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# Antimicrobial and Anti – inflammatory activities of *Plectranthus amboinicus* Leaf extract on Silkworm Pathogen *Streptococcus pyogenes* SA 1

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**ABSTRACT: To study the antimicrobial effect of herbal plant *Plectranthus amboinicus* on the silkworm pathogen *Streptococcus pyogenes* SA1. The herbal plant *P. amboinicus* - leaf was extracted by using known solvents such as acetone, methanol and distilled water and the antimicrobial effect of these extracts were studied against *S. pyogenes* SA 1 by agar well diffusion method. The phytochemical constituents of these extracts were also determined and GC-MS analysis was done. The phytochemical analysis of acetonic extract of *P. amboinicus* - leaf was revealed the presence of alkaloids, flavonoids, coumarins, steroids, glycosides, carbohydrates, tannins and saponins. The acetone and the methanol extracts of *P. amboinicus* - leaf showed minimum inhibitory activity 10 ± 0.03 mm and 3 ± 0.08 mm respectively in 0.5µl concentration and maximum inhibitory activity 18 ±0.15 mm, 10± 0.01 mm respectively against bacterial pathogen *S. Pyogenes* SA 1. The distilled water extract of *P. amboinicus* - leaf showed no inhibitory activity and maximum inhibitory activity 2 ±0.004 mm in 2.0 µl concentration on *S. Pyogenes* SA 1. The GC-MS analysis of the acetone extract of *P.amboinicus* – leaf was showed the presence of 18 compounds. The acetone and methanol extract of *P. amboinicus* – leaf showed remarkable antimicrobial activity against silkworm pathogen *S. pyogenes* SA 1 and the GC-MS analysis of the acetonic extract of *P. amboinicus* – leaf showed the presence of various antimicrobial compounds. In vitro and in vivo tests have to be carried out to confirm these findings.**

**Keywords:** *Plectranthus amboinicus*, chemical composition, GC-MS, antimicrobial activity.

## INTRODUCTION

Herbal plants are the local heritage with global importance and it is blessed with diversity of herbal plants (Suriyavathana *et al.,* 2010). In developing countries, these plants are used by 80 % of the world population and it is remedy for various diseases (Hashim *et al.,* 2010). The herbal plants are the economically important plants that provide the ingredients for manufacture various pharmacologically important medicinal products (Nataraj and Ramachandramurty 2014). The vast majority of plant extracts showed certain biological characteristics that are used in medical treatments (Bhavadharaniparkavi and Abirami 2023). Both traditional and contemporary healthcare systems continue to depend on the therapeutic benefits of medicinal plants (Sheeba *et al*., 2023).

The genus of the plant *Plectranthus* consists of 300 species, distributed from Africa to Asia and Australia (Waldia *et al*., 2011). In India, there are about 30 *Plectranthus* species are known and among these species *P. amboinicus, P. vettiveroides, P.barbatus, P. mollis, P. coetsa*, and *P. incanus* are the most common species used in the traditional Indian ayurvedic medicines (Sripathi and Ravi 2017). In India *Plectranthus amboinicus* grows naturally and is distributed on the plains of Rajasthan and Uttarakhand districts of the Western Ghats of India (Lukhoba *et al.,* 2006). Due to the presence of numerous significant constituents or secondary metabolites like flavonoids, glycosides, phenols, tannins. The plant has medicinal properties such as antimicrobial activity, antifungal activity, anti-inflammatory activity, anti-inflammatory activity, antidiabetic activity, anxiolytic activity, antineoplastic, analgesic, antimalarial, antibiofilm efficacy, diuretic, wound healing activity, skincare, respiratory disorders (Punet Kumar & Kumar 2020). This plant is used by traditional healers to treat cough, colds, stomach flatulence, indigestion, constipation, and other conditions (Sahu *et al*., 2022). The species *P. amboinicus* has a scientific synonym known as Coleus amboinicus which is routinely used in culinary services, and as a phototherapeutic product which is also used as

a primary raw material in the pharmaceutical industry (Souza and Lorenzi 2005). Its constituents identified by chemical and phytochemical assays, include germacrene, thymol and carvacrol have excellent antimicrobial and anti-inflammatory activities (Bandeira *et al.,* 2011). Some of the pharmacological properties that have been recognized for *P. amboinicus* include anti-epileptic, urolithiasis, anti-tumor, antimutagenic radio protective, anti-microbial, neuro pharmacological and diuretic properties (Patel *et al*., 2010). Herbal plants are composed of complex chemical substances of different proportion which occur as secondary metabolites. The phytochemicals are classified into two groups, namely primary and secondary constituents as per their specific functions in plant metabolism. The primary constituents comprise common sugars, amino acids, proteins and chlorophyll, while secondary constituents consist of alkaloids, terpenoids, flavonoids, tannins and phenolic compounds (Krishnaiah *et al.,* 2007).

At present, the interest for the study of the organic chemical compounds from the herbal medicinal plants and their important activity has increased. A lot of extraction methods and analytical methods such as spectrophotometry, capillary electrophoresis, Gas Chromatography (GC) with Flame Ionization Detection (FID), Gas Chromatography - Mass Spectrometry (GC-MS) are developed for identification of plant active compounds. The combination of an ideal separation technique (GC) with the best identification technique (MS) made GC-MS an ideal technique for determination of qualitative and quantitative volatile and semi volatile compounds (Iordache *et al.,* 2009). In the view of the medicinal values of the selected plant *P. amboinicus,* the present study is aimed to screen the antimicrobial bioactive compounds and their effect on the silkworm pathogen *S. pyogenes* SA 1.

## MATERIALS AND METHODS

**Collection and preparation of herbal plant material.** The leaves of herbal plant *P.amboinicus* were collected from Vilavancode taluk, Kanyakumari District, Tamilnadu, India. The plant leaves were taken to the laboratory and air dried at room temperature and crushed into powder for extraction.

**Isolation of bacterial pathogen.** The bacterial pathogen *S. pyogenes* SA 1 was isolated from the disease infected mature fifth stage silkworm larva. The isolated pathogen was identified through morphological, biochemical and 16S rRNA technique (Accession no: OL452034).

**Preparation of herbal plant extract.** The herbal plant *P. amboinicus* leaf powder each 10 gram with triplicates were taken in 250 ml conical flask and individually soaked in 100 ml of solvents such as the acetone, methanol and distilled water. Then, the mixture was kept on the shaker and kept undisturbed for 24 hours. The above preparation was filtered with Whatman No. 1 filter paper and the filtrate was concentrated under room temperature to get a semi solid extract (Bag *et al.,* 2009).

**Determination of antimicrobial activity.** Antimicrobial activity of different plant extracts was determined by the agar well diffusion method. The bacterial strain *S. pyogenes* SA 1 was swabbed on the solidified nutrient agar media, then 4 wells with 6 mm diameter were punched in the agar media by using sterile metallic borer. Stock solutions of crude extract and fractions in dimethyl sulfoxide (DMSO) at concentration of 20 mg / ml was prepared and 0.5, 1.0, 1.5 and 2.0µl of stock solution were added into the respective wells (Choudhary and Thomsen 2001). The petri dishes were incubated at 37ºC for 24 hours. Then, the plates were observed for zone of inhibition. The antibacterial activity was evaluated by measuring the diameter of the zone of inhibition against the tested bacterial pathogen (Jain *et al*., 2009).

**Phytochemical analysis.** Phytochemical analysis of the crude extract of acetone, methanol and distilled water fraction of *P. amboinicus* was carried out by using the standard procedure. Crude extracts were subjected to the initial phytochemical analysis for the presence of alkaloids, flavonoids, coumarins, steroids, glycosides, tannins, carbohydrates and saponins (Gnanavel *et al.,* 2015).

**Gas chromatography - mass spectroscopy (GC-MS) analysis.** The analysis of the acetone fraction *of P. amboinicus* - leaf was carried out by using Perkin Elmer workstation, with model Clarus 680 GC which comprised of an auto sampler and gas chromatography interfaced to a mass spectrometer instrument employing the following condition: Elite – 5MS capillary column (30.0m × 250µm, film thickness 0.25/m) and the components were separated using Helium as carrier gas at a constant flow of 1ml/min. The injector and MS transfer line temperatures were set at 260ºC during the chromatographic run. The 1µl of extracted sample injected into the instrument, the oven temperature was as follows: 60ºC (2min); followed by 300ºC, where it was held for 6min. The mass detector conditions were: transfer line temperature 230ºC; ion source temperature 230ºC; and ionization mode electron impact at 70 eV, a scan time 0.2 sec and scan interval of 0.1 sec. The fragments from 40 to 600 Da. The spectrums of the components were compared with the database of spectrum of known components stored in the GCMS, National Institute of Standards and Technology (NIST) library (Adams, 2001).

## RESULTS AND DISCUSSION

**Determination of antimicrobial activity.** The *P.amboinicus* leaf extracts were showed antibacterial activity against the selected silkworm pathogen *S. pyogenes* SA 1. The results revealed that the acetone extract of *P. amboinicus* – leaf on *S. pyogenes* SA 1 showed minimum inhibitory zone (10 ± 0.03 mm) at 0.5 µl concentration and maximum inhibitory zone (18 ± 15 mm) at 2.0 µl concentration. Similarly, the methanol extract of *P. amboinicus*– leaf on *S. pyogenes* SA 1 exhibited lower inhibitory activity (3±0.08mm) at 0.5 µl concentration and higher inhibitoryactivity (10±0.01mm) at 2.0 µl concentration. The distilled water extract of *P.amboinicuson S. pyogenes* SA 1

showed no inhibitory activity in distilled water at 0.5, 1.0 and 1.5µl concentration and exhibited inhibitory activity (2±0.004 mm) at 2.0 µl concentration. In this study, a significant maximum zone of inhibition on *S.pyogenes* SA 1 was observed in the acetone extract of *P.amboinicus* when compared to the methanol extract and very low level of inhibitory zone was observed at diss tilled water extract (Plate 1, Table 1). According to previous reports, the herbal extracts with various polar solvents exhibited antimicrobial activity against various bacterial pathogens. The herbal plant *P.amboinicus* used as a therapeutically active agent for the treatment of various disease causing bacterial strains such as *S. aureus* (Hasani *et al.,* 2003), *S.epidermidis*, Enterococcus faecalis (Bugayong *et al.,* 2019), Aeromonascaviae (da Costa *et al.,* 2010), *E. coli* (Bugayong *et al.,* 2019), Pseudomonas aeruginosa (Manjamalai *et al.,* 2012), *Salmonella* sp. (Dao *et al.,* 2019), *Aspergillus niger* (Hasani *et al.,* 2003) and *C. albicans* (Manjamalai and Tom 2012) which were showed the inhibitory zone ranged from 17 to 42 mm with different concentration of extract was partially resembled with our present study. The main compounds of *P.amboinicus* such as phenol and flavonoids may be inhibited the bacterial growth of all the 35 strains of *Streptococcus sp*. (Swamy *et al.,* 2017; Silva *et al.,* 2020). Earlier studies on the methanol extract of marigold petal showed maximum inhibitory zone (18mm) *on S. aureus* was contrast to the present study (Efstratiou *et al*., 2012).

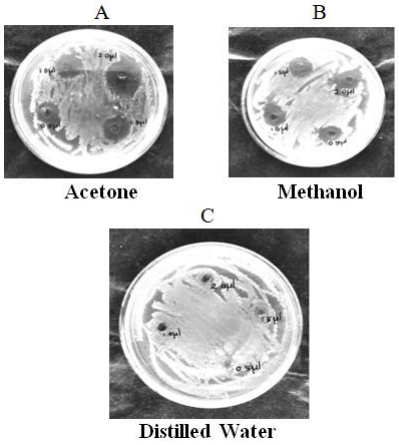


**Plate 1.** Zone of inhibition of the acetone, methanol and distilled water extracts of *P. amboinicus* – leaf against the silkworm pathogen *S. pyogenes* SA 1.

**Table 1: Effect of *P. amboinicus*– leaf extract on *S. pyogenes* SA 1.**

| Sr. No | Concentration of extract (µl) | Zone of inhibition (mm) | | |
|---|---|---|---|---|
| | | Acetone extract | Methanol extract | Distilled water |
| 1. | 0.5 | 10 ± 0.03 | 3 ± 0.08 | - |
| 2. | 1.0 | 12 ± 0.14 | 5 ± 0.11 | - |
| 3. | 1.5 | 15 ± 0.09 | 9 ± 0.05 | - |
| 4. | 2.0 | 18 ± 0.15 | 10 ± 0.01 | 2 ± 0.004 |

**Phytochemical screening.** The phytochemical screening of the crude extract of *P. amboinicus* – leaf with different solvents such as acetone, methanol and distilled water indicated the presence of various Phytoconstituents. Both the acetone and methanol extract of *P.ambonicus* – leaf indicated the presence of alkaloids, flavonoids, coumarins, steroids, tannins, and carbohydrates, except glycosides and saponins. The distilled water extract of *P. amboinicus* - leaf also indicated the presence of alkaloids, flavonoids, glycosides, tannins and carbohydrates except coumarins, steroids and saponins (Table 2). The herbal plant *P. amboinicus* was a succulent perennial herb with aromatic pubescence and inherent healing power due to the presence of various phytochemical compounds (Arumugam *et al.,* 2016). These herbal plants synthesize secondary metabolites such as alkaloids, flavonoids, tannins, coumarins and glycosides with different molecular structures and few of them possess antimicrobial properties was showed resemblance with the present study (Lanciotti *et al*., 2004).

**Table 2: Phytochemical screening of crude extract of *P. amboinicus* - leaf in different solvents.**

| Sr. No. | Constituents | Acetone | Methanol | Distilled water |
|---|---|---|---|---|
| 1. | Alkaloids | + | + | + |
| 2. | Flavonoids | + | + | + |
| 3. | Coumarins | + | + | - |
| 4. | Steroids | + | + | - |
| 5. | Glycosides | - | - | + |
| 6. | Tannins | + | + | + |
| 7. | Carbohydrate test | + | + | + |
| 8. | Saponins | - | - | - |

**(+) present, (-) absent**

**GCMS analysis.** The GCMS analysis of the acetone extract of *P. amboinicus* – leaf revealed the presence of 18 compounds (Table 3). The major compounds were detected in the acetone extract of *P.amboinicus* – leaf was 1,8- Nonadiyne (16.442%), Thymol (16.168%) 1, 3, 7 - Octatriene, 3, 7 - Dimethyl (12.020%), Phenol, 2 methyl - 5 - (1 - Methyl ethyl) – (10.969%), E - 2- Octadecadien - 1 - OL (8.402%), 1,2 - Benzene dicarboxylic acid, BIS (2- Methyl propyl) ester (4.759%), URS -12- ENE (4.743%), 1-Oxaspiro (2.5) OCT – 5-ENE, 8, 8 - dimethyl - 4 - methylene - (3.984%), 1- Hexacosanol (3.898%), 9, 19 - Cyclogest - 24 (28) - EN, 3 - OL, 4, 14 - Dimethyl -, Acetate, (3. Beta; 4. Alpha, 5. Alpha) - (3.318%), (1S, 4R) - P - Mentha - 2, 8 - Diene, 1 - Hydroperoxide (3.242%), Geranylgeraniol (2.673%) Hexadecane, 1- Chloro – (1.262%), Octadecanoic acid (2.020%), N-Hexdecanoic acid (1.872%), Stigmasterol (1.794%), Sigmastan - 6, 22 - Dien, 3, 5 - Dedihydro (1.298%), Hexatriacondane (1.134%) - (Table 3, Fig. 1). The GCMS analysis of the earlier studies revealed that the acetone extract of *P. amboinicus* possesses antimicrobial agents such as Phenol 1,2 - methyl -5- (1- methyl ethyl)-; thymol; (1S, 4R)- P -mentha - 2,8 -Diene, 1 - hydroperoxide; Octadecanoic acid; 1- Hexacosanol; and stigmastan-6, 22 - dien, 3,5, - dedihydro- were showed resemblance with previous studies (Gurgel *et al.,* 2009).

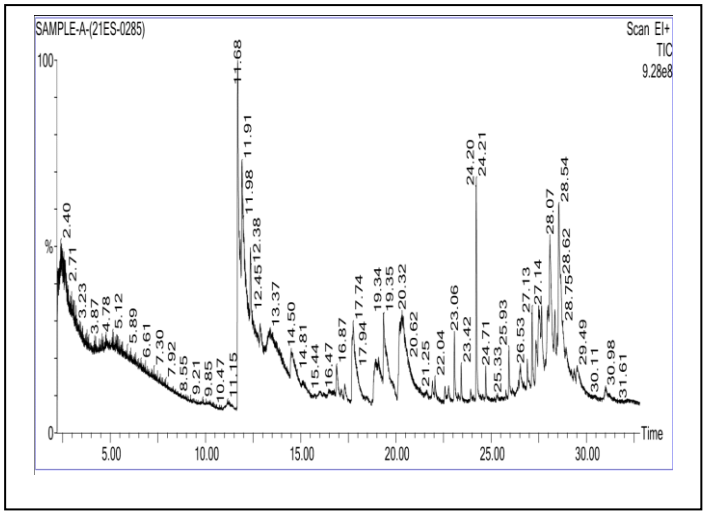


**Fig. 1.** Chromatogram of the acetone extract of *P. amboinicus* – leaf.

**Table 3: GC-MS analysis of acetone extract of *P. amboinicus* – leaf.**

| Sr. No. | Name of the Compound | Retention time (min) | Area (%) | Molecular weight (g/mol) | Molecular formula | Properties |
|---|---|---|---|---|---|---|
| 1. | Phenol 1,2 - Methyl - 5- (1-Methyl ethyl)- | 11.682 | 10.969 | 150 | $C_{10}H_{14}O$ | Antimicrobial agent (Gurgel *et al.*, 2009) |
| 2. | 1, 8 – Nonadiyne | 11.907 | 16.442 | 120 | $C_9H_{12}$ | Antioxidant activity (Chun *et al.*, 2005) |
| 3. | 1, 3, 7 - Octatriene, 3, 7 – Dimethyl- | 12.362 | 12.020 | 136 | $C_{10}H_{16}$ | Antioxidant activity (Chun *et al.*, 2005) |
| 4. | 1-Oxaspiro (2.5) OCT - 5 ENE, 8, 8 - Dimethyl - 4-Methylene | 12.873 | 3.984 | 150 | $C_{10}H_{14}O$ | Anticancer activity (Sathasivam and Elangovan 2011) |
| 5. | Thymol | 13.398 | 16.168 | 150 | $C_{10}H_{14}O$ | Antimicrobial activity (Gurgel *et al.*, 2009) |
| 6. | (1S, 4R)- P - Mentha -2, 8 - Diene, 1- Hydroperoxide | 14.498 | 3.242 | 168 | $C_{10}H_{16}O_2$ | Antibacterial activity (Gurgel *et al.*, 2009) |
| 7. | 1, 2 - Benzene dicarboxylic Acid, BIS (2- Methyl Propyl) Ester | 17.745 | 4.759 | 278 | $C_{16}H_{22}O_4$ | Anticancer activity (Sathasivam and Elangovan 2011) |
| 8. | N- Hexdecanoic acid | 18.920 | 1.872 | 256 | $C_{16}H_{32}O_2$ | Anti-inflammatory activity (Gurgel *et al.*, 2009) |
| 9. | Octadecanoic acid | 19.080 | 2.020 | 284 | $C_{18}H_{36}O_2$ | Antimicrobial activity (Gurgel *et al.*, 2009) |
| 10. | 1- Hexacosanol | 19.350 | 3.898 | 382 | $C_{26}H_{54}O$ | Antimicrobial activity (Gurgel *et al.*, 2009) |
| 11. | E-2- Octadecadien - 1 – OL | 20.316 | 8.402 | 268 | $C_{18}H_{36}O$ | Antioxidant activity (Chun *et al.*, 2005) |
| 12. | Geranylgeraniol | 24.212 | 2.673 | 290 | $C_{20}H_{34}O$ | Anti-inflammatory activity (Gurgel *et al.*, 2009) |
| 13. | Hexatriacontane | 27.143 | 1.134 | 506 | $C_{36}H_{74}$ | Antioxidant activity (Chun *et al.*, 2005) |
| 14. | Stigmasterol | 27.489 | 1.794 | 412 | $C_{29}H_{48}O$ | Anticancer activity (Sathasivam and Elangovan 2011) |
| 15. | Hexdecane, 1-Chloro- | 27.649 | 1.262 | 260 | $C_{16}H_{33}Cl$ | Anticancer activity (Sathasivam and Elangovan 2011) |
| 16. | Stigmastan - 6, 22 - Dien, 3, 5 - Dedihydro- | 27.984 | 1.298 | 394 | $C_{29}H_{46}$ | Antibacterial activity (Gurgel *et al.*, 2009) |
| 17. | 9, 19 - Cycloergost - 24(28) - EN-3-OL, 4-14-Dimethyl -, Acetatte, (3. Beta., 4. Alpha., 5. Alpha)- | 28.074 | 3.318 | 468 | $C_{32}H_{52}O_2$ | - |
| 18. | URS - 12- ENE | 28.539 | 4.743 | 410 | $C_{30}H_{50}$ | Antioxidant activity (Chun *et al.*, 2005) |

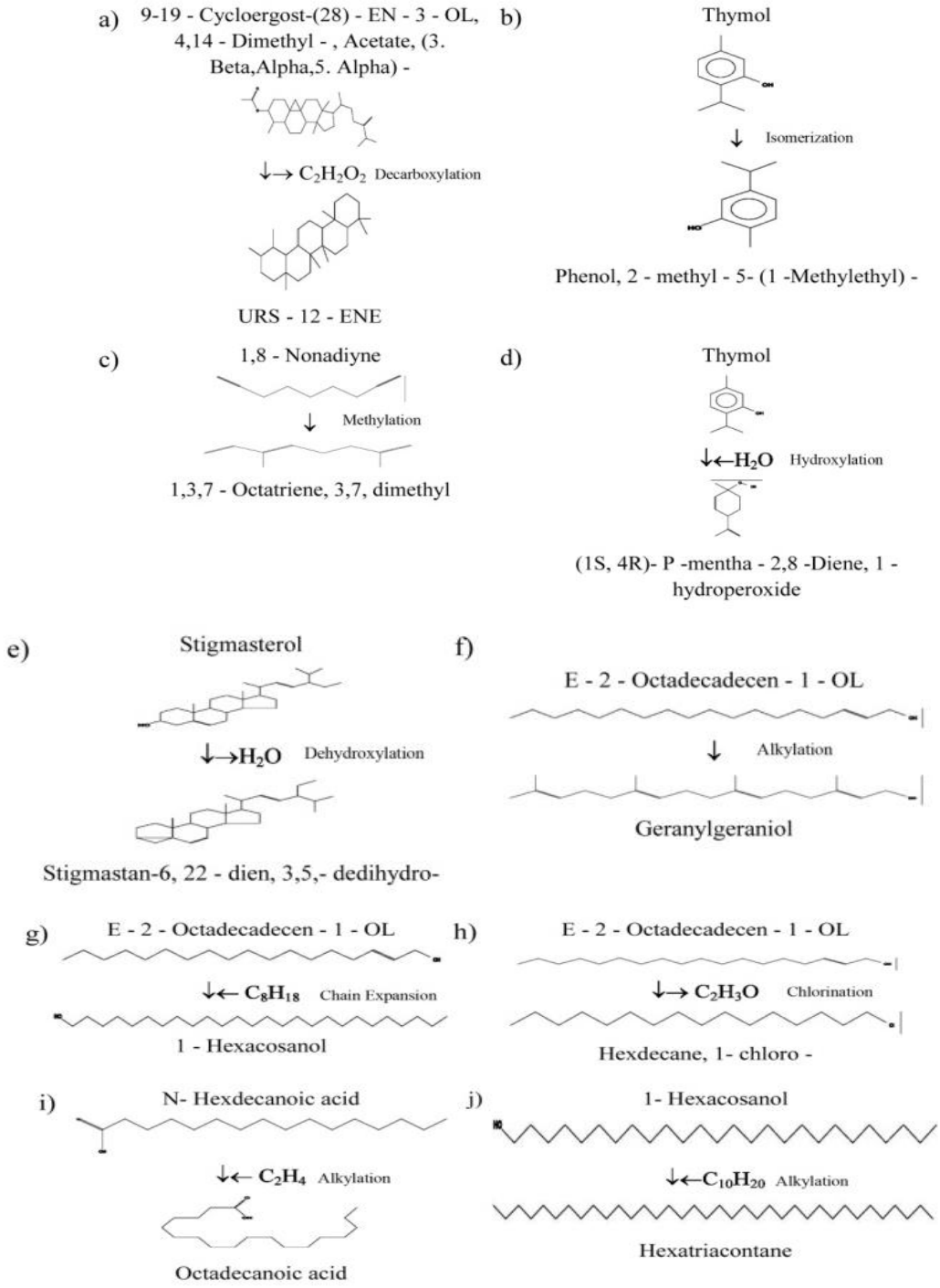


**Fig. 2.** Probable pathways for the internal conversion of major compounds in the acetone extract of *P.amboinicus* – leaf.

As per the previous GCMS report of (Chun *et al.,* 2005) the acetone extract *P. amboinicus* possesses an antioxidant active compound such as 1,8 - Nonadiyne; 1,3,7 - Octatriene, 3,7, dimethyl; E - 2 - Octadecadien - 1 - OL; Hexatriacontane; and URS 12- ENE; were in agreement with the sample analyzed in the present study.

These anti-microbial compounds could be playing a vital role in degradation of bacterial pathogen *S. pyogenes* SA 1. As per results obtained through GCMS analysis of the acetone extract of *P. amboinicus,* a probable internal conversion of major compounds to minor compounds may be occurred which were illustrated as pathways.

The compound, 9-19 - Cycloergost-(28) - EN - 3 - OL,4,14 - Dimethyl -, Acetate, (3. Beta, 4. Alpha, 5. Alpha) - may be undergo removal of $C_2H_2O_2$ and decarboxylation and ring opening reaction into URS - 12 - ENE. (Fig. 2a). The compound, Thymol may be internally converted into Phenol, 2 - methyl - 5- (1 - methyl ethyl) - due to the process called stereo isomerization (Fig., 2b). The compound 1,8 - Nonadiyne may be under go methylation and transform into 1,3,7 - Octatriene, 3,7, dimethyl (Figure, 2c).The compound Thymol may be undergo addition of $H_2O$

into (1S, 4R)- P -mentha - 2,8 -Diene, 1 - hydroperoxide due to the process is called hydroxylation and resonance breakdown (Fig. 2d).The compound Stigmasterol may be undergo the removal of $H_2O$ and dihydroxylation followed by formation new bicyclic ring and internally converted into Stigmastan-6, 22 - dien, 3,5,- dedihydro- (Fig. 2e).The compound E - 2 - Octadecadien - 1 - OL may be undergo two carbon alkylation and converted into Geranylgeraniol (Fig. 2f). The compound E - 2 - Octadecadien - 1 - OL may be under go addition of $C_8H_{18}$ and chain expansion and transform into 1 –Hexacosanol (Fig. 2g). The compound E - 2 - Octadecadien - 1 – OL may be internally change into Hexdecane, 1- chloro -due to the process called chlorination with removal of $C_2H_3O$ (Fig., 2h). The compound N- Hexdecanoic acid may be internally converted into Octadecanoic acid due to the process called alkylation chain extension with crown model and addition of $C_2H_4$ (Fig. 2i). The compound 1-Hexacosanol may be internally transform into Hexatriacontane and this process are alkylation and addition of $C_{10}H_{20}$ with removal of oxygen (Fig. 2j).

The results of the present study also revealed that the acetone extract of *P. amboinicus* possess an anti-cancer active compound such as 1 - Oxaspiro (2.5) OCT - 5ENE, 8, 8 -dimethyl - 4 -methylene; 1,2 Benzene dicarboxylic acid, BIS (2 -Methyl propyl) ester; stigmasterol; and Hexdecane, 1- chloro which were in accordance with the sample analyzed in the previous studies (Sathasivam and Elangovan 2011).

The results of the GCMS analysis on the acetone extract of *P. amboinicus* showed anticancer and anti-inflammatory effect due to the presence of Hexadacane, Stigmasterol and Geranylgeraniol compounds. The previous studies on the crude hydroalcoholic extract of *P. ambonicus* leaves also found to possess an anti-inflammatory activity (Hamalainen, 2007; Gurgel *et al.*, 2009). A significant anticancer effect was observed in the tumor cells due to thepresence of compounds in the hydroalcoholic extract of *P. amboinicus* leaves (Akagi *et al.,* 1995; Yang *et al.,* 2000).

## CONCLUSIONS

*P. amboinicus* is an important aromatic medicinal herb packed with many bioactive constituents and nutrients, which are important for maintaining good health. The biological properties are attributed to the occurrence of a wide range of bioactive compounds in *P. amboinicus*-leaf extracts which possess promising anti-microbial effects. The GC-MS studies of the acetonic extract of *P. amboinicus* – leaf was showed various compounds. Further study is required to find out the accurate compound responsible for the plants medicinal value. The major components of nonadiyne are used in biological activities.

## FUTURE SCOPE

*P. amboinicus* is an important medicinal plant with antimicrobial, anti-inflammatory effect. It is effective against various bacteria. This plant possesses several unknown bioactive properties that provide opportunities for additional research.

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**Conflict of Interest.** None.

## REFERENCES

Adams, R. P. (2001). Identification of essential oil components by gas chromatography/quadrupole mass spectroscopy. Allured publishing corporation.

Akagi, K., Hirose, M., Hoshiya, T., Mizoguchi, Y., Ito, N. & Shirai, T. (1995). Modulating effects of ellagic acid, vanillin and quercetin in a rat medium term multi-organ carcinogenesis model. *Cancer letters*, *94*(1), 113-121.

Arumugam, G., Swamy, M. K. & Sinniah, U. R. (2016). *Plectranthus amboinicus* (Lour.) Spreng: botanical, phytochemical, pharmacological and nutritional significance. *Molecules*, *21*(4), 369.

Bag, A., Bhattacharyya, S. K., Bharati, P., Pal, N. K. & Chattopadhyay, R. R. (2009). Evaluation of antibacterial properties of Chebulic myrobalan (fruit of *Terminalia chebula* Retz.) extracts against methicillin resistant *Staphylococcus aureus* and trimethoprim-sulphamethoxazole resistant uropathogenic *Escherichia coli*. *Afr J Plant Sci.*, *3*(2), 25-29.

Bandeira, J. M., Barbosa, F. F., Barbosa, L. M. P., Rodrigues, I. C. S., Bacarin, M. A., Peters, J. A. & Braga, E. J. B. (2011). Essential oil composition of four *Plectranthus* species. *Revista Brasileira de Plantas Medicinais*, *13*, 157-164.

Bhavadharaniparkavi, K. and Abirami, P. (2023). Phytochemical Analysis and Bioactive components of a Medicinal Plant *Acalypha paniculata* Miq. *Biological Forum – An International Journal*, *15*(4), 385-392.

Choudhary, M. I. & Thomsen, W. J. (2001). Bioassay techniques for drug development. CRC Press.

Chun, S. S., Vattem, D. A., Lin, Y. T. & Shetty, K. (2005). Phenolic antioxidants from clonal oregano (*Origanum vulgare*) with antimicrobial activity against *Helicobacter pylori*. *Process Biochemistry*, *40*(2), 809-816.

da Costa, J. G., Pereira, C. K., Rodrigues, F. F. & de Lima, S. G. (2010). Chemical composition, antibacterial and fungicidal activities of leaf oil of *Plectranthus amboinicus* (Lour.) Spreng. *Journal of Essential Oil Research*, *22*(2), 183-185.

Dao, T. P., Nguyen, D. C., Nguyen, D. T., Tran, T. H., Nguyen, P. N., Le, N. H. & Bach, L. G. (2019). Extraction process of essential oil from *Plectranthus amboinicus* using microwave-assisted hydrodistillation and evaluation of its antibacterial activity. *Asian J. Chem.*, *31*, 977-981.

Efstratiou, E., Hussain, A. I., Nigam, P. S., Moore, J. E., Ayub, M. A. & Rao, J. R. (2012). Antimicrobial activity of *Calendula officinalis* petal extracts against fungi, as well as Gram-negative and Gram-positive clinical pathogens. *Complementary Therapies in Clinical Practice*, *18*(3), 173-176.

Gnanavel, S., Kavitha, S., Kumar, M. D. & Kannan, K. (2015). In vitro antioxidant and anticancer activities of seed extract of *Solanum virginianum*. *Asian Journal of Pharmaceutical Research and Health Care*, *7*(1).

Gurgel, A. P. A. D., da SILVA, J. G., Grangeiro, A. R., Xavier, H. S., Oliveira, R. A., Pereira, M. S. & de SOUZA, I. A. (2009). Antibacterial effects of *Plectranthus amboinicus* (Lour.) spreng (Lamiaceae) in methicillin resistant *Staphylococcus aureus*

(MRSA). *Latin American Journal of Pharmacy*, *28*(3), 460-464.

Hamalainen, M. (2007). Anti-inflammatory effects of flavonoids: genistein, kaempferol, quercetin, and daidzein inhibit STAT-1 and NF-κB activations, whereas flavone, isorhamnetin, naringenin, and pelargonidin inhibit only NF-κB activation along with their inhibitory effect on iNOS expression and NO production in activated macrophages. *Mediators Inflamm., 2007*, 1-10.

Hasani, A., Pavia, D., Toms, N., Dilworth, P. & Agnew, J. E. (2003). Effect of aromatics on lung mucociliary clearance in patients with chronic airways obstruction. *The Journal of Alternative & Complementary Medicine*, *9*(2), 243-249.

Iordache, A., Culea, M., Gherman, C. & Cozar, O. (2009). Characterization of some plant extracts by GC–MS. Nuclear instruments and methods in physics research section B: beam interactions with materials and atoms, *267*(2), 338-342.

Jain, P., Bansal, D. & Bhasin, P. (2010). Antibacterial activity of aqueous plant extracts against *Escherichia coli* and *Bacillus subtilis*. *Drug Invention Today*, *2*(4).

Krishnaiah, D., Sarbatly, R. & Bono, A. (2007). Phytochemical antioxidants for health and medicine: A move towards nature. *Biotechnol. Mol. Biol. Rev.*, *1*(4), 97-104.

Lanciotti, R., Gianotti, A., Patrignani, F., Belletti, N., Guerzoni, M. E. & Gardini, F. (2004). Use of natural aroma compounds to improve shelf-life and safety of minimally processed fruits. *Trends in food science & technology*, *15(*3-4), 201-208.

Lukhoba, C. W., Simmonds, M. S. & Paton, A. J. (2006). *Plectranthus*: A review of ethnobotanicaluses. *Journal of ethnopharmacology*, *103*(1), 1-24.

Manjamalai, A., Alexander, T. & Grace, V. B. (2012). Bioactive evaluation of the essential oil of *Plectranthus amboinicus* by GC-MS analysis and its role as a drug for microbial infections and inflammation. *Int. J. Pharm. Pharm. Sci.*, *4*(3), 205-211.

Nataraj, N. D. & Ramachandramurty, B. (2014). Preliminary Phytochemical Screening of *Solanum trilobatum* (L) young leaves. *International Research Journal of Pharmacy*, *5*(2), 12-19.

Patel, R., Mahobia, N. K., Gendle, R., Kaushik, B. & Singh, S. K. (2010). Diuretic activity of leaves of *Plectranthus amboinicus* (Lour) Spreng in male albino rats. *Pharmacognosy research*, *2*(2), 86.

Punet Kumar, S. & Kumar, N. (2020). *Plectranthus amboinicus*: A review on its pharmacological and pharmacognostical studies. *American Journal of Physiology*, *10*(2), 55-62.

Sheeba, S. Jeba, R. Raja JeyaSekar, A. Harish & S. M. Vijila (2023). In Vitro Antibacterial Activity and FTIR Analysis of *Anisomeles malabarica* (L.) Leaves Extract against *Mycobacterium marinum* Affecting Gold Fish (*Carassius auratus*). *Biological Forum – An International Journal*, *15*(5), 251-253

Sahu, D., Bolleddu, R., Das, M., Das, D., Mandal, T. K., Debnath, S. K. & Prasad, P. V. V. (2022). Pharmacognostical and phytochemical studies of leaves of *Plectranthus amboinicus* (lour.) spreng. (Parnayavani). *Research Journal of Pharmacy and Technology*, *15*(2), 717-722.

Sathasivam, A. & Elangovan, K. (2011). Evaluation of phytochemical and antibacterial activity of *Plectranthus amboinicus. International Journal of Research in Ayurveda and Pharmacy*, *1*, 292-294.

Silva, J. M. D. S., Almeida, J. R. G. D. S., Alves, C. D. S. C., Nery, D. A., Damasceno, L. M. O., Araújo, C. D. S. & Oliveira, A. P. D. (2020). Antimicrobial Activity from Species *Plectranthus amboinicus* (Lour.) Spreng, a Review. *European Journal of Medicinal Plants*, *31*(18), 1-14.

Souza, V. C. & Lorenzi, H. (2005). Botânica sistemática: guia ilustrado para identificação das famílias de Angiospermas da flora brasileira, baseado em APG II.

Sripathi, R. & Ravi, S. (2017). Chemical composition and antibacterial activity of the essential oil from the seeds *P. hadiensis*. *International Journal of Pharmacognosy and Phytochemical Research*, *9*(5), 637-639.

Suriyavathana, M., Usha, V. & Shanthanayaki, M. (2010). Studies on phytochemical analysis and antioxidant activity of selected medicinal plants from Kolli hills. *Journal of pharmacy Research*, *3*(2), 260-262.

Swamy, M. K., Arumugam, G., Kaur, R., Ghasemzadeh, A., Yusoff, M. M. & Sinniah, U. R. (2017). GC-MS based metabolite profiling, antioxidant and antimicrobial properties of different solvent extracts of Malaysian *Plectranthus amboinicus* leaves. Evidence-Based Complementary and Alternative Medicine, 2017.

Waldia, S., Joshi, B. C., Pathak, U. & Joshi, M. C. (2011). The genus *Plectranthus* in India and its chemistry. *Chemistry & biodiversity*, *8*(2), 244-252.

Yang, K., Lamprecht, S. A., Liu, Y., Shinozaki, H., Fan, K., Leung, D. & Lipkin, M. (2000). Chemoprevention studies of the flavonoid's quercetin and rutin in normal and azoxymethane-treated mouse colon. *Carcinogenesis*, *21*(9), 1655-1660.

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