Available online on 17.10.2022 at http://jddtonline.info

Journal of Drug Delivery and Therapeutics

Open Access to Pharmaceutical and Medical Research

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Research Article

Phytochemical Screening, GC-MS and FTIR analysis of Bioactive Compounds in Methanolic Leaf Extracts of Costus igneus (CIMLE) as a Natural Source of Drug Lead Molecules for Next-generation Drug-design, Development and Therapeutics

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Article Info:

Article History:

Received 29 August 2022
Reviewed 06 Oct 2022
Accepted 09 Oct 2022
Published 17 Oct 2022

Cite this article as:

Vijaya V, Karunai Selvi B, Arockia John PJ, Ramya S, Jayakumararaj R, Phytochemical Screening, GC-MS and FTIR analysis of Bioactive Compounds in Methanolic Leaf Extracts of *Costus igneus* (CIMLE) as a Natural Source of Drug Lead Molecules for Next-generation Drug-design, Development and Therapeutics, Journal of Drug Delivery and Therapeutics. 2022; 12(5-S):142-155

DOI: http://dx.doi.org/10.22270/jddt.v12i5-s.5658

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Abstract

Diabetes mellitus (DM) is a metabolic disorder that affects people of all ages. Increased prevalence of diabetes worldwide has led to the development of synthetic drugs to provide an interim solution to the ill effects of the issue. However, such drugs, although effective as antihyperglycemic agents, are accompanied by significant side effects, costly, and inaccessible to majority of people in remote in underdeveloped countries. Local medicinal plants have been used by such indigenous people through ages to treat such complicate ailments due to their ease of availability and GRAS nature. As diabetes continues to become prevalent, health care practitioners are considering PBNPs as a potential source of antidiabetic drugs due to their high potency and fewer side effects. To better understand the mechanism of action of medicinal plants, their active phytoconstituents are being isolated and investigated thoroughly. Phytochemical screening followed by GCMS analysis of methanolic leaf extracts of *Costus igneus* depicted the presence of 19 bioactive compounds viz., Bicyclo [3.1.1]heptane, 2,6,6- trimethyl-; 2-Pentadecanone, 6,10,14-trimethyl-; phthalic acid; 3,7,11,15-Tetramethyl-2-hexadecen- 1-ol; 5,9,13-Pentadecatrien-2-one, 6,10,14- trimethyl; 2(3H)-Furanone,dihydro-5-methyl-5- pentyl; Hexamethyl-2,6,10,14,18,22- tetracosahexaen-1-yl]-6-methox.; Oxalic acid, cyclohexyl isohexyl ester; 6-Octadecenoic acid; Phytol; 4,8,12,16-Tetramethylheptadecan-4- olide; 5-methyl-2,3-dihydro-1H-indole; Bis(2-ethylhexyl) phthalate; Adamantane-1-carboxylic acid methyl ester; Benzopyran-6-ol,3,4-dihydro-; Benzoquinoline; gamma-Tocopherol; dimethyl-5,5'-diphenyl-1H,; 1H-benzo[b]furo[2,3-f]indole that may be ADMET predicted for potential biomedical application in the treatment of diabetics and long term complications associated with the disease.

Keywords: *Costus igneus*; CIMLE; GCMS; Phytochemical Screening; Antidiabetic Leads; NDDT; Antidiabetic Medicinal Plant

INTRODUCTION

According to World Health Organization (WHO), 80% of the global population uses medicinal-plant-based medicine to alleviate or cure diseases.[1] In addition, although estimates vary depending on what is considered a natural-product-derived drug, it is safe to say that up to 50% of currently marketed drugs owe their origins to natural products.[2] New molecules from natural resources with potential bioactivity are reported every day; however, only a few of these molecules are evaluated for their suitability for use as drugs.[3] Identifying bioactive compounds (hits or leads) is the initial step for drug discovery. Therefore, it is necessary to select suitable bioassays to evaluate both the activity against the disease and the potency. For this purpose, target-based screening is mainly used to identify compounds that modulate the activity of a target involved in a disease. This screening involves different in vitro biological assays designed to measure primary activities, selectivity, cellular toxicity, and physiologically relevant activity. The initial phases of a target-based screening cascade typically employ a range of in vitro assays, especially high-throughput screening (HTS); however, the study is more expensive and time-consuming.[4] In the first instance, the assays can be selected considering that structurally similar compounds have similar biological activity; however, this cannot always be carried out, especially when working with natural compounds or natural extracts.

Extracts from various plants are commonly used in traditional medicine, either alone or in combination, but in many cases only a few of them are evaluated for their biological activity. However, due to inadequate fractionation processes or the

degradation of active compounds during separation, it is not always easy to identify the molecules responsible for the activity of these extracts. Since obtaining an isolated compound very often requires infrastructure and specialized personnel and is expensive, it is challenging to offer pharmacological alternatives of this nature to people with low incomes. In addition, since medicinal herbs can be grown locally at a reasonable cost, natural extracts remain an option for treating some diseases in populations with limited resources or living in remote areas.[5]

An important advantage of using crude extracts vs. isolated molecules is the presence of molecules in the extract that can interact synergistically with the bioactive compound, potentiating its beneficial effect.[6] However, despite their potential as accessible treatment options and as sources of bioactive molecules for drug discovery, it must be highlighted that similar to other pharmacological alternatives, natural extracts can also present adverse effects that should be considered and evaluated. Having many assays on hand to discard or confirm activities is critical when looking for bioactive compounds because the aim while looking for therapeutic agents is to identify an acceptable technique that can screen the source material for bioactivity.

Currently, there are numerous antidiabetic agents available for the treatment of diabetes mellitus (DM), which target different receptors.[7] The most important classes of antidiabetic oral medicines include biguanides, such as metformin, sulfonylureas, meglitinide, thiazolidinedione, dipeptidyl peptidase 4 inhibitors, sodium glucose cotransporter (SGLT2) inhibitors and α-glucosidase inhibitors.[8] Sulfonylureas increase insulin secretion by blocking KATP channels and therefore lower blood glucose levels. They are divided into first-generation agents, such as tolbutamide, chlorpropamide, acetohexamide, metahexamide and tolazamide, and second-generation agents, such as glipizide, glyburide, gliclazide, glibenclamide and glimepiride, which are sometimes also considered third-generation agents.[9] Another class of drugs for the treatment of DM is meglitinides (glinides), which include repaglinide and nateglinide. Diazoxide (DZ) is a direct insulin secretion inhibitor that is often used for the treatment of insulinoma, a rare neuroendocrine tumor of the pancreas that leads to hypoglycemia. DZ inhibits insulin release by opening KATP channels, in contrast to sulfonylureas, which stimulate insulin secretion by blocking KATP channels.[10]

Medicinal plants are used extensively as drugs for various diseases. Especially in developing countries, medicinal plants are used to treat DM due to the costs of conservative medicines.[11] Medicinal plants are a source of biological and chemical compounds that are important pharmaceuticals and are currently an important tool for the identification of novel drug lead compounds. A large number of plants, their extracts and their phytochemicals have been shown to affect the insulin secretion mechanism.[12] Galega officinalis, a plant that contains biguanide, has been used since the middle ages for the treatment of diabetes.[13] Several plant species are known for their antidiabetic properties, and a variety of plant extracts have been described to have valuable antidiabetic treatment effects. Importantly, these plants and their extracts are considered to be less toxic and have fewer side effects than synthetic drugs.[14-16] On the one hand, plant extracts can be used as complementary and alternative remedies to prevent metabolic diseases, and on the other hand, they are an interesting source of compounds for potential new drug candidates.[17]

Costus igneus Nak (syn. *Costus pictus* D. Don, *Costus mexicanus* Liebm ex Petersen or *Costus congenitus* Rowle), commonly known as fiery *Costus*, Step ladder or Spiral flag or Insulin plant, is native to South and Central America. This plant has been introduced to India from America as an herbal cure for diabetes and is popular as 'insulin plant.'[18] CI is a perennial, upright, herb grows up to 2 ft, in group from the rhizome. Leaves simple, alternate, entire, oblong, evergreen, 4- 21 inches in Lt with parallel venation (Prakash et al., 2014). Leaves - large, smooth, underside of leaves is shiny and spirally arranged around stems, aerial shoot arise from underground rootstocks (Prakash et al., 2014, Nayagam, 2015). Yellow flowers with red stripes (1.5-inch dia), appear on cone-like heads at tip of branches, and usually bloom during summer. CI is propagated by aerial stem cutting, adventitious buds and rhizome. Costus species has been used in folk medicine. CI contains diosgenin, steroidal saponins (prosapogenin, α & β dioscin), furostanol saponins (costunolide, octasanoic acid, cycloartenol). The plant exhibits hypolipidemic, diuretic, ameliorative, antimicrobial (antibacterial and antifungal), anticancer and putative agent of antidiabetic, hepatoprotective, antifertility, and antioxidants such as vitamin C, β-carotene and phenolic compounds (Vidigal Minim et al., 2011) activity. Trace elements like nitrogen, calcium, potassium, sodium, magnesium and phosphorus (Singh (2011) Ukana et al., (2012). screening for phytochemicals of *C. igneus* leaves revealed that it is rich in protein, iron, and antioxidant components such as ascorbic acid, α-tocopherol, β-carotene, terpinoids, steroids, and flavonoids.[19-21]

MATERIALS AND METHODS

Phytochemical Screening

C. igneus plant was collected from Botanical Garden maintained by Department of Botany, E.M.G. Yadava Women's College (A) Madurai, TamilNadu, India. Identity of the plant specimen was established followed by authentication at PG Department of Government Arts College, Melur, Madurai India. The plant material was cleaned in distilled water ($D.H_2O$) containing 2% mercury chloride followed by rinsing with double distilled water. Subsequently, the plant material was shade-dried at RT (37°C). Leaves were cut and pulverised to fine powder at RT. The fine powder was processed for the preparation of extract in 70% methanol (solvent) in an accelerated solvent extractor at −20 °C and 15 atmp pressure. The standard operational method was used to ensure quality during the preparation of extract (Fibigr et al., 2018). The extract was allowed to dry at optimum temperature (37°C). The yield of C. igneus was 70%. The dried extract was stored in a refrigerator at 4°C till further screening.

Phytochemical Screening/ GCMS, FTIR Analysis

The methanolic leaf extracts of *Costus igneus* were subjected to various chemical tests for the detection of phytoconstituents and GCMS, FTIR analysis using standard procedures described previously[22-40].

TEST FOR ALKALOIDS

Mayer's test: Few drops of Mayer's reagent was added to 1 mL of plant extract, appearance of a deep yellow or white precipitate indicated the presence of alkaloids in the solution. (Mayer's reagent was freshly prepared by dissolving mercuric chloride (1.36 g) and potassium iodide (5.00 g) in 100 ml water).

Dragendorff's test: To 2 mL of the extract added 1 mL of Dragendorff's reagent along the side of the test tube. Formation of orange or orange reddish brown precipitate

indicated the presence of alkaloids. Dragendorff's reagent was prepared by Sol A: 0.85g bismuth subnitrate, 40mL water, and 10mL glacial acetic acid and Sol B: 8g potassium iodide and 20mL water. 5mL each of Sol A & B with 20mL of glacial acetic acid and 70-100 mL of water is mixed to prepare Dragendorff's reagent.

Hager's test: Hager's test was done by adding a few drops of Hager's reagent to plant extracts and appearance of a yellow-color precipitate indicated the presence of alkaloids in the solution. Hager's reagent is saturated solution of picric acid.

Wagner's test: Approximately, 1 ml of crude extract was mixed with 2 ml of Wagner's reagent. Reddish brown colour precipitate indicates the presence of alkaloids. Wagner's Reagent was prepared by mixing 2.5 gm iodine in 12.5 gm of potassium iodide (KI 2); add 250 ml of water to produce solution.

TEST FOR GLYCOSIDES

Test for Anthraquinones Glycosides

Borntragers test: 0.5 g of extract was boiled with 10% hydrochloric acid for few minutes in water bath. It was filtered and allowed to cool. Equal volume of CHCl3 was added to the filtrate. Few drops of 10% ammonia was added to the mixture and heated. Formation of rose – pink color indicates of n-hexane, chloroform, ethyl acetate and methanol of the presence of the anthroquinones.

Baljet test: Part of plant containing cardiac glycoside is dipped in sodium picrate solution; formation of a yellow to orange colour indicates the presence of aglycones or glycosides in the plant tissues.

Legal's Test: To the concentrated ethanolic extract few drops of 10% NaOH were added, to make it alkaline. Then freshly prepared sodium nitroprusside was added to the solution. Presence of blue coloration indicated the presence of glycosides in the extract.

TEST FOR CARDIAC GLYCOSIDES

Keller-Kiliani test: 5 ml of extract was treated with 2 ml of glacial acetic acid containing one drop of ferric chloride solution. This was underlayed with 1 ml of concentrated sulphuric acid. A browning of the interface indicates a deoxy-sugar characteristic of carotenoids. A violet ring may appear below the brown ring, while in the acetic acid layer, a greenish ring may form just gradually throughout thin layer.

TEST FOR CARBOHYDRATES

Molisch's test: Small portion of the plant extract was put in a test tube; 10 ml of distilled water was added and shaken vigorously and gently. The mixture was then filters and divided into two portions. To the first portion, two drops of Molish's reagent was added followed by few drops of concentrated sulphuric acid by the wall of the test tube. Formation of brown or purple ring at the interphase indicated the presence of carbohydrates.

Fehling's test Equal volume of Fehling A and Fehling B reagents were mixed together and then add 2ml of crude extract in it and gently boiled. A brick red precipitate appeared at the bottom of the test-tube indicates the presence of reducing sugars.

Benedict's test 1 ml of crude extract was mixed with 2ml of Benedict's reagent and boiled. A reddish brown precipitate was formed which indicates the presence of the carbohydrates.

TEST FOR PHYTOSTEROLS

Libermann Burchard's Test: Dissolve one or two crystals of cholesterol in dry chloroform in a dry test tube. Add few drops of acetic anhydride and then 2 drops of concentrated H2SO4 and mix well. The formation of a green or green-blue colour after a few minutes indicates the presence of phytosterols. After the reaction, concentration of cholesterol can be measured spectrophotometry.

Salkowski's Test: On adding a few drops of conc. Sulphuric acid to the plant extract and allow the solution to stand for some time, formation of brown ring indicated the presence of phytosterols in the plant extract.

TEST FOR FLAVONOIDS

$FeCl_3$ Test: To 1 ml of the extract, 3 ml of distilled water followed by few drops of 10% aqueous Ferric chloride solution was added. Formation of blue or green colour indicates the presence of flavonoids. Shinoda Test: To 2 ml of the extract, 1 ml of 1% ammonia solution was added. Appearance of yellow colour indicates the presence of flavonoids.

Shinod's Test: In this test, four pieces of magnesium fillings (ribbon) are added to the ethanolic extract followed by a few drops of concentrated hydrochloric acid. A reddish colour indicates the presence of flavonoid.

TEST FOR FIXED OILS AND FATS

Spot test: Take the sample to be tested, press a little in the folds of the filter paper. On folding, if there is the appearance of greasy spot indicates the presence of oils or fats. The spot grows larger on heating and drying the filter paper.

Saponification: Take approximately 100 mg of oil or fat in a test tube. Add 3 mL of alcoholic-KOH and mix well. Place the tube in a boiling water bath for 15-20 min. Saponification value represents mg of potassium hydroxide required to saponify one gram of fat under the conditions specified. It is a measure of the average molecular weight of all the fatty acids present in the sample as triglycerides.

TEST FOR FREE AMINO ACIDS

Millon's reagent test: Millon's test is specific to phenol containing structures (tyrosine is the only common phenolic amino acid). Millon's reagent is concentrated HNO3, in which mercury is dissolved. As a result of the reaction a red precipitate or a red solution is considered as positive test.

Ninhydrin reagent test: A 2% solution of ninhydrin is prepared by dissolving 0.2 grams of ninhydrin in 10ml of either ethanol or acetone. 1% solution of the amino acid (analyte) in distilled water is prepared, few drops of 2% ninhydrin solution is added to this solution. Test tube is kept in a warm water bath for 5 min; development of a deep blue/violet colour indicates presence of amino acids.

TESTS FOR FIXED OILS AND FATS

Spot test Take the sample and place it between the folds of filter paper and rub it lightly. Presence of translucent spots on the filter paper confirms the presence of fats in in the plant material.

Saponification Take a sample a test tube, add strong alkali NaOH, boil the solution in a water bath for 5 min, add ethanol. Observe for the appearance of froth, formation of forth in the test tube indicates the presence of fat in the sample.

TEST FOR FREE AMINO ACID

Millon's test 1 ml of crude extract was mixed with 2ml of Millon's reagent; white precipitate appeared which turned red upon gentle heating that confirmed the presence of protein.

Ninhydrin test 1 ml of crude extract was mixed with 2ml of 0.2% solution of Ninhydrin and boiled. A violet colour precipitate was appeared suggesting the presence of amino acids and proteins.

TEST FOR TANNINS

5% Ferric chloride test: 5 mg of extract was taken and 0.5 ml of 5% ferric chloride was added. The development of dark bluish black color indicates the presence of tannins.

10% Lead acetate test: 10 mg of extract was taken and 0.5 ml of 1% lead acetate solution was added and the formation of precipitate indicates the presence of tannins and phenolic compounds.

TEST FOR SAPONINS

Foam Test: 2 ml of crude extract was mixed with 5 ml of distilled water in a test tube and it was shaken vigorously. Add some drops of olive oil. The formation of stable foam was taken as an indication for the presence of saponins.

GUMS & MUCILAGE

Ruthenium red test: 50 mg of dried mucilage powder was dissolved in 2 mL of distilled water, mixed with a few drops of Ruthenium red solution. Observed for pink color indicates the presence of gums and mucilage.

GC-MS Analysis:

Leaf samples of were collected from University Campus, Vellore, Tamilnadu, India. Phyto-components were identified using GC–MS detection system as described previously, however with modification, whereby portion of the extract was analyzed directly by headspace sampling. GCMS analysis was accomplished using an Agilent 7890A GC system set up with 5975C VL MSD (Agilent Technologies, CA, and USA). Capillary column used was DB-5MS (30 m × 0.25 mm, film thickness of 0.25 µm; J&W Scientific, CA, USA). Temperature program was set as: initial temperature 50°C held for 1 min, 5°C per min to 100°C, 9°C per min to 200°C held for 7.89 min, and the total run time was 30 min. The flow rate of helium as a carrier gas was 0.811851 mL/ min. MS system was performed in electron ionization (EI) mode with Selected Ion Monitoring (SIM). The ion source temperature and quadruple temperature were set at 230°C and 150°C, respectively. Identification of phyto-components was performed and confirmed by comparison of their retention times and mass with those of authentic standards spectra using computer searches in NIST 08.L and Wiley 7n.l libraries.

Fourier Transform Infrared Spectroscopy (FTIR) Analysis

The methanolic leaf extracts of CI (CIMLE) were subjected to FTIR analysis as describe previously, using Agilent Cary 630 FTIR spectrometer equipped with Micro-lab PC software with ATR sampling unit with a resolution of 8 cm-1and scan range of 4000 $cm^{-1}$to 650 cm^{-1}.

RESULTS AND DISCUSSION

Phytochemical screening of bioactive compounds in the methanolic leaf extracts of *Costus igneus* (CIMLE) Test for Alkaloids in the CIMLE using Mayer's Test (**+++**); Dragendorff's Test (**+++**); Hager's Test (**+++**); Wagner's Test (**+++**) showed the presence of alkaloids[41]; Test For Anthroquinone Glycosides in the leaf extracts of CI using Borntrager's Test (++); Baljet Test (++); Legal's Test (+) indicated the presence of anthroquinone glycosides[42]; Test for Cardiac Glycosides in the leaf extracts of CI using Keller-Killani Test (++) indicated the presence of cardiac glycosides; Test for Carbohydrates in the leaf extracts of CI using Molish's Test (++); Fehling's Solution Test (+); Bendict's Reagent Test (++) presence of carbohydrates in the CIMLE[41]; Test for Phytosterol in the leaf extracts of CI using Libermann Burchard's (++) and Salkowski's Test (+) depicted the presence of phytosterols in the leaf samples of CI[43]; Test for Flavonoids in the leaf extracts of CI using Ferric Chloride Test (++) and Shinod's Test (++) showed the presence of flavonoids as indicated by Reddy et al.[44]; Test for Fixed Oils and Fats in the leaf extracts of CI Spot Test **(+);** ; Saponification **(+);** ; Test for Free Amino Acids in the leaf extracts of CI Million's Reagent (++); Ninhydrin Reagent (++); Test for Tannins in the leaf extracts of CI using 5% Ferric Chloride (-) and 10% Lead Acetate (-) showed no results indicating the absence of tannins in the sample; Test for Saponins in the leaf extracts of CI Foam Test (+) indicated the presence of saponins; however, gums & mucilage were absent in CIMLE samples (Table 1). In the present study, phytochemical screening of methanolic leaf extracts of *C. igneus* showed the presence of alkaloids, glycosides, saponins, phytosterols, phenolics, and carbohydrates as indicated earlier by Khanday et al[45].

GCMS profile of *Costus igneus* indicated the presence of 21 compounds in the sample. At RTI of 16.303 Bicyclo [3.1.1]heptane, 2,6,6- trimethyl- ($C_{10}H_{18}$); at RTI of 16.361 - 2-Pentadecanone, 6,10,14-trimethyl- ($C_{18}H_{36}O$); at RTI of 16.564 - Bicyclo [3.1.1]heptane, 2,6,6- trimethyl- ($C_{10}H_{18}$); at RTI of 16.637 phthalic acid ($C_8H_6O_4$); at RTI of 16.739 - 3,7,11,15-Tetramethyl-2-hexadecen-1-ol ($C_{20}H_{40}O$); at RTI of 17.145 - 5,9,13-Pentadecatrien-2-one, 6,10,14- trimethyl ($C_{18}H_{30}O$); at RTI of 17.595 - 2(3H)-Furanone,dihydro-5-methyl-5- pentyl ($C_{10}H_{18}O_2$); at RTI of 17.828 - Hexamethyl-2,6,10,14,18,22-tetracosahexaen-1-yl]-6-methox ($C_{30}H_{50}O$); at RTI of 18.525 - Oxalic acid, cyclohexyl isohexyl ester ($C_{14}H_{24}O_4$); at RTI of 18.844 - 6-Octadecenoic acid ($C_{18}H_{34}O_2$); at RTI of 19.077 - Phytol ($C_{20}H_{40}O$); at RTI of 21.066 - 4,8,12,16-Tetramethylheptadecan-4- olide ($C_{21}H_{40}O_2$); at RTI of 21.313 - 5-methyl-2,3-dihydro-1H-indole ($C_9H_7BrN_2O$); at RTI of 22.591 - Bis(2-ethylhexyl) phthalate ($C_{12}H_{14}O_4$); at RTI of 24.232 - Adamantane-1-carboxylic acid methyl ester ($C_{12}H_{18}O_2$); at RTI of 25.815 - Benzopyran-6-ol,3,4-dihydro- ($C_{22}H_{36}O_2$); at RTI of 25.815 - Benzoquinoline ($C_{13}H_9N$); at RTI of 26.193 - gamma-Tocopherol ($C_{28}H_{48}O_2$); at RTI of 26.411 - dimethyl-5,5'-diphenyl-1H, ($C_{14}H_7NO_3$); at RTI of 28.56 - 1H-benzo[b]furo[2,3-f]indole ($C_{18}H_{16}N_6S_2$) were detected in the samples[46,47] (Table 2; Fig. 1a-l). IUPAC name and 2D structure of bioactive compounds in *Costus igneus* have been listed in Table 3. Further, FTIR analysis confirmed the presence of the reported compounds in the samples (Table 4; Fig.2). Recently, Adetayo and Anyasor[48] through *in-silico* approach demonstrated gastroprotective activity of bioactive compounds from n-butanol fraction of *Costus igneus* on antiulcer druggable targets and showed that NQP exhibited substantial inhibitory effects on proton pump, urease activity, muscarinic and histamine receptors.

CONCLUSION

In the present study, both phytochemical screening and GCMS/ FTIR analysis of CIMLE showed the presence of as much as 20 bioactive compounds in the methanolic leaf extracts. If further explored for potential source of drug leads under deeper dimensions of ADMETox, this traditional medicinal plant could provide novel leads for the management of diabetics and its associated complications.

REFERENCES

1. Malaquias, G.; Santos Cerqueira, G.; Pinheiro Ferreira, P.M.; Landim Pacheco, A.C.; de Castro e Souza, J.M.; do Socorro Meireles de Deus, M.; Peron, A.P. Utilização na medicina popular, potencial terapêutico e toxicidade em nível celular das plantas Rosmarinus officinalis L., Salvia officinalis L. e Mentha piperita L. (Família Lamiaceae). Rev. Intertox Toxicol. Risco Ambient. Soc. 2015; 7:50-68 https://doi.org/10.22280/revintervol7ed3.183

2. Kingston, D.G.I. Modern natural products drug discovery and its relevance to biodiversity conservation. J. Nat. Prod. 2011; 74:496-511 https://doi.org/10.1021/np100550t

3. Fabricant, D.S.; Farnsworth, N.R. The value of plants used in traditional medicine for drug discovery. Environ. Health Perspect. 2001; 109(Suppl. S1):69-75 https://doi.org/10.1289/ehp.01109s169

4. Batool, M.; Ahmad, B.; Choi, S. A Structure-Based Drug Discovery Paradigm. Int. J. Mol. Sci. 2019, 20, 2783; Martin, Y.C.; Kofron, J.L.; Traphagen, L.M. Do structurally similar molecules have similar biological activity? J. Med. Chem. 2002; 45:4350-4358 https://doi.org/10.1021/jm020155c

5. Rasoanaivo, P.; Wright, C.W.; Willcox, M.L.; Gilbert, B. Whole plant extracts versus single compounds for the treatment of malaria: Synergy and positive interactions. Malar. J. 2011; 10 (Suppl. S1), S4 https://doi.org/10.1186/1475-2875-10-S1-S4

6. Gilbert, B.; Alves, L. Synergy in plant medicines. Curr. Med. Chem. 2003; 10:13-20 https://doi.org/10.2174/0929867033368583

7. Kerru, N.; Singh-Pillay, A.; Awolade, P.; Singh, P. Current anti-diabetic agents and their molecular targets: A review. Eur. J. Med. Chem. 2018; 152:436-488 https://doi.org/10.1016/j.ejmech.2018.04.061

8. Chaudhury, A.; Duvoor, C.; Reddy Dendi, V.S.; Kraleti, S.; Chada, A.; Ravilla, R.; Marco, A.; Shekhawat, N.S.; Montales, M.T.; Kuriakose, K.; et al. Clinical Review of Antidiabetic Drugs: Implications for Type 2 Diabetes Mellitus Management. Front. Endocrinol. 2017, 8:6. https://doi.org/10.3389/fendo.2017.00006

9. Doyle, M.E.; Egan, J.M. Pharmacological agents that directly modulate insulin secretion. Pharmacol. Rev. 2003; 55:105-131 https://doi.org/10.1124/pr.55.1.7

10. Sola, D.; Rossi, L.; Schianca, G.P.C.; Maffioli, P.; Bigliocca, M.; Mella, R.; Corlianò, F.; Fra, G.P.; Bartoli, E.; Derosa, G. Sulfonylureas and their use in clinical practice. Arch. Med. Sci. 2015; 11:840-848 https://doi.org/10.5114/aoms.2015.53304

11. Mariot, P.; Gilon, P.; Nenquin, M.; Henquin, J.C. Tolbutamide and diazoxide influence insulin secretion by changing the concentration but not the action of cytoplasmic Ca2+ in beta-cells. Diabetes 1998; 47:365-373 https://doi.org/10.2337/diabetes.47.3.365

12. Arumugam, G.; Manjula, P.; Paari, N. A review: Anti diabetic medicinal plants used for diabetes mellitus. J. Acute Dis. 2013; 2:196-200 https://doi.org/10.1016/S2221-6189(13)60126-2

13. Govindappa, M. A Review on Role of Plant(s) Extracts and its Phytochemicals for the Management of Diabetes. J. Diabetes Metab. 2015; 6:1-38

14. Witters, L.A. The blooming of the French lilac. J. Clin. Investig. 2001; 108:1105-1107 https://doi.org/10.1172/JCI14178

15. Pothuraju, R.; Sharma, R.K.; Onteru, S.K.; Singh, S.; Hussain, S.A. Hypoglycemic and Hypolipidemic Effects of Aloe vera Extract Preparations: A Review. Phytother. Res. 2016; 30:200-207 https://doi.org/10.1002/ptr.5532

16. Gushiken, L.F.; Beserra, F.P.; Rozza, A.L.; Bérgamo, P.L.; Bérgamo, D.A.; Pellizzon, C.H. Chemical and Biological Aspects of Extracts from Medicinal Plants with Antidiabetic Effects. Rev. Diabet. Stud. 2016; 13:96-112 https://doi.org/10.1900/RDS.2016.13.96

17. Thomford, N.E.; Senthebane, D.A.; Rowe, A.; Munro, D.; Seele, P.; Maroyi, A.; Dzobo, K. Natural Products for Drug Discovery in the 21st Century: Innovations for Novel Drug Discovery. Int. J. Mol. Sci. 2018; 19:1578 https://doi.org/10.3390/ijms19061578

18. Newman, D.J.; Cragg, G.M. Natural products as sources of new drugs over the last 25 years. J. Nat. Prod. 2007; 70:461-477 https://doi.org/10.1021/np068054v

19. Jose B, Reddy LJ. Analysis of the essential oils of the stems, leaves and rhizomes of the medicinal plant Costus pictus from southern India. Int J Pharmacy Pharm Sci. 2010; 2(Suppl 2):100-1

20. Shankarappa L, Gopalakrishna B, Jagadish NR, Siddalingappa GS. Pharmacognostic and phytochemical analysis of Costus ignitius. Internationale Pharmaceutica Sciencia. 2011; 1:36-41.

21. Hegde PK, Rao HA, Rao PN. A review on Insulin plant (Costus igneus Nak). Pharmacognosy reviews. 2014 Jan; 8(15):67 https://doi.org/10.4103/0973-7847.125536

22. Hajam YA, Kumar R, Reshi MS, Rawat DS, AlAsmari AF, Ali N, Ali YS, Ishtikhar M. Administration of Costus igneus Nak leaf extract improves diabetic-induced impairment in hepatorenal functions in male albino rats. Journal of King Saud University-Science. 2022 Jun 1; 34(4):101911. https://doi.org/10.1016/j.jksus.2022.101911

23. Chandran M, Priyanka R, Kavipriya D, Ramya S, Jayakumararaj R, Loganathan T, Pandiarajan G, Kaliraj P, Pushpalatha GG, Abraham GC, Dhakar RC. Reformulation and Scientific Evaluation of CUSOCO: A Traditional Toothpaste Formula from Classical Tamil Literature towards treatment of Halitosis. Journal of Drug Delivery and Therapeutics. 2022; 12(5):127-31. https://doi.org/10.22270/jddt.v12i5.5604

24. Jeevalatha A, Kalaimathi RV, Basha AN, Kandeepan C, Ramya S, Loganathan T, Jayakumararaj R. Profile of bioactive compounds in Rosmarinus officinalis. Journal of Drug Delivery and Therapeutics. 2022; 12(1):114-22. https://doi.org/10.22270/jddt.v12i1.5189

25. Kalaimathi RV, Jeevalatha A, Basha AN, Kandeepan C, Ramya S, Loganathan T, Jayakumararaj R. In-silico Absorption, Distribution, Metabolism, Elimination and Toxicity profile of Isopulegol from Rosmarinus officinalis. Journal of Drug Delivery and Therapeutics. 2022; 12(1):102-8. https://doi.org/10.22270/jddt.v12i1.5188

26. Kalaimathi RV, Krishnaveni K, Murugan M, Basha AN, Gilles AP, Kandeepan C, Senthilkumar N, Mathialagan B, Ramya S, Ramanathan L, Jayakumararaj R. ADMET informatics of Tetradecanoic acid (Myristic Acid) from ethyl acetate fraction of Moringa oleifera leaves. Journal of Drug Delivery and Therapeutics. 2022; 12(4-S):101-11. https://doi.org/10.22270/jddt.v12i4-S.5533

27. Kandeepan C, Kalaimathi RV, Jeevalatha A, Basha AN, Ramya S, Jayakumararaj R. In-silico ADMET Pharmacoinformatics of Geraniol (3, 7-dimethylocta-trans-2, 6-dien-1-ol)-acyclic monoterpene alcohol drug from Leaf Essential Oil of Cymbopogon martinii from Sirumalai Hills (Eastern Ghats), INDIA. Journal of Drug Delivery and Therapeutics. 2021; 11(4-S):109-18. https://doi.org/10.22270/jddt.v11i4-S.4965

28. Kandeepan C, Sabitha M, Parvathi K, Senthilkumar N, Ramya S, Boopathi NM, Jayakumararaj R. Phytochemical Screening, GCMS Profile, and In-silico properties of Bioactive Compounds in Methanolic Leaf Extracts of Moringa oleifera. Journal of Drug Delivery and Therapeutics. 2022; 12(2):87-99. https://doi.org/10.22270/jddt.v12i2.5250

29. Krishnaveni K, Sabitha M, Murugan M, Kandeepan C, Ramya S, Loganathan T, Jayakumararaj R. vNN model cross validation towards Accuracy, Sensitivity, Specificity and kappa performance measures of β-caryophyllene using a restricted-unrestricted applicability domain on Artificial Intelligence & Machine Learning approach based in-silico prediction. Journal of Drug Delivery and Therapeutics. 2022; 12(1-S):123-31. https://doi.org/10.22270/jddt.v12i1-S.5222

30. Loganathan T, Barathinivas A, Soorya C, Balamurugan S, Nagajothi TG, Ramya S, Jayakumararaj R. Physicochemical, Druggable, ADMET Pharmacoinformatics and Therapeutic Potentials of Azadirachtin-a Prenol Lipid (Triterpenoid) from Seed Oil Extracts of Azadirachta indica A. Juss. Journal of Drug Delivery and

Therapeutics. 2021; 11(5):33-46. https://doi.org/10.22270/jddt.v11i5.4981

31. Murugan M, Krishnaveni K, Sabitha M, Kandeepan C, Senthilkumar N, Loganathan T, Pushpalatha GL, Pandiarajan G, Ramya S, Jayakumararaj R. In silico Target Class Prediction and Probabilities for Plant Derived Omega 3 Fatty Acid from Ethyl Acetate Fraction of Moringa oleifera Leaf Extract. Journal of Drug Delivery and Therapeutics. 2022; 12(3):124-37. https://doi.org/10.22270/jddt.v12i3.5352

32. Nazar S, Jeyaseelan M, Jayakumararaj R. Local Health Traditions, Cultural Reflections and Ethno-taxonomical Information on Wild Edible Fruit Yielding Medicinal Plants in Melur Region of Madurai District, TamilNadu, India. Journal of Drug Delivery and Therapeutics. 2022; 12(3):138-57. https://doi.org/10.22270/jddt.v12i3.5405

33. Parvathi K, Kandeepan C, Sabitha M, Senthilkumar N, Ramya S, Boopathi NM, Ramanathan L, Jayakumararaj R. In-silico Absorption, Distribution, Metabolism, Elimination and Toxicity profile of 9, 12, 15-Octadecatrienoic acid (ODA) from Moringa oleifera. Journal of Drug Delivery and Therapeutics. 2022; 12(2-S):142-50. https://doi.org/10.22270/jddt.v12i2-S.5289

34. Ramya S, Loganathan T, Chandran M, Priyanka R, Kavipriya K, Pushpalatha GG, Aruna D, Ramanathan L, Jayakumararaj R, Saluja V. Phytochemical Screening, GCMS, FTIR profile of Bioactive Natural Products in the methanolic extracts of Cuminum cyminum seeds and oil. Journal of Drug Delivery and Therapeutics. 2022; 12(2-S):110-8. https://doi.org/10.22270/jddt.v12i2-S.5280

35. Ramya S, Loganathan T, Chandran M, Priyanka R, Kavipriya K, Pushpalatha GL, Aruna D, Abraham GC, Jayakumararaj R. ADME-Tox profile of Cuminaldehyde (4-Isopropylbenzaldehyde) from Cuminum cyminum seeds for potential biomedical applications. Journal of Drug Delivery and Therapeutics. 2022; 12(2-S):127-41. https://doi.org/10.22270/jddt.v12i2-S.5286

36. Ramya S, Murugan M, Krishnaveni K, Sabitha M, Kandeepan C, Jayakumararaj R. In-silico ADMET profile of Ellagic Acid from Syzygium cumini: A Natural Biaryl Polyphenol with Therapeutic Potential to Overcome Diabetic Associated Vascular Complications. Journal of Drug Delivery and Therapeutics. 2022; 12(1):91-101. https://doi.org/10.22270/jddt.v12i1.5179

37. Ramya S, Neethirajan K, Jayakumararaj R. Profile of bioactive compounds in Syzygium cumini-a review. J. Pharm. Res. 2012; 5(8):4548-53.

38. Ramya S, Soorya C, Pushpalatha GG, Aruna D, Loganathan T, Balamurugan S, Abraham GC, Ponrathy T, Kandeepan C, Jayakumararaj R. Artificial Intelligence and Machine Learning approach based in-silico ADME-Tox and Pharmacokinetic Profile of α-Linolenic acid from Catharanthus roseus (L.) G. Don. Journal of Drug Delivery and Therapeutics. 2022; 12(2-S):96-109. https://doi.org/10.22270/jddt.v12i2-S.5274

39. Ramya S, Sutha S, Chandran M. Priyanka R, Loganathan T, Pandiarajan G, Kaliraj P, Grace Lydial Pushpalatha G, Abraham GC Jayakumararaj R, ADMET-informatics, Pharmacokinetics, Drug-likeness and Medicinal Chemistry of Bioactive Compounds of Physalis minima Ethanolic Leaf Extract (PMELE) as a Potential Source of Natural Lead Molecules for Next Generation Drug Design, Development and Therapies , Journal of Drug Delivery and Therapeutics. 2022; 12(5):188-200 https://doi.org/10.22270/jddt.v12i5.5654

40. Sabitha M, Krishnaveni K, Murugan M, Basha AN, Pallan GA, Kandeepan C, Ramya S, Jayakumararaj R. In-silico ADMET predicated Pharmacoinformatics of Quercetin-3-Galactoside, polyphenolic compound from Azadirachta indica, a sacred tree from Hill Temple in Alagarkovil Reserve Forest, Eastern Ghats, INDIA. Journal of Drug Delivery and Therapeutics. 2021; 11(5-S):77-84. https://doi.org/10.22270/jddt.v11i5-S.5026

41. Suganandam K, Jeevalatha A, Kandeepan C, Kavitha N, Senthilkumar N, Sutha S, Seyed MA, Gandhi S, Ramya S, Grace Lydial Pushpalatha G, Abraham GC, Jayakumararaj R, Profile of Phytochemicals and GCMS Analysis of Bioactive Compounds in Natural Dried-Seed Removed Ripened Pods Methanolic Extracts of Moringa oleifera, Journal of Drug Delivery and Therapeutics. 2022; 12(5-S):133-141

42. Hegde PK, Rao HA, Rao PN. A review on Insulin plant (Costus igneus Nak). Pharmacognosy reviews. 2014 Jan; 8(15):67. https://doi.org/10.4103/0973-7847.125536

43. Thiruchenduran S, Maheswari KU, Prasad TN, Rajeswari B, Suneetha WJ. UV-Vis scanning coupled with PCA as an alternative method for phytochemical screening of natural products-Costus Igneus leaf metabolites. Journal of Pharmacognosy and Phytochemistry. 2017; 6(1):411-6.

44. Muthukumar C, Cathrine L, Gurupriya S. Qualitative and quantitative phytochemical analysis of Costus igenus leaf extract. Journal of Pharmacognosy and Phytochemistry. 2019; 8(4):1595-8.

45. Reddy Peasari J, sri Motamarry S, Varma KS, Anitha P, Potti RB. Chromatographic analysis of phytochemicals in Costus igneus and computational studies of flavonoids. Informatics in Medicine Unlocked. 2018 Jan 1; 13:34-40. https://doi.org/10.1016/j.imu.2018.10.004

46. Khanday W, Wani N, Paulraj B. Antioxidant and cytotoxic potential of leaf extracts of Costus igneus. Journal of Natural Science, Biology and Medicine. 2019 Jul 1; 10(2):157-66. https://doi.org/10.4103/jnsbm.JNSBM_216_18

47. Shiny CT, Saxena A, Gupta SP. Phytochemical investigation of the insulin plant "Costus pictus" D. Don. Int J Pharm Biomed Res. 2013;4(2):97-104.

48. Kumar A, Maurya AK, Chand G, Agnihotri VK. Comparative metabolic profiling of Costus speciosus leaves and rhizomes using NMR, GC-MS and UPLC/ESI-MS/MS. Natural product research. 2018 Apr 3; 32(7):826-33. https://doi.org/10.1080/14786419.2017.1365069

49. Adetayo MO, Anyasor GS. In Silico Investigation of Gastroprotective Compounds from n-Butanol Fraction of Costus igneus on Antiulcer Druggable Targets. The FASEB Journal. 2022 May; 36. https://doi.org/10.1096/fasebj.2022.36.S1.R3085

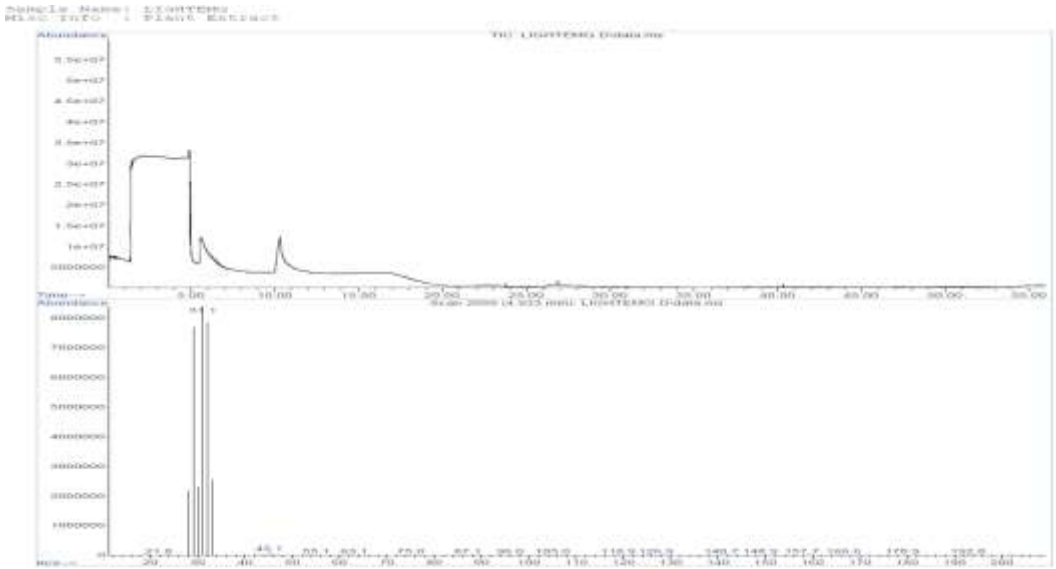
Table 1 Phytochemical Examination with solvent plant extracts

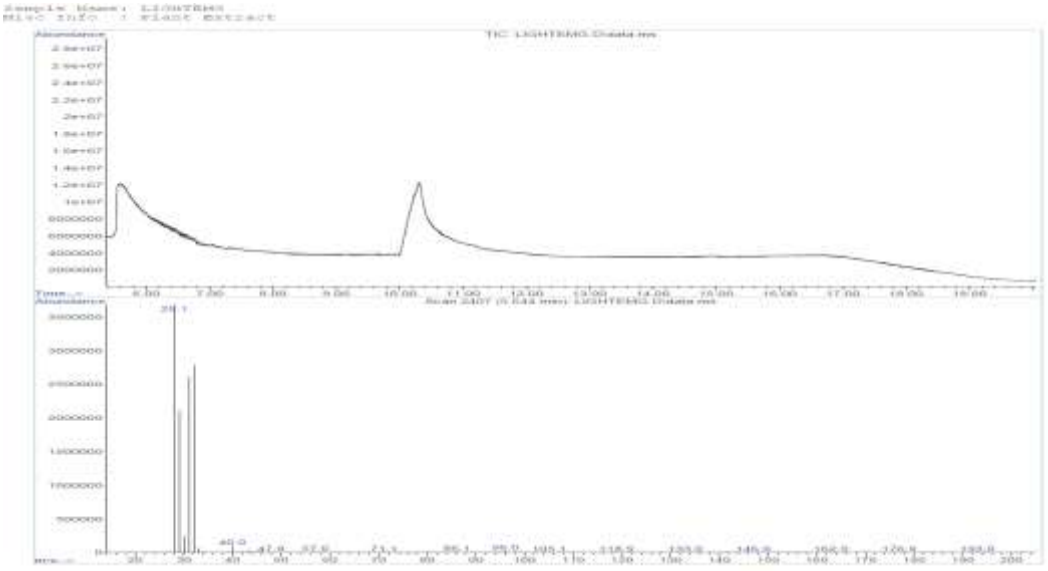
S. No	Plant constituents tested & Reagent used	Methanol Extract (CIMLE)
1	**TEST FOR ALKALOIDS**	
1.1	*Mayer's test*	**+++**
1.2	*Dragendorff's test*	**+++**
1.3	*Hager's test*	**+++**
1.4	*Wagner's test*	**+++**
2.1	**TEST FOR GLYCOSIDES – Anthroquinone**	
2.1.1	*Borntrager's test*	**++**
2.1.2	*Baljet test*	**++**
2.1.3	*Legal's test*	**+**
2.2	**TEST FOR GLYCOSIDES - Cardiac**	
2.2.1	*Keller-Killani test*	**++**
3	**TEST FOR CARBOHYDRATES**	
3.1	*Molish's test*	**++**
3.2	*Fehling's solution test*	**+**
3.3	*Bendict's reagent test*	**++**
4	**TEST FOR PHYTOSTEROLS**	
4.1	*Libermann Burchard's*	**++**
4.2	*Salkowski's test*	**+**
5	**TEST FOR FLAVONOIDS**	
5.1	*Ferric chloride test*	**+**
5.2	*Shinod's test*	**++**
6	**TEST FOR FIXED OILS AND FATS**	
6.1	*Spot test*	**+**
6.2	*Saponification*	**+**
7	**TEST FOR FREE AMINO ACIDS**	
7.1	*Million's reagent*	**++**
7.2	*Ninhydrin reagent*	**++**
8	**TEST FOR TANNINS**	
8.1	*5% Ferric chloride*	**-**
8.2	*10% Lead acetate*	**-**
9	**TEST FOR SAPONINS**	
9.1	*Foam test*	**+**
10	**GUMS & MUCILAGE**	**-**

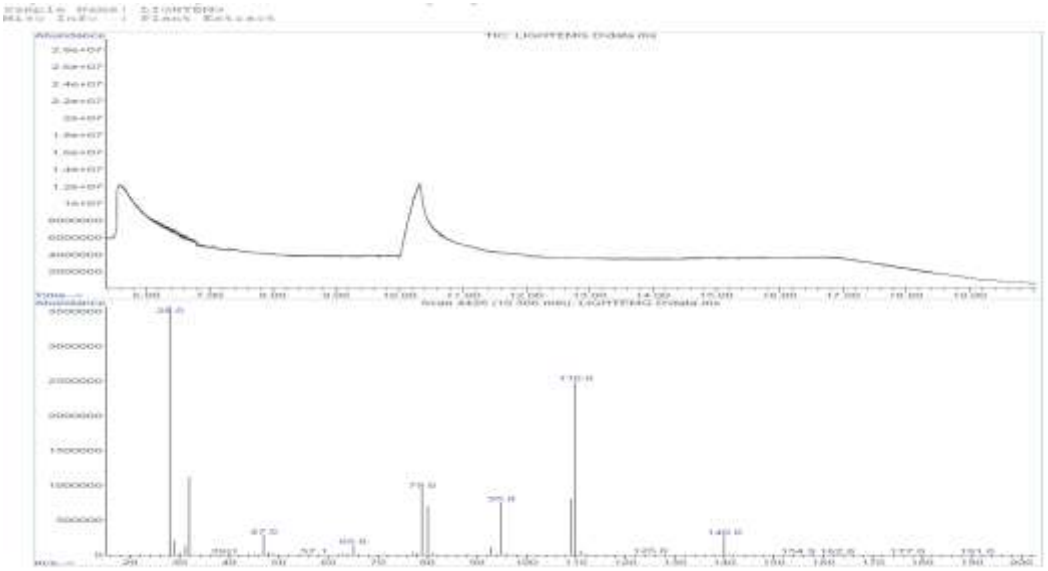
Note: + indicates positive result; - indicates negative result

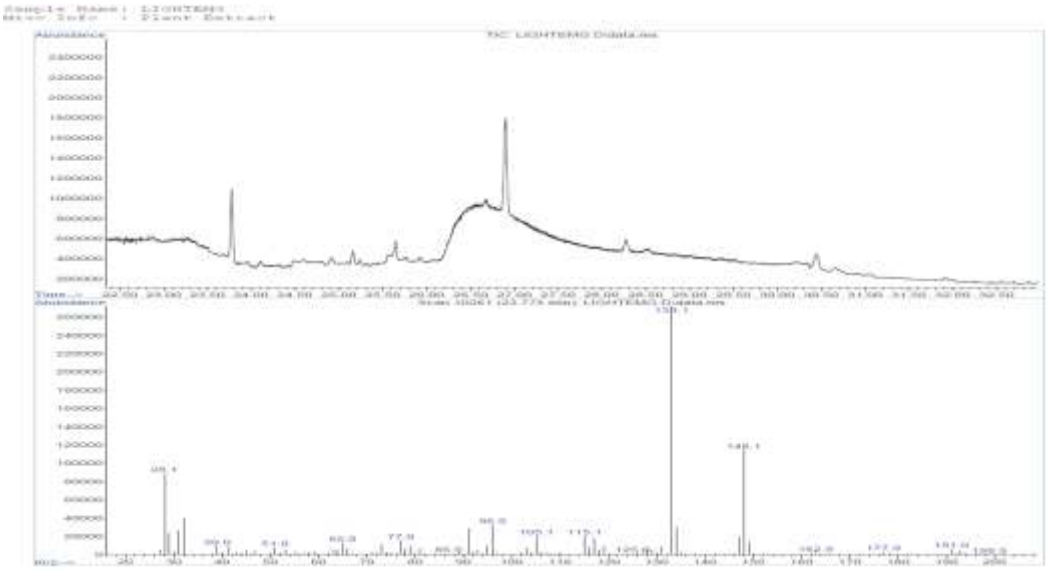
Table 2 GCMS Profile of Bioactive Compounds in *Costus igneus*

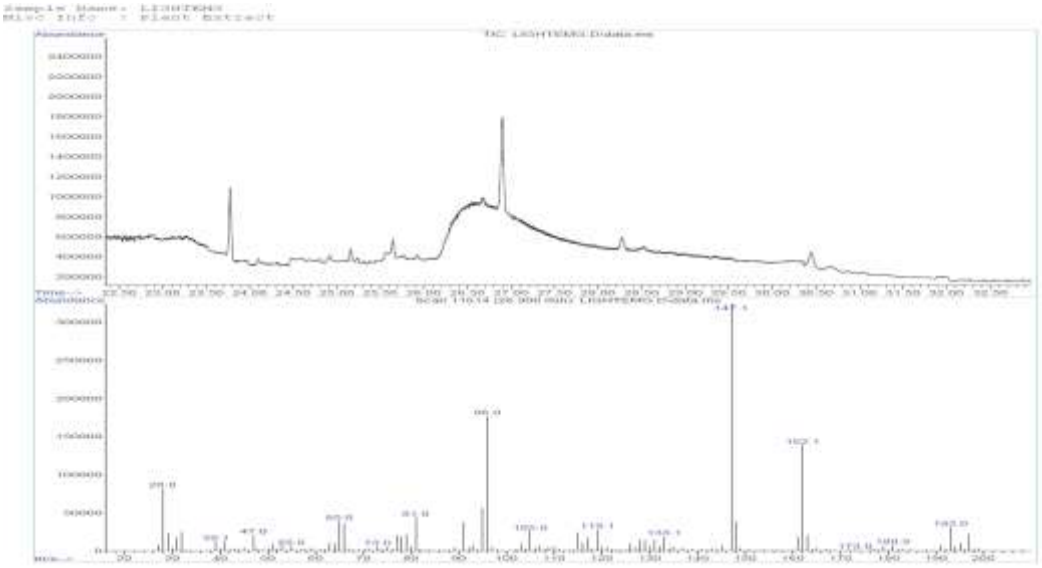
RT	COMPOUND	MW	MF	AREA%
16.303[a]	**Bicyclo [3.1.1]heptane, 2,6,6- trimethyl-**	**138.24**	**$C_{10}H_{18}$**	**4.27**
16.361[b]	**2-Pentadecanone, 6,10,14-trimethyl-**	**268.47**	**$C_{18}H_{36}O$**	**6.68**
16.564	Bicyclo [3.1.1]heptane, 2,6,6- trimethyl-	138.24	$C_{10}H_{18}$	0.79
16.637	phthalic acid	166.13	$C_8H_6O_4$	0.34
16.739[c]	**3,7,11,15-Tetramethyl-2-hexadecen- 1-ol**	**296.54**	**$C_{20}H_{40}O$**	**2.43**
17.145[d]	**5,9,13-Pentadecatrien-2-one, 6,10,14- trimethyl**	**262.41**	**$C_{18}H_{30}O$**	**14.33**
17.595[e]	**2(3H)-Furanone,dihydro-5-methyl-5- pentyl**	**170.24**	**$C_{10}H_{18}O_2$**	**3.92**
17.828	Hexamethyl-2,6,10,14,18,22- tetracosahexaen-1-yl]-6-methox.	426.71	$C_{30}H_{50}O$	0.82
18.525	Oxalic acid, cyclohexyl isohexyl ester	256.33	$C_{14}H_{24}O_4$	0.83
18.844	6-Octadecenoic acid	282.46	$C_{18}H_{34}O_2$	0.77
19.077[f]	**Phytol**	**296.53**	**$C_{20}H_{40}O$**	**9.52**
21.066[g]	**4,8,12,16-Tetramethylheptadecan-4- olide**	**324.54**	**$C_{21}H_{40}O_2$**	**5.37**
21.313	5-methyl-**2**,3-dihydro-1H-indole	239.08	$C_9H_7BrN_2O$	0.64
22.591	Bis(2-ethylhexyl) phthalate	222.24	$C_{12}H_{14}O_4$	1.05
24.232	Adamantane-1-carboxylic acid methyl ester	194.27	$C_{12}H_{18}O_2$	1.04
25.815[h]	**Benzopyran-6-ol,3,4-dihydro-**	**332.51**	**$C_{22}H_{36}O_2$**	**3.37**
25.815[i]	**Benzoquinoline**	**179.23**	**$C_{13}H_9N$**	**1.33**
26.193[j]	**gamma-Tocopherol**	**416.68**	**$C_{28}H_{48}O_2$**	**4.96**
26.411[k]	**dimethyl-5,5'-diphenyl-1H,**	**237.21**	**$C_{14}H_7NO_3$**	**15.05**
28.56[h]	**1H-benzo[b]furo[2,3-f]indole**	**380.5**	**$C_{18}H_{16}N_6S_2$**	**20.57**

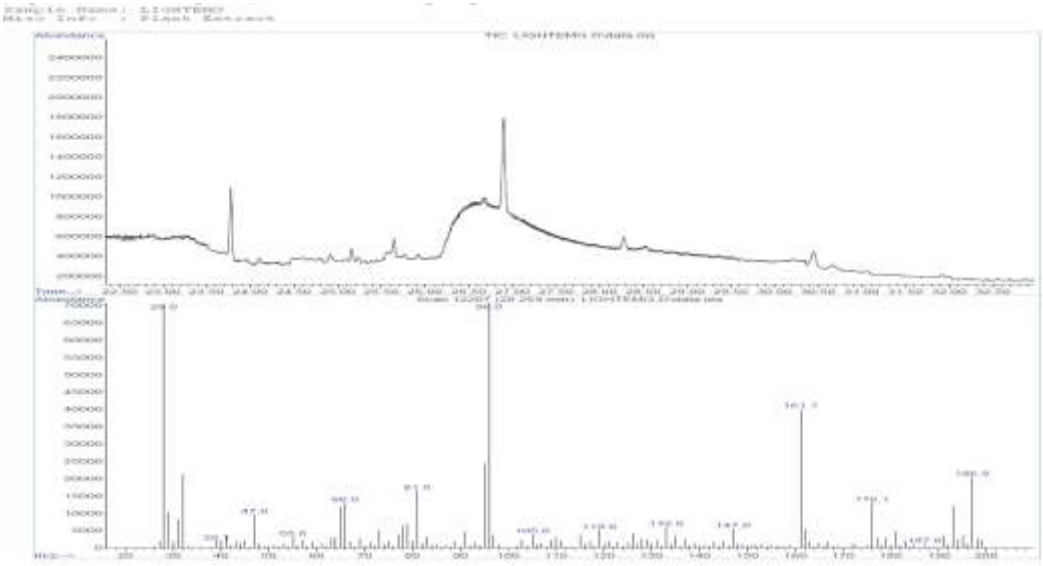


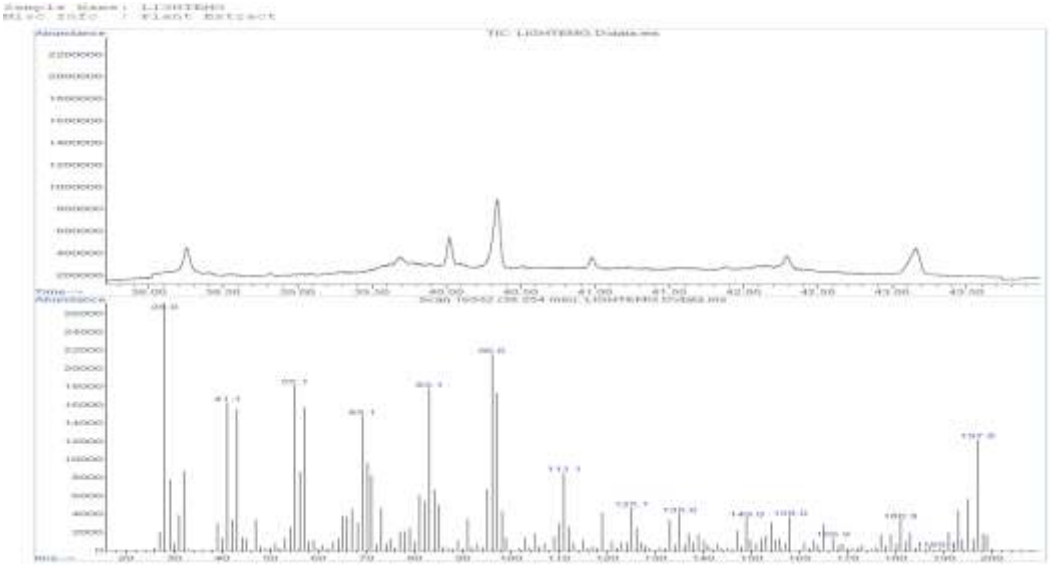


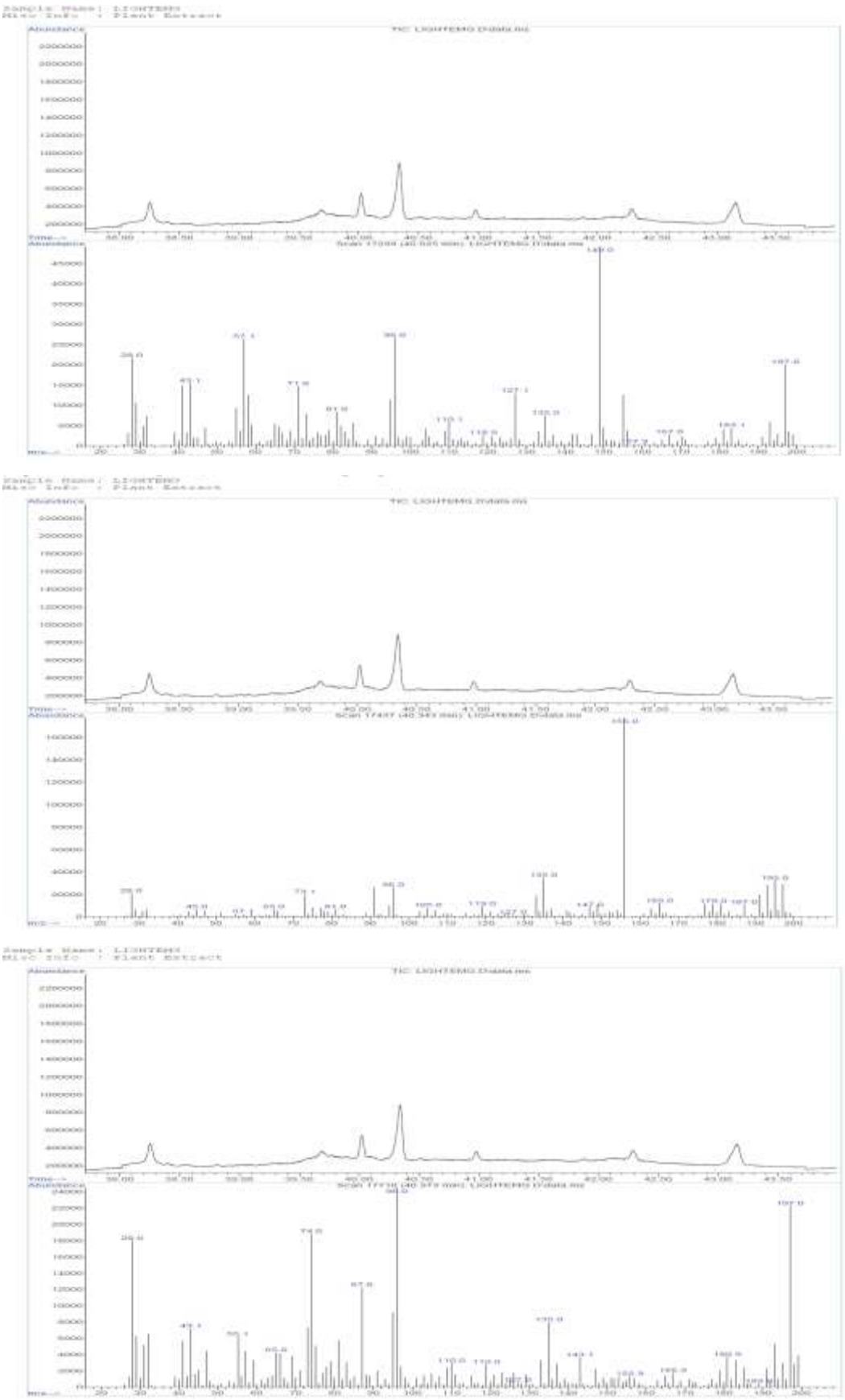












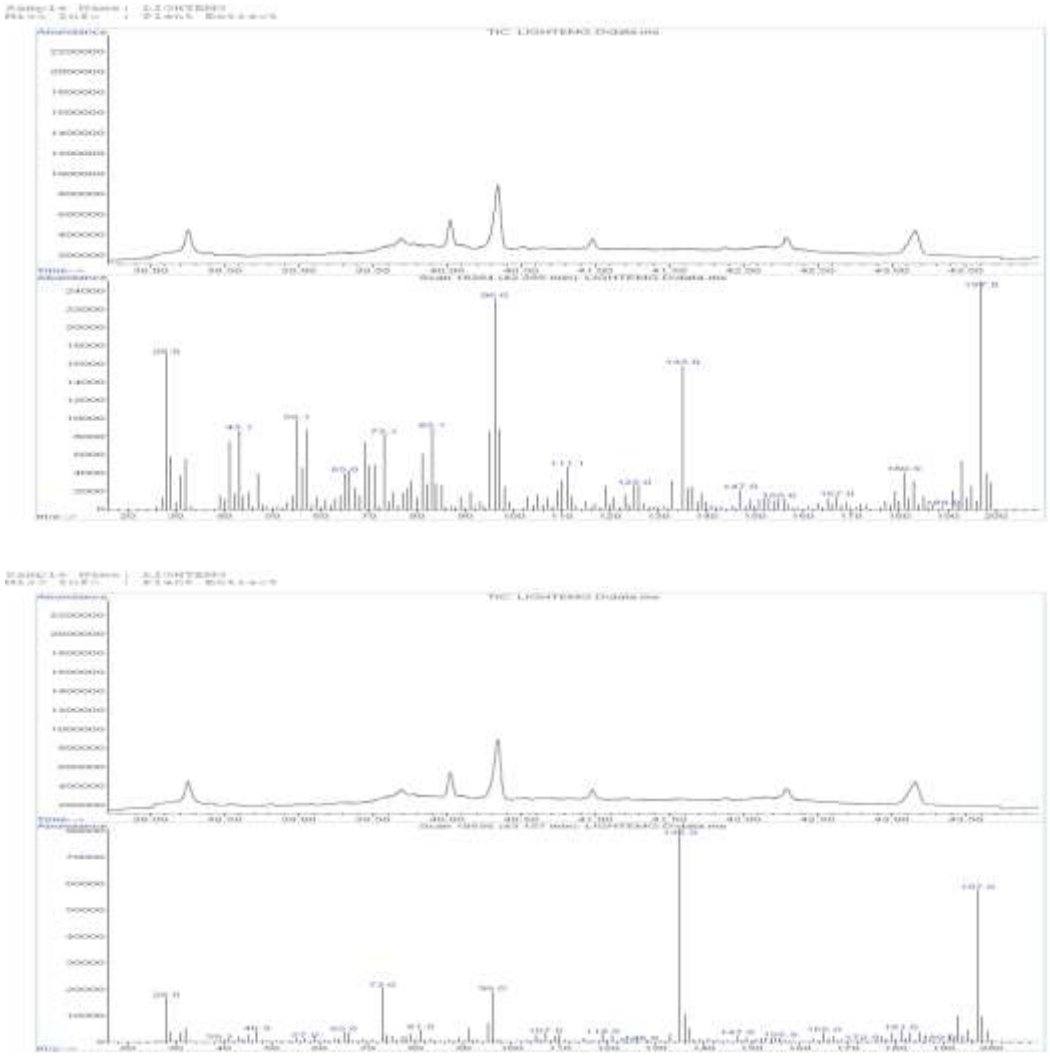
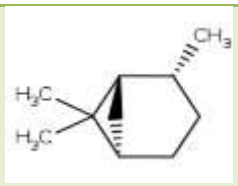
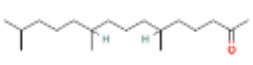
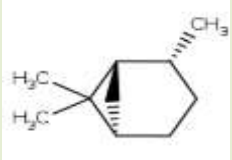
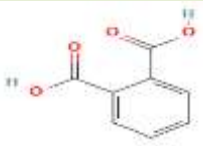
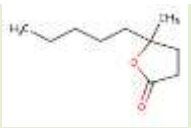
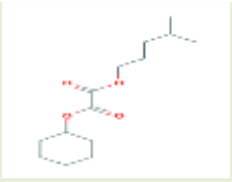
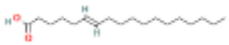
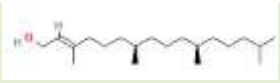
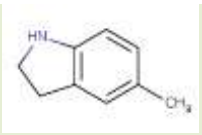
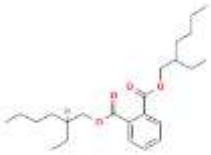
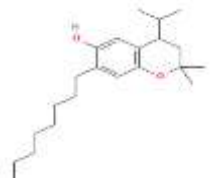
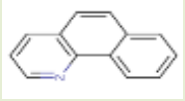
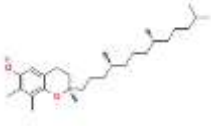
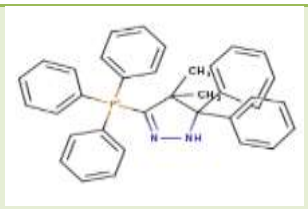
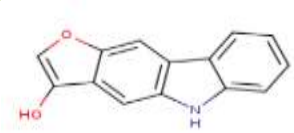


Fig. 1(a-l) GC-MS profile of bioactive compounds in *Costus igneus*

Table 3 IUPAC name and 2D structure of bioactive compounds in *Costus igneus*

COMPOUND	CID	IUPAC NAME	2D STRUCTURE
Bicyclo [3.1.1]heptane, 2,6,6-trimethyl-	12314300	(1S,2R,5R)-2,6,6-trimethylbicyclo[3.1.1]heptane	
2-Pentadecanone, 6,10,14-trimethyl-	10408	6,10,14-trimethylpentadecan-2-one	
Bicyclo [3.1.1]heptane, 2,6,6-trimethyl-	12314300	(1S,2R,5R)-2,6,6-trimethylbicyclo[3.1.1]heptane	
Phthalic Acid	1017	Phthalic Acid	

3,7,11,15-Tetramethyl-2-hexadecen- 1-ol	5366244	(E)-3,7,11,15-tetramethylhexadec-2-en-1-ol	
5,9,13-Pentadecatrien-2-one, 6,10,14- trimethyl	53946054	1,1-dimethoxy-6,10,14-trimethylpentadeca-5,9,13-trien-2-one	
2(3H)-Furanone,dihydro-5-methyl-5- pentyl	103702	Dihydro-5-methyl-5-pentylfuran-2(3H)-one	
Hexamethyl-2,6,10,14,18,22-tetracosahexaen-1-yl]-6-methox.	57417215	2,6,10,14,18,22-Tetracosahexaene	
Oxalic acid, cyclohexyl isohexyl ester	6421306	2-O-cyclohexyl 1-O-(4-methylpentyl) oxalate	
6-Octadecenoic acid	5282754	(E)-octadec-6-enoic acid	
Phytol	5280435	(E,7R,11R)-3,7,11,15-tetramethylhexadec-2-en-1-ol	
4,8,12,16-Tetramethylheptadecan-4- olide	567149	5-methyl-5-(4,8,12-trimethyltridecyl)oxolan-2-one	
5-methyl-2,3-dihydro-1H-indole	14023679	5-methyl-2,3-dihydro-1H-indole	
Bis(2-ethylhexyl) phthalate	8343	bis(2-ethylhexyl) benzene-1,2-dicarboxylate	
Adamantane-1-carboxylic acid methyl ester	136553	methyl adamantane-1-carboxylate	
Benzopyran-6-ol,3,4-dihydro-	91221	2,2-dimethyl-7-octyl-4-propan-2-yl-3,4-dihydrochromen-6-ol	
Benzoquinoline	9191	benzo[h]quinoline	
gamma-Tocopherol	92729	(2R)-2,7,8-trimethyl-2-[(4R,8R)-4,8,12-trimethyltridecyl]-3,4-dihydrochromen-6-ol	

dimethyl-5,5'-diphenyl-1H,	4051786	(4,4-dimethyl-5,5-diphenyl-1H-pyrazol-3-yl)-triphenylphosphanium	
1H-benzo[b]furo[2,3-f]indole	129780852	9H-furo[3,2-b]carbazol-1-ol	

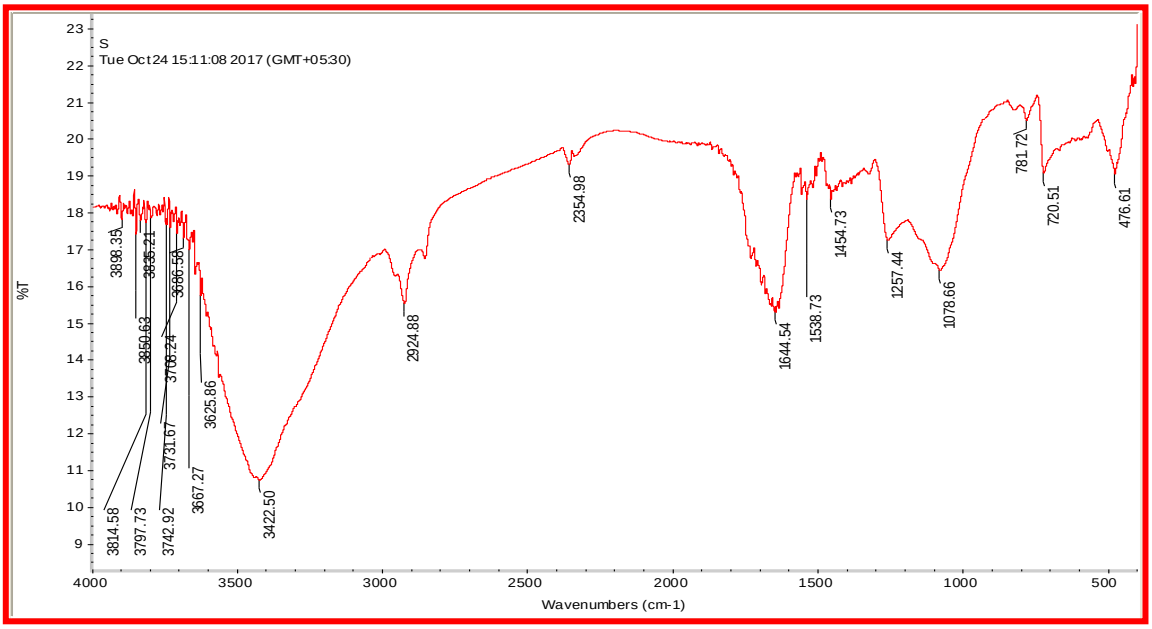


Fig. 2 FTIR spectra of bioactive compounds in *Costus igneus*

Table 4 FTIR profile of bioactive compounds in *Costus igneus*

Absorption Range (cm^{-1})	**Frequency Range** (cm^{-1})	**Appearance** of the Peak	Participatory Function **Group**	**Compound Class**
3898.26	3900-3584	Medium, Sharp	O-H Stretching	Alcohol
3850.62	3900-3584	Medium, Sharp	O-H Stretching	Alcohol
3835.10	3900-3584	Medium, Sharp	O-H Stretching	Alcohol
3742.73	3900-3584	Medium, Sharp	O-H Stretching	Alcohol
3731.73	3900-3584	Medium, Sharp	O-H Stretching	Alcohol
3708.45	3900-3584	Medium, Sharp	O-H Stretching	Alcohol
3686.55	3900-3584	Medium, Sharp	O-H Stretching	Alcohol
3667.59	3900-3584	Medium, Sharp	O-H Stretching	Alcohol
3625.96	3900-3584	Medium, Sharp	O-H Stretching	Alcohol
3419.82	3400-3300	Medium	N-H Stretching	Aliphatic Primary Amine
2924.35	3000-2840	Medium	C-H Stretching	Alkane
2357.90	2400-2000	Strong	O=C=O Stretching	Carbon Dioxide
1644.76	1648-1638	Strong	C=C Stretching	Alkene
1556.02*	1550-1500	Strong	N-O Stretching	Nitro Compound
1538.93	1550-1500	Strong	N-O Stretching	Nitro Compound
1454.87	1465-1450	Medium	C-H Bending	Alkane
1077.64	1250-1020	Medium	C-N Stretching	Amine
720.50	840-790	Medium	C=C Bending	Alkene
478.53*	750 ± 20	--	--	Benzene Derivative