}H_{48}O_2$	22.293	427.3553	74.3	2317
89	N-Oleoyl-L-Serine	$C_{21}H_{39}NO_4$	16.674	370.2956	74.28	4628
90	17beta-Nitro-5alpha-androstane	$C_{19}H_{31}NO_2$	15.053	306.2438	74.14	4918
91	7,10-Heptadecadiynoic acid	$C_{17}H_{26}O_2$	21.305	285.183	74.05	3375
92	N-propyl α,α-dimethylarachidonoyl amine	$C_{25}H_{43}NO$	26.085	374.3404	73.89	3790
93	27-Norcholestanehexol	$C_{26}H_{46}O_6$	16.333	472.3629	73.59	8204
94	1α,25-dihydroxy-2β-(3-hydroxypropoxy)-19-norvitamin D3 / 1α,25-dihydroxy-2β-(3-hydroxypropoxy)-19 -norcholecalciferol	$C_{29}H_{50}O_5$	19.656	501.3547	73.44	9173
95	Capsi-amide	$C_{17}H_{35}NO$	21.478	270.2788	73.43	4612
96	15(R)-17-phenyl trinor PGF2α isopropyl ester	$C_{26}H_{38}O_5$	19.554	448.3052	73.13	9692
97	1-Monopalmitin	$C_{19}H_{38}O_4$	18.07	331.283	73.11	3357
98	N-ethyl N-(2-hydroxy-ethyl) arachidonoyl amine	$C_{24}H_{41}NO_2$	18.689	376.3197	72.49	3248
99	(20R)-24-Hydroxy-19-norgeminivitamin D3	$C_{31}H_{54}O_5$	19.655	524.4299	72.39	3794
100	16-hydroxy hexadecanoic acid	$C_{16}H_{32}O_3$	12.919	290.2679	72.25	4326
101	N-stearoyl valine	$C_{23}H_{45}NO_3$	22.563	406.3282	72.1	4505
102	6E-Heneicosen-11-one	$C_{21}H_{40}O$	24.593	326.3418	71.95	8413
103	(-)N-(1R-methyl-propyl) arachidonoyl amine	$C_{24}H_{41}NO$	24.062	360.3266	71.87	3134
104	28-Homobrassinolide	$C_{29}H_{50}O_6$	19.322	517.3487	71.83	1550
105	Terazosin	$C_{19}H_{25}N5O_4$	16.794	405.2236	71.55	3851
106	11S-hydroxy-tetradecanoic acid	$C_{14}H_{28}O_3$	9.761	262.2366	71.38	3085
107	N-(3-hydroxyphenyl)-Arachidonoyl amide	$C_{26}H_{37}NO_2$	18.134	396.2893	71.37	2764
108	(2S)-2-hydroxyphytanic acid	$C_{20}H_{40}O_3$	14.241	346.3309	71	4669
109	Vinylacetylglycine	$C_6H_9NO_3$	1.707	144.0648	70.05	7023
110	11-acetoxy-3beta,6alpha-dihydroxy-9,11-seco-5alpha-cholest-7-en-9-one.	$C_{29}H_{48}O_5$	20.692	499.3385	69.81	1773
111	Militarinone A	$C_{26}H_{37}NO_6$	15.145	460.2691	69.2	4120
112	N-Nitrosothiazolidine-4-carboxylic acid	$C_4H_6N_2O_3S$	0.915	200.9727	69.08	10612
113	Palmitic amide	$C_{16}H_{33}NO$	23.67	256.2638	68.37	3912
114	Lycopersiconol	$C_{21}H_{34}O_3$	20.272	335.2567	66.94	3372
115	Stearamide	$C_{18}H_{37}NO$	26.463	284.294	66.69	3772
116	PG (17:1(9Z)/18:0)	$C_{41}H_{79}O_{10}P$	22.497	763.5448	66.06	4751
117	5,12-dihydroxy-6,8,10,14-eicosatetraenoic acid	$C_{20}H_{32}O_4$	15.057	337.2365	65.63	2288
118	PA(O-20:0/0:0)	$C_{23}H_{49}O_6P$	25.458	470.3617	65.23	2016
119	Leupeptin	$C_{20}H_{38}N_6O_4$	15.552	444.3306	65.08	2970

No	Name of compound	Formula	RT	m/z	Score	Height
120	Stearamide	$C_{18}H_{37}NO$	26.11	284.2952	64.09	2295
121	AUDA	$C_{23}H_{40}N_2O_3$	16.996	410.3388	63.91	1743
122	3,5-Dichlorosalicylic acid	$C_7H_4Cl_2O_3$	0.917	223.9886	63.74	3774
123	13,14-dihydro-16,16-difluoro Prostaglandin E1	$C_{20}H_{34}F_2O_5$	20.145	393.245	63.61	2123
124	MGDG-O(16:3(7Z,10Z,13Z))	$C_{43}H_{68}O_{11}$	21.611	761.4819	62.24	1645
125	N-(α-Linolenoyl) Tyrosine	$C_{27}H_{39}NO_4$	19.017	459.3224	62.02	2547
126	Phytomonic Acid	$C_{19}H_{36}O_2$	21.592	297.2798	61.58	1817
127	16-phenoxy tetranor PGF2α methyl amide	$C_{23}H_{33}NO_5$	15.561	421.268	61.5	2189
128	Kolanone	$C_{33}H_{42}O_4$	15.99	520.3397	60.51	4251
129	N-Cyclohexanecarbonylpentadecylamine	$C_{22}H_{43}NO$	22.583	338.3405	60.4	2514
130	Camptothecin	$C_{20}H_{16}N_2O_4$	22.414	371.1011	60.23	4831
131	2-hexyl-decanoic acid	$C_{16}H_{32}O_2$	20.441	279.2303	59.62	4754
132	N-Cyclohexanecarbonylpentadecylamine	$C_{22}H_{43}NO$	26.016	338.3408	59.01	2544
133	Ceanothenic acid	$C_{29}H_{42}O_4$	26.806	455.3153	58.5	1274
134	C18-OH Sulfatide	$C_{42}H_{81}NO_{12}S$	24.805	841.5803	58.06	2080
135	Fasciculic acid C	$C_{38}H_{63}NO_{11}$	22.678	727.4756	57.97	3202
136	Alliosterol 1-rhamnoside 16-galactoside	$C_{39}H_{66}O_{13}$	22.498	743.4565	57.62	1607
137	Sulfated Dihydromenaquinone-9	$C_{56}H_{82}O_6S$	24.336	883.5919	57.59	858
138	2,5-Dichloro-4-oxohex-2-enedioate	$C_6H_4C_{l2}O_5$	0.969	226.9513	57.4	23886
139	Cerebroside B	$C_{41}H_{77}NO_9$	22.768	750.5516	56.81	1216
140	C18-OH Sulfatide	$C_{42}H_{81}NO_{12}S$	25.203	841.5822	56.66	1780
141	1α,25-dihydroxy-26,27-dimethyl-24a-homo-22-thia-20-epivitamin D3 / 1α,25-dihydroxy-26,27-dimethyl-24a-homo-22-thia-20-epicholecalciferol	$C_{29}H_{48}O_3S$	14.839	477.3416	56.45	2689
142	Cerebroside B	$C_{41}H_{77}NO_9$	22.488	750.5499	56.45	3623
143	MGDG-O(16:3(7Z,10Z,13Z))	$C_{43}H_{68}O_{11}$	21.75	761.4806	56.41	1646
144	1-(O-alpha-D-glucopyranosyl)-(1,3R,27S,29R)-triacontanetetraol	$C_{36}H_{72}O_9$	21.611	687.4816	56.11	1283
145	Istamycin C	$C_{18}H_{37}N_5O_5$	15.121	421.3152	53.78	1755
146	1-(O-alpha-D-glucopyranosyl)-(1,3R,27S,29R)-triacontanetetraol	$C_{36}H_{72}O_9$	22.776	687.4832	53.68	4587
147	PE(22:6(4Z,7Z,10Z,13Z,16Z,19Z)/P-18:1(11Z))	$C_{45}H_{76}NO_7P$	21.62	796.5217	50.28	1006
148	MIPC(t18:0/16:0(2OH))	$C_{46}H_{90}NO_{18}P$	26.031	993.6258	47.95	1209
149	9-keto palmitic acid	$C_{16}H_{30}O_3$	15.492	288.2537	47.2	1970
150	9,10-Epoxy-18-hydroxystearate	$C_{18}H_{34}O_4$	15.468	332.28	46.97	2651
151	N-(2'-(4-benzenesulfonamide)-ethyl) arachidonoyl amine	$C_{28}H_{42}N_2O_3S$	22.554	509.2817	46.12	975
152	9,10-Epoxy-18-hydroxystearate	$C_{18}H_{34}O_4$	15.949	332.2802	46.08	977
153	9,10-Epoxy-18-hydroxystearate	$C_{18}H_{34}O_4$	15.343	332.2786	44.47	1847
154	(5Z)-(3S)-1α,25-dihydroxy-3-deoxy-3-thiavitamin D3 3-oxide / (5Z)-(3S)-1α,25-dihydroxy-3-deoxy-3-thia cholecalciferol 3-oxide	$C_{26}H_{42}O_3S$	17.802	452.3181	44.41	1555
155	1-Monopalmitin	$C_{19}H_{38}O_4$	18.194	331.2838	43.97	1778
156	PE(O-18:1(9Z)/0:0)	$C_{23}H_{48}NO_6P$	25.453	483.3555	43.02	2094

No	Name of compound	Formula	RT	m/z	Score	Height
157	Vitamin E succinate(tocopherol succinate)	$C_{33}H_{54}O_5$	22.262	531.4062	42.29	1346
158	Homodolicholide	$C_{29}H_{48}O_6$	21.755	515.3325	41.39	855
159	Emmotin A	$C_{16}H_{22}O_4$	18.557	279.1576	39.74	3361
160	PG (17:1(9Z)/18:0)	$C_{41}H_{79}O_{10}P$	22.775	763.5458	39.55	1500
161	Vitamin E succinate(tocopherol succinate)	$C_{33}H_{54}O_5$	22.546	531.4067	38.49	794
162	(R)-Butaprost (free acid)	$C_{23}H_{38}O_5$	18.235	806.5815	20.97	1248
163	PA (20:1(11Z)/22:0)	$C_{45}H_{87}O_8P$	24.345	825.5806	11.71	1012
164	PE (22:2(13Z,16Z)/24:0)	$C_{51}H_{98}NO_8P$	24.382	922.6621	1.82	934

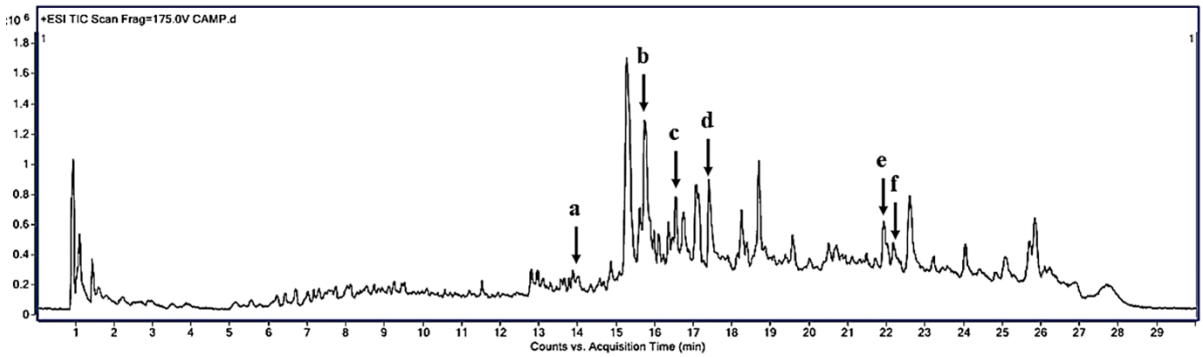

Figure 3: Total Ion Chromatogram (TIC) scan of the *K. striatus* methanolic extract from LCMS-ESI-QTOF analysis in positive electrospray ionization (ESI) mode; (a) enigmol=14.15 minutes (b) kolanone=15.99 minutes; (c) terazosin=16.79 minutes; (d) cannabidiol dimethyl ether=17.68 min; (e) alverine = 22.21 min; (f) camptothecin = 22.41 min.

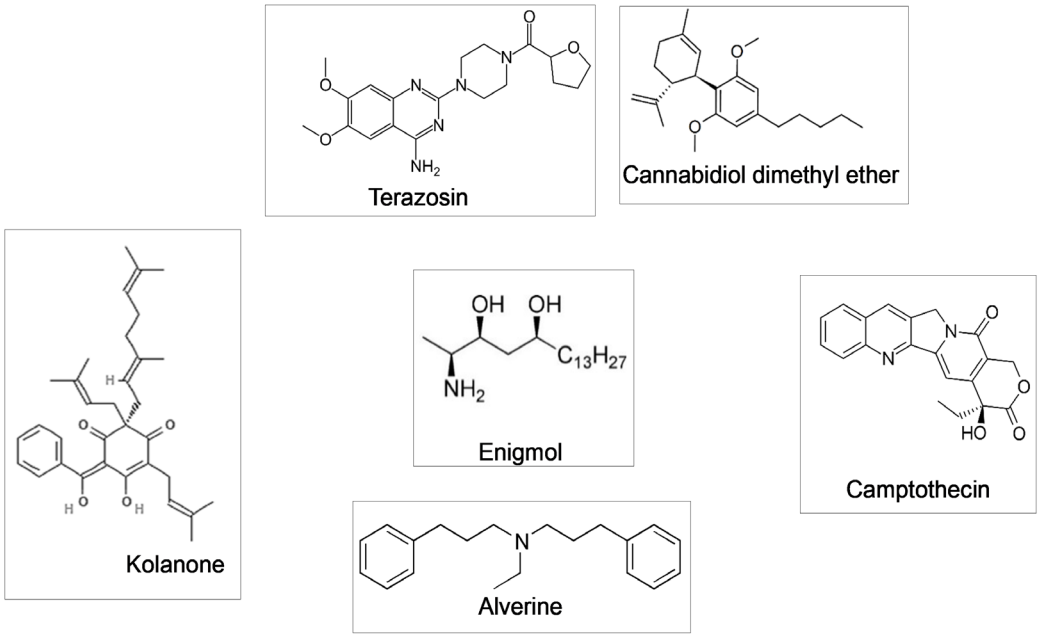

Figure 4: Compounds identified from LCMS-ESI-QTOF analysis of *K. striatus* methanolic extract with reported biological activities.

wide range of cancers, including breast, ovarian, colon, lung, and stomach cancers.[29]

A compound 24(S),25-epoxycholesterol was also detected, which could be used to monitor the synthesis of cholesterol and guard against spikes in the creation of this potentially deadly molecule. Furthermore, endogenous 24(S),25-epoxycholesterol is a natural ligand for liver X receptors that promotes the expression of genes linked to cholesterol efflux.[30]

CONCLUSION

K. striatus exhibits a rich diversity of metabolites, as evidenced by thorough GC-MS and LC-MS analyses. These methods have pinpointed multiple bioactive compounds, notably β-Sitosterol trimethylsilyl ether, recognized for its potential as an anti-hypercholesterolemic agent. Moreover, the *K. striatus* extract contains additional compounds with antihypertensive properties. Notably, LC-MS analysis identified terazosin, a known antihypertensive medication that offers favorable effects for hypertensive patients suffering from dyslipidemia or impaired glucose metabolism. These findings underscore the pharmacological potential of *K. striatus* in developing therapeutic interventions targeting cardiovascular health. The importance of GC-MS and LC-MS analysis lies in their ability to accurately characterize the phytochemicals present in *K. striatus*. This precise identification is crucial for understanding the potential pharmacological activities of these compounds. Further validation through *in vivo* studies is necessary to establish the efficacy of *K. striatus* phytoconstituents in treating hypercholesterolemia. These findings provide a foundation for the development of new drugs derived from seaweed, highlighting the potential of *K. striatus* as a valuable source of therapeutic agents.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

K. striatus: *Kappaphycus striatus*; **GCMS:** Gas chromatography-mass spectroscopy; **LCMS:** Liquid chromatography mass spectrophotometer; **HPLC:** High Performance liquid chromatography; **TIC:** Total ion chromatogram; **MIC:** Minimum inhibitory concentration; **CVD:** Cardio vascular disease; **TGs:** Triglycerides.

SUMMARY

The study aimed to analyse phytoconstituents present in the seaweed *K. striatus* for the treatment of hypertension and hypercholesterolemia. This seaweed *K. striatus* has been found to contain many valuable phytoconstituents such as carotenoids, phenolics, chitosan, gelatin, polyunsaturated fatty acids, and different vitamins and minerals, are thought to have favorable health effects. The analysis of phytoconstituents was carried out via GCMS and LCMS/MS methods. LCMS and GCMS analysis results showed the presence of different types of bioactive compounds in the extract of *K. striatus*. Some of the reported compounds were found to be useful in the treatment of hypertension and hypercholesterolemia. Further *in vivo* study is recommended to establish the potential role of *K. striatus* phytoconstituents in the treatment of hypercholesterolemia.

REFERENCES

1. Carina D, Sharma S, Jaiswal AK, Jaiswal S. Seaweeds polysaccharides in active food packaging: a review of recent progress. Trends Food Sci Technol. 2021;110:559-72. doi: 10.1016/j.tifs.2021.02.022.
2. Menaa F, Wijesinghe PA, Thiripuranathar G, Uzair B, Iqbal H, Khan BA, *et al.* Ecological and industrial implications of dynamic seaweed-associated microbiota interactions. Mar Drugs. 2020;18(12):641. doi: 10.3390/md18120641, PMID 33327517.
3. Cotas J, Leandro A, Pacheco D, Gonçalves AM, Pereira LA. A Comprehensive review of the nutraceutical and therapeutic applications of red seaweeds (Rhodophyta). Life (Basel). 2020;10(3):19. doi: 10.3390/life10030019, PMID 32110890.
4. Cermeño M, Kleekayai T, Amigo-Benavent M, Harnedy-Rothwell P, FitzGerald RJ. Current knowledge on the extraction, purification, identification, and validation of bioactive peptides from seaweed. Electrophoresis. 2020;41(20):1694-717. doi: 10.1002/elps.202000153, PMID 32627212.
5. Vieira EF, Soares C, Machado S, Correia M, Ramalhosa MJ, Oliva-Teles MT, *et al.* Seaweeds from the Portuguese coast as a source of proteinaceous material: total and free amino acid composition profile. Food Chem. 2018;269:264-75. doi: 10.1016/j.foodchem.2018.06.145, PMID 30100434.
6. Seca AM, Pinto DC. Overview on the antihypertensive and anti-obesity effects of secondary metabolites from seaweeds. Mar Drugs. 2018;16(7):237. doi: 10.3390/md16070237, PMID 30011911.
7. Gabbia D, De Martin S. Brown seaweeds for the management of metabolic syndrome and associated diseases. Molecules. 2020;25(18):4182. doi: 10.3390/molecules25184182, PMID 32932674.
8. Menon VV, Lele SS. Nutraceuticals and bioactive compounds from seafood processing waste. In: Springer handbook of marine biotechnology. Berlin, Heidelberg, Germany: Springer; 2015. p. 1405-25.
9. Moyama S, Minami K, Yano M, Okumura M, Hayashi S, Takayama H, *et al.* Relationship between dietary patterns and brachial-ankle pulse wave velocity among middle-aged adults in Japan. Asia Pac J Clin Nutr. 2017;26(3):539-44. doi: 10.6133/apjcn.032016.14, PMID 28429921.
10. Osonoi Y, Mita T, Osonoi T, Saito M, Tamasawa A, Nakayama S, *et al.* Relationship between dietary patterns and risk factors for cardiovascular disease in patients with type 2 diabetes mellitus: a cross-sectional study. Nutr J. 2016;15:15. doi: 10.1186/s12937-016-0132-6, PMID 26847556.
11. Lordan S, Ross RP, Stanton C. Marine bio actives as functional food ingredients: potential to reduce the incidence of chronic diseases. Mar Drugs. 2011;9(6):1056-100. doi: 10.3390/md9061056, PMID 21747748.
12. Fitzgerald C, Gallagher E, Tasdemir D, Hayes M. Heart health peptides from macroalgae and their potential use in functional foods. J Agric Food Chem. 2011;59(13):6829-36. doi: 10.1021/jf201114d, PMID 21574559.
13. Wada K, Nakamura K, Tamai Y, Tsuji M, Sahashi Y, Watanabe K, *et al.* Seaweed intake and blood pressure levels in healthy pre-school Japanese children. Nutr J. 2011;10:83. doi: 10.1186/1475-2891-10-83, PMID 21827710.
14. Lopes G, Barbosa M, Vallejo F, Gil-Izquierdo Á, Andrade PB, Valentão P, *et al.* Profiling phlorotannins from *Fucus* spp. Of the northern Portuguese coastline Chemical approach by HPLC-DAD-ESI/MSN and UPLC-ESI-QTOF/MS. Algal Res. 2018;29:113-20. doi: 10.1016/j.algal.2017.11.025.

15. Liu B, Kongstad KT, Wiese S, Jäger AK, Staerk D. Edible seaweed as future functional food: identification of α-glucosidase inhibitors by combined use of high-resolution α-glucosidase inhibition profiling and HPLC–HRMS–SPE–NMR. Food Chem. 2016;203:16-22. doi: 10.1016/j.foodchem.2016.02.001, PMID 26948583.
16. Uma G, Balasubramaniam V. GC-MS analysis of *Nothapodytes nimmoniana*, Mabberly leaves. J Chem Pharm. 2012;4(9):4417-9.
17. Héthelyi E, Tétényi P, Dabi E, Dános B. The role of mass spectrometry in medicinal plant research. Biomed Environ Mass Spectrom. 1987;14(11):627-32. doi: 10.1002/bms.1200141110, PMID 2962668.
18. Rezaeinasab R, Jafari E, Khodarahmi G. Quinazolinone-based hybrids with diverse biological activities: A mini-review. J Res Med Sci. 2022;27:68. doi: 10.4103/jrms.jrms_1025_21, PMID 36353342.
19. Mahadi M, Azizul MS, Eshak Z, Ibrahim AH, Akim AM, Kamal N. *Kappaphycus alvarezii* Supplementation Attenuates blood pressure, Blood cholesterol, ACE and Antioxidant Activities in Hypertensive and Hypercholesteroleamic Rats. Malays J Med Health Sci. 2021;17(11):72-80.
20. Luther RR. Terazosin: a new antihypertensive agent with favorable effects on lipids. Int J Clin Pharmacol Ther Toxicol. 1989;27(7):313-9. PMID 2570758.
21. Shionoiri H, Gotoh E, Ito T, Hata T, Iwatsubo H, Takegawa K, *et al.* Long-term therapy with terazosin may improve glucose and lipid metabolism in hypertensives: A multicenter prospective study. Am J Med Sci. 1994; 307(2);Suppl 1:SUPPL.7908168:S91-5. PMID 7908168.
22. Syakilla N, George R, Chye FY, Pindi W, Mantihal S, Wahab NA, *et al.* A review on nutrients, phytochemicals, and health benefits of green seaweed, *Caulerpa lentillifera*. Foods. 2022;11(18):1-24. doi: 10.3390/foods11182832, PMID 36140958.
23. Martinenghi LD, Jønsson R, Lund T, Jenssen H. Isolation, purification, and antimicrobial characterization of cannabidiolic acid and cannabidiol from cannabis sativa L. Biomolecules. 2020;10(6):1-16. doi: 10.3390/biom10060900, PMID 32545687.
24. Wang X, Wang Y, Xu J, Xue C. Sphingolipids in food and their critical roles in human health. Crit Rev Food Sci Nutr. 2021;61(3):462-91. doi: 10.1080/10408398.2020.1736510, PMID 32208869.
25. Symolon H et al. Enigmol: A novel sphingolipid analogue with anticancer activity against cancer cell lines and *in vivo* models for intestinal and prostate cancer," Mol Cancer Ther. 2011;4:648-57.
26. Aderibigbe SA. Antimicrobial activities of *Garcinia kola* seed oil against some clinical microbial isolates. Int Res J Pharm. 2012;2(3):68-72.
27. Uwagie-Ero EA, Nwaehujor CO, Ode JO. Investigation of polyisoprenyl benzophenone for anti-ulcer potentials in ethanol-HCl-induced gastric ulcerations in albino rats. Trop J Nat. Prod Res. 2020;4(6):228-32. doi: 10.26538/tjnpr/v4i6.3.
28. Lee CY, Park SH, Lim HY, Jang SG, Park KJ, Kim DS, et al. *In vivo* anti-inflammatory effects of *Prasiola japonica* ethanol extract. J Funct Foods. 2021;80:104440. doi: 10.1016/j.jff.2021.104440.
29. Behera A, Padhi S. Passive and active targeting strategies for the delivery of the camptothecin anticancer drug: a review. Environ Chem Lett. 2020;18(5):1557-67. doi: 10.1007/s10311-020-01022-9.
30. Andrew J, Brown. 25-epoxycholesterol: A messenger for cholesterol homeostasis. Interl J Biochem Cell Biol. 2009; 41(4). 24: 744-7.

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