



***Plectranthus amboinicus*: A review on its pharmacological and pharmacognostical studies**

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ABSTRACT

In this review, information regarding the phytochemistry, traditional uses, medicinal uses, side effects, and future perspectives of *Plectranthus amboinicus* are given. *Plectranthus amboinicus* has been used in herbal medicines for the treatment of various disorders such as asthma, flu, eczema, and cardiovascular disorders. The plant possesses medicinal properties (such as antimicrobial activity, antifungal activity, anti-inflammatory activity, antidiabetic activity, anxiolytic activity, antineoplastic, analgesic, antimalarial, antibiofilm efficacy, diuretic, wound healing activity, skincare, respiratory disorders, and antiplatelet aggregation activity) due to the presence of various important constituents or secondary metabolites such as flavonoids, glycosides, phenols, tannins, and steroids, which have been identified through various spectroscopic methods. The different parts of the plant have used to prepare medicines. Due to the presence of various important constituents, this plant can be used for medicines without side effects.

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Introduction

Plectranthus amboinicus is a well-known plant which belongs to the *Lamiaceae* family. It is found in almost all over India. It is a medicinal plant which has been used for treatment in folkloric medicines (syrup). It can also be used in other diseases such as flu, bronchitis, and epilepsy. Photochemical study shows that it contains flavonoids such as apigenin, luteolin, and salvigenin [1].

Lamiaceae is a family which contains approximately 200 genera and species in the 3200 with a history of treatment in diseases and use in food. The botanical name of this herb *Plectranthus amboinicus* helps us to identify its taxonomic place. In this case, *amboinicus* refers to Ambon, a mountainous, fertile island located in the Maluku Islands near Indonesia. From there, the plant propagated throughout the East Indies and Africa and was eventually naturalized in Latin America by the Spanish, who named this herb as “oregano de la Hoja Ancha.” Cuban oregano can still be found growing wild in

the rainforests of Indonesia and Malaysia, and as it is easy to grow and can survive a considerable neglect, it is a popular house plant worldwide [2].

The herb *Coleus aromaticus* belongs to the family *Lamiaceae* (family *Labiatae*) and genus *Coleus* (now known as *Plectranthus*). It is a big juicy perennial aromatic herb with 30–90 cm height and thick, fleshy leaves and stem. This is a highly branched, succulent herb with very unique smelling leaves that are aromatic. This plant is found in all over India, and it is also cultivated in gardens due to taste and aroma; the leaves of this plant are ideal for flavoring meat and fish, as it increases the taste of the dishes and is also useful to cover bad odor [3,4]. There is a considerable scope for research on its applications in the food industry [5,6].

Distribution

Plectranthus amboinicus is cultivated throughout India and in Malaysia. It is also found growing in various Asian and American countries, and it can

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Figure 1. *Plectranthus amboinicus* plant.

also be grown in gardens. This plant is widely cultivated and naturalized in the old and new world tropics. It is also known as Cuban oregano, Spanish thyme, Orégano Brujo (Puerto Rico), Indian borage, Mexican thyme, or Mexican mint (syn. *Coleus amboinicus* Lour., *C. aromaticus* Benth) [7,8].

Plant morphology

Herbs are perennial aged 3–10 years old and highly fragrant. This plant can climb, or progress, and can reach about 1-m height, and the leaves are thick, simple, and light blade, a fat green opposite arrangement of leaves (2.5–3 cm long). Shape of the leaves is broadly oval or triangular shapes (cutting base and apex acute extensively) [9]. Margins of the leaf are having crenate surfaces below which contain numerous glandular hairs to make winter trunk: trunk has tomatoes (densely covered with soft short hairs). Flowers have a bell-shaped calyx and the throat is smooth inside with two lips, the upper lip being ovate and thin, the lower lip having four narrow teeth. The corolla is pale purplish and five times longer than the calyx, with a short tube, inflated throat, and short lips [10].

Classification

Division:	<i>Magnoliophyta</i>
Kingdom:	<i>Plantae</i>
Clade:	<i>Angiosperms</i>
Class:	<i>Magnoliopsida</i>
Order:	<i>Lamiales</i>
Family:	<i>Lamiaceae</i>
Genus:	<i>Plectranthus</i>
Species:	<i>Coleus aromaticus</i>
Synonyms:	<i>Coleus amboinicus</i> Lour. [11]

Common names of *Plectranthus amboinicus*

This plant is commonly known by different names at different places:

Kannada:	Doddapatre, doddapatre soppu
Hindi:	Patta ajavayin, Patharchur, Amroda, pathercheer
English:	Country borage, Indian borage, Indian mint
Bengali:	Amalkuchi
Malayalam:	Panikoorka
Gujarati:	Ovapan
Marathi:	Pan ova
Sanskrit:	Karpuravalli, Sugandhavalakam, Parnayavani
Marathi:	Pathurchur [10]

Coleus aromaticus is very popular drug in India which is also called as oregano. In some countries, this herb is used in the treatment of ulcers. It is a kind of big juicy herb and has aromatic smell, and it is very common without widespread cultivation. When crushed or squeezed, the leaves give smell of mint and also they are thick and juicy. Different kinds of phytochemicals are present in different parts of the plant such as fruits, flower stems, leaves, and roots [10]. Few nutrients of this plant are found to have an important role in the treatment of diabetes. *Coleus aromaticus* is able to lower blood glucose levels, so it can be used as an antidiabetic agent and also helps in other problems caused due to high sugar levels such as it may be useful in terms of diabetic wound healing to heal faster, due to its ability to prevent, or it can decrease the risk of infection and complications [11–13].

Pharmacological Uses of *P. amboinicus*

This herb has a traditional history. From many years, this golden herb is very effective in folkloric medicines. This plant is effective in wound healing with very less side effects, so this herb is pretty impressive in this sense. The fatal toxic dose of this particular herb was tested in laboratory mice which showed that the plant *P. amboinicus* is a herb which has no side effects or we can say that this amazing herb have no side effects [14,15].

Plectranthus amboinicus is a herb which is used in the treatment of famous diseases such as cephalgia, otalgia, anorexia, dyspepsia bloating, colic, diarrhea, cholera, gums, seizures, asthma, cough, chronic bronchitis, kidney calculi, vesicle calculi, hiccough, strangury, hepatopathy, fever, and malaria. Mouth corner cracks are treated with this plant in Jawa. *Plectranthus amboinicus* shows anthelmintic activity which is already reported and it is cultivated widely because of this reason. To accommodate the

increase in demand for herbal medicines, constant research and analysis have been conducted which will to prove the antioxidant activity of *P. amboinicus* [16].

Members of the genus *Coleus* are very important because they provide food, medicine, and ornamentals. Ayurvedic practitioners have used the *Coleus* varieties in chronic cough and asthma includes calculus, gonorrhoea, heart disease, fever, piles, Dyspepsia. Since ancient times, the plant was also widely studied for activities, such as previous biochemical antimutagenic and cancer, these components are antigen toxic in characteristics, and also they are a good source for the treatment of diseases [17].

Antimicrobial activity

The essential oil was isolated by hydrodistillation of *P. amboinicus* (Lour) Spring. dried leaves from Archipelago of the Comoros. The oil was analyzed by capillary gas chromatography (GC) and gas chromatography/mass spectrometry (GC/MS). Carvacrol (23.0 %), camphor (22.2 %), Δ -3-carene (15.0 %), λ -terpinene (8.4 %), O-cymene (7.7 %), and α -terpinene (4.8 %) were the major constituents of the oil. The antimicrobial activity of *P. amboinicus* Spring. leaf essential oil was investigated using agar gel diffusion. The results obtained showed that the essential oil of *P. amboinicus* (Lour.) Spring. exhibited more antimicrobial activity on Gram-positive (*Staphylococcus aureus*) than on Gram-negative (*Escherichia coli*). The minimum inhibitory concentration (MIC) was 0.2% and 0.1% for *E. coli* and *S. aureus*, respectively [18,19].

Antifungal activity

Fungi are the reason for destruction of food materials, plants, and grains during storage. After that, the food will release their nutritional value which makes it useless for consumption. From the world's total grain, approximately 25% are contaminated by the mycotoxins also known by the metabolites of fungi (300 or more), which are known to be toxic for humans and animals. *P. amboinicus* nanoparticle, made from its extracts from various solvents and essential oil, was effective as antifungal. *Coleus aromaticus* leaves have activity against *Aspergillus niger* and *Candida albicans* [20].

Anti-inflammatory activity

Tissue protein denaturation is a very common factor which is responsible for problems such as

inflammation and arthritis. Autoantigen production inside the body is also caused by metamorphism process of tissue proteins. Agents that prevent denaturation variables are worthwhile to develop as anti-inflammatory drugs. By doing a comparison of reference standard drug and the plant extract, we can find the concentration that inhibits the protein denaturation. When compared with standard drug, the effects were more effective. Extracts of *P. amboinicus* were used to study the effect of inflammation at different concentrations using egg albumin. The acetaminophen is used as a standard drug. Depending on the potency of extract, an inhibition of proteins varies. After the study, we found that plant extract shows anti-inflammatory activity as it prevents *in vitro* denaturation. Effects are due to the presence of polyphenolic content and may be due to the synergistic activity of more than one compound [1–3].

Antibacterial activity

The ethanol extracts of *Plectranthus amboinicus* have antibacterial properties, with a concentration of 50 g/ml against *Streptococcus mutans*. Leaves of *P. amboinicus* were selected in the study against bacteria due to various reasons. The leaves were used in the traditional system for the treatment of nasal congestion, bronchitis, asthma, cold, and cough. Hence, we can say that this plant is effective against *S. mutans*. This plant is very well known in India. *Plectranthus amboinicus* is widely cultivated in India, so parts of the plants are easily available and they are also low-priced [17,21].

Skin care

The most popular uses of *Plectranthus amboinicus* are in the treatment of skin. In case of bites and stings of bugs to other skin diseases, such as psoriasis and eczema, *Plectranthus amboinicus* shows the anti-inflammatory compounds which are capable of reducing swelling and redness in a very less time. To eliminate irritation and itching, this plant is very useful [22].

Antidiabetic activity

Viswanathaswamy et al. [12] investigated the anti-diabetic and antihyperglycemic effects of ethanol extract of *Plectranthus amboinicus* is normal and alloxan-induced diabetic rats. Diabetes was induced in Wistar rats by single intraperitoneal administration of alloxan monohydrate (150 mg/kg). Normal as well as diabetic rats were divided into groups

($n = 6$) receiving different treatments. Graded doses (200 and 400 mg/kg) of the ethanol extract of *Plectranthus amboinicus* were studied in both the normal and alloxan-induced diabetic rats for 15 days. Glibenclamide (600 μ g/kg) was used as a reference drug. Oral administration with graded doses of the ethanol extract of *Plectranthus amboinicus* exhibited hypoglycemic effect in normal rats and significantly reduced the peak glucose levels after 120 minutes of glucose loading. In alloxan-induced diabetic rats, the daily oral treatment with the ethanol extract of *P. amboinicus* showed a significant reduction in blood glucose. Besides, an administration of the ethanol extract of *P. amboinicus* for 15 days significantly decreased serum contents of total cholesterol and triglycerides, whereas HDL-cholesterol, total proteins, and calcium were effectively increased. Furthermore, the effect of the ethanol extract of *P. amboinicus* showed profound elevation of serum amylase and reduction of serum lipase. An histology examination showed that the ethanol extract of *P. amboinicus* exhibited almost normalization of damaged pancreatic architecture in rats with diabetes mellitus. Studies clearly demonstrated that the ethanol extract of *P. amboinicus* leaves possesses hypoglycemic and antihyperlipidemic effects mediated through the restoration of the functions of pancreatic tissues and insulin tropic effect [12,17].

Anxiolytic activity

Anxiolytic effects of the alcoholic extract of *P. amboinicus* in mice was performed using the elevated plus maze model, light-dark model, and hole-board test. The extract administered orally in three different doses of 250, 500, and 750 mg/kg was able to increase the time spent and the number of arm entries in the open arms of the elevated plus-maze and also to increase the time spent by mice in the illuminated side of the light-dark test; a dose of 500 and 750 mg/kg showed more significant increase in nose poking and decrease locomotion in hole-board test, in comparison with control animals. This effect was comparable to that of the diazepam (1.0 mg/kg p.o.). These results indicate that alcoholic extract of *Plectranthus amboinicus* is an effective anxiolytic agent [14].

Diuretic activity

The diuretic properties of the extract were evaluated in male rats which show that the ethanolic extract of plant acts as diuretic. Furosemide (10 mg/kg) is used as standard, whereas the normal saline solution (0.9%) was used as controls. Results show that there are significant increases in the

urinary concentrations of ions such as Na, K, and Cl and also in urine volume. Hence, from this study, it may be concluded that *Plectranthus amboinicus* Spring. leaves have diuretic activity [15,16].

Antineoplastic activity

Anticancer activity of the essential oil of *P. amboinicus* (Lour) on B16F-10 melanoma cell line injected C57BL/6 mice, and it was simultaneously treated with the essential oil of *P. amboinicus* (Lour) (50 μ g/dose) through i.p. for 21 days. The present investigation exhibited the potent chemotherapeutic/chemopreventive effect of the essential oil of *P. amboinicus* (Lour) over lung metastasis that developed. To the best of our knowledge, this is the first report to evaluate the effect of essential oil of *P. amboinicus* (Lour) using lung cancer model [17,18,20].

Wound healing activity

Plectranthus amboinicus has many capabilities to increase the healing process of wounds. The plant shows antimicrobial properties, and also it is a powerful immune stimulant which aids the removal process of microorganisms that retard healing process and for the maintenance of path of normal progress. A high content of zinc is present, which supports important functions to promote and facilitate the healing of wounds. *Plectranthus amboinicus* is known as an anti-inflammatory which makes the process of healing fast; this is very important because the long-term inflammation will slow wound healing. *Plectranthus amboinicus* also noted is a good antibacterial, and antibacterials are the ones which can increase the healing activity of wounds. Therefore, *Plectranthus amboinicus* is regarded as antibacterial agent and also the best wound healing agent proved by preventing the infection in various cases [23,24].

Respiratory disorders

Coleus aromaticus leaf infusion or aromatic syrup is found very effective against the cough. The details regarding this are not explained, and only in the Zulu medicine, its use is reported. To flavor food, the leaves of the plant are used. Further, this species is used in cattle [24] in the treatment of sore throat, a stuffy nose, congestion, painful sinuses, and so on. After chewing, leaves give relief as it contains those types of chemical compounds which act as good expectorant and remove the phlegm and mucus, which helps to clear the sinuses. It also prevents the development of bacteria and other pathogens, which helps to increase the immunity [21,24,25].

Antiuro lithiatic activity

There is a water extract of the leaves of *C. aromaticus* which is used for the determination of antiuro lithiatic activity on calcium stones in male rats. The extract prepared from water of *C. aromaticus* was found effective in decreasing the buildup of calcium oxalate. These results demonstrate that the *C. aromaticus* is effective in the treatment of calcium oxalate stones in the kidneys and urinary tract. The study revealed that there is a high level of crystals of calcium oxalate in the kidney and also high lipid levels in the blood serum. This shows that when hydroalcoholic extract of *Plectranthus amboinicus* leaves was given, it helps to decrease the level of cholesterol and also other lipids such as triglycerides in the urolithiatic rats [27,28].

Analgesic activity

When evaluated the ability of *P. amboinicus* as analgesic on two animal models using intraperitoneal injection of acetic acid which causes an increase in abdominal fluid prostaglandins, such as PGE₂, PGF₂, serotonin, and histamine, a study found that *Plectranthus amboinicus* reduces the cramps caused by acetic acid in rats and also the pain response but not neurogenic (phase) pain caused by intraplantar injection of formalin. Such results suggest that *P. amboinicus* shows an effective analgesic activity [45]. The *P. amboinicus* exerts analgesic effects and also anti-inflammatory effect which is associated with the inhibition of iNOS expression and NF- κ B COX-2 by inactivating them, and this is the possible reason for the use of this plant as an anti-inflammatory agent [29].

Rheumatoid arthritis

Plectranthus amboinicus may show different activities from the indomethacin that acts on the enzyme cyclooxygenase. According to the previous observation, prednisolone is the only drug which efficiently decreases the production of cytokines and provides maximum protection in joint problems. *Plectranthus amboinicus* activity against rheumatoid arthritis is based on the different mechanisms from non-steroidal anti-inflammatory drugs. *Plectranthus amboinicus* may improve healing, and the use of NSAIDs is reduced, so side effects produced are also less. Ingredients should be identified. Information which is unpublished says that when it is given in a dose of 5000 mg/kg once, it does not produced toxicity. We can say that the plant can be developed as disease modifying drugs against rheumatoid [30–32].

Antiplatelet aggregation activity

The stem extract of *P. amboinicus* was evaluated for the determination of activity against platelet aggregation using different concentrations (50–250 g/ml, platelet-rich plasma), and adenosine triphosphate is the agonist used for this study; after the study, the findings said that capacity of platelets to aggregate depends on dosage, meaning that higher is the concentration, higher is the ability. We knew that platelets play an important role in blood and also has an important role in the cardiovascular diseases. The activity of platelets can affect the disease progression and also the stability of atherosclerosis, so the natural antithrombotic agents which are useful in improving platelet function are of great interest these days, which can show their effect in improving platelet function and also helpful in preventing cardiovascular disease [33,34].

Antibiofilm efficacy

The methanol and ethyl acetate extract of *P. amboinicus* showed a dose-dependent inhibition on film-forming pyrogens which are inflammatory conditions such as pharyngitis. From both the extracts, methanolic extract gives good results against test pathogen at minimal concentration. The extract prepared from methanol contains various phytochemicals which have effects on biofilm formed by the pathogen. We can also say that this is the first plant which shows activity against *S. pyrogens* which are present in the upper respiratory tract [35].

Other uses

Plectranthus amboinicus leaves are used in the laundry, and they are also used to scent hairs when they are fresh. Leaves are also rubbed on hairs and body after bath. They can also be rubbed on body to protect the body from insects. Essential oils from plant have medicinal properties. Leaves and stems contain essential oil which are used in skin cream and used commercially to prepare cosmetics. [36,37]

Culinary uses

Plectranthus amboinicus is called as Indian borage in India because of its flavor. It is used to give flavor to curry fish and lamb dishes because the flavor is similar to oregano thyme or ajowan caraway spices. It is also changeable with those herbs. In the West Indies, this herb is used with some of jerk seasonings after drying; in Cuba, it is used with black beans and salsa; and in Japan, the leaves of the plant are cooked and prepared like spinach [38,39].

Adverse effects of Country borage

No adverse effect is known after the use of *P. amboinicus*. Some people suffer from burning sensation of the tongue and esophagus after the intake of juice of the leaf [40,41].

Discussion

As discussed above, results from various studies were that *P. amboinicus* can be used for the treatment of various diseases such as antineoplastic, anti-inflammatory, and antianxiety and it influences on the other body systems such as urinary and more. Clinical studies are required, including studies in animal models by the help of biochemical marks which help to understand what the mechanism behind this is. It should also be examined for any effects or prevent diseases. For its action which is responsible to fight against cancer, the studies must be performed. One model is not sufficient, but other studies are also required to confirm its effects as anticancer [42,43]. The studies should also be required to verify the results that *P. amboinicus* is an antitumor agent when it is used in combination with the other anticancer drugs. The effect of this plant in the endocrine system and the heart of animals is not clear. The studies show a possible benefit of *P. amboinicus* in the diseases associated with the CNS [44]. The lack of systematic toxicity study is of some concern about the quality of the existing toxicity studies. The above data regarding *P. amboinicus* explain that plant may be useful in several diseases, including wound healing, skin diseases, and respiratory disorders, and as an antitumor agent. This review article provides comprehensive information on the botany, phytochemistry, pharmacology and nutritional importance of *P. amboinicus* essential oil and its various solvent extracts. This article allows researchers to further explore the further potential of this multi-utility herb for various biomedical applications [45,46].

Conclusion

The results, from this review, show that this plant can be used for the treatment of various diseases. As the plant was successfully used in traditional system of medicine from ancient times, there is a requirement of more research on this plant to identify its use so that it can be used therapeutically. One of the important things about this plant shows more effect if given in combination with other medicinal plants.

Conflict of interest

The authors report no conflict of interest.

References

- [1] Janakiraman D, Somasundaram C. Evaluation of Anti inflammatory effect of *Plectranthus amboinicus* leaf extract—an in vitro study. JAPER 2014; 4(2).
- [2] Rao DS, Rao VP, Rao KS. Pharmacological effects of forskolin isolated from *Coleus aromaticus* on the lung damage rats. Int J Adv Pharm Sci 2010; 1(1):17–21.
- [3] Muniandy K, Hassan Z, Isa MH. The action of *Coleus aromaticus* as a potential wound healing agent in experimentally induced diabetic mice. PERINTIS J. 2014; 4(1).
- [4] Saraswati. Jatinder KK. Avinash KN. Analytical techniques for phytochemicals screening and bioactivities of some *Coleus* species: a review. J Pharm Sci Res 2016; 8(4):227–37.
- [5] Girish K. Antimicrobial activities of *coleus aromaticus*. J Pharm Res 2016; 10(10):635–64.
- [6] Wadikar DD, Patki PE. *Coleus aromaticus*: a therapeutic herb with multiple potentials. J Food Sci Technol 2016; doi:10.1007/s13197-016-2292-y
- [7] *Plectranthus amboinicus* (Indian borage). Available via <https://www.cabi.org/isc/datasheet/119834> (Accessed 4 March 2020).
- [8] *Plectranthus amboinicus*. Available via https://en.wikipedia.org/wiki/Plectranthus_amboinicus (Accessed 4 March 2020).
- [9] *Plectranthus amboinicus*. Available via <https://www.nparks.gov.sg/florafaunaweb/flora/3/7/3718> (Accessed 4 March 2020).
- [10] Fu L, Fu Z. *Plectranthus amboinicus* leaf extract-assisted biosynthesis of ZnO nanoparticles and their photocatalytic activity. Ceram Int. 2015; 41(2):2492–6.
- [11] Herbs-Medicinal plants usage and Identification Data base Country borage (*Parnayavani-Plectranthus amboinicus*) Medicinal uses Available via <https://herbs.indianmedicinalplants.info/index.php/1165-country-borage-parnayavani-plectranthus-amboinicus-medicinal-uses-adverse-effects-research-pharmacology> (Accessed 4 March 2020).
- [12] Viswanathaswamy AH, Koti BC, Gore A, Thippeswamy AH, Kulkarni RV. Antihyperglycemic and antihyperlipidemic activity of *Plectranthus amboinicus* on normal and alloxan-induced diabetic rats. Indian J Pharm Sci 2011; 73(2):139.
- [13] Tiwari DK, Nagar H, Dwivedi G, Tripathi RK, Jena J. Evaluation of Anti-Anxiety Activity of *Plectranthus amboinicus* (Lour.) on Rats. Asian J Pharm Clin Res 2012; 5(4):110–3.
- [14] Archana CE. Antianxiety effect of alcoholic leaf extract of *Plectranthus amboinicus* in mice. AJBPS 2013; 3:49–53.

- [15] Manjamalai A, Grace VB. The chemotherapeutic effect of essential oil of *Plectranthus amboinicus* (Lour) on lung metastasis developed by B16F-10 cell line in C57BL/6 mice. *Cancer Invest* 2013; 31(1):74–82.
- [16] Aragao GF, Carneiro LM, Junior AP, Vieira LC, Bandeira PN, Lemos TL, et al. A possible mechanism for anxiolytic and antidepressant effects of alpha- and beta-amyrin from *Protium heptaphyllum* (Aubl.) March. *Pharmacol Biochem Behav* 2006; 85(4):827–34.
- [17] Koti BC, Gore A, Thippeswamy AH, Swamy AV, Kulkarni R. Alcoholic leaf extract of *Plectranthus amboinicus* regulates carbohydrate metabolism in alloxan-induced diabetic rats. *Indian J Pharmacol* 2011; 43(3):286.
- [18] Patel R, Mahobia NK, Gendle R, Kaushik B, Singh SK. Diuretic activity of leaves of *Plectranthus amboinicus* (Lour) Spreng in male albino rats. *Pharmacogn Res* 2010; 2(2):86.
- [19] Hassani MS, Zainati I, Zrira S, Mahdi S, Oukessou M. Chemical composition and antimicrobial activity of *Plectranthus amboinicus* (Lour) Spring. Essential oil from Archipelago of Comoros. *J Essent Oil Bear Plants* 2012; 15(4):637–44.
- [20] Brandao EM, Brandão PH, Souza IA, Paiva GS, de C Carvalho M, Lacerda CM. Antineoplastic effect of aqueous extract of *Plectranthus amboinicus* in Ehrlich Ascites Carcinoma. *J Cancer* 2013; 4(7): 573–6. doi:10.7150/jca.6730
- [21] Ashwini S, Girish K. Phytochemical screening and antibacterial activity of methanolic leaf extract of coleus. *Int J Res Pharm Sci* 2014; 5(4):270–4.
- [22] Vera R, Mondon JM, Pieribattesti JC. Chemical composition of the essential oil and aqueous extract of *Plectranthus amboinicus*. *Planta Med* 1993; 59(2):182–3.
- [23] Krithi Nikhil, Puja C. Yavagal, Antibacterial efficacy of *Plectranthus amboinicus* extracts against *Streptococcus mutans* an in vitro study. *IJAPR* 2015; 3(11):55–8.
- [24] Sreedharren B, Jaiganesh KP, Kannappan N, Sulochna N. Pharmacognostic studies on *Plectranthus amboinicus* Lour. *Res J Pharm Biol Chem Sci* 2010; 1(4):413–24.
- [25] Arumugam G, Swamy MK, Sinniah UR. *Plectranthus amboinicus* (Lour.) Spreng: botanical, phytochemical, pharmacological and nutritional significance. *Molecules* 2016; 21(4):369. doi:10.3390/molecules21040369
- [26] Rai VM, Pai VR, Kedilaya PH, Hegde S. Preliminary phytochemical screening of members of Lamiaceae family: *Leucas linifolia*, *coleus aromaticus* and *Pogestemon patchouli*. *Int J Pharm Sci Rev Res* 2013; 21(1):131–7.
- [27] Rice LJ, Brits GJ, Potgieter CJ, Van Staden J. *Plectranthus*: a plant for the future? *S Afr J Bot* 2011; 77(4):947–59.
- [28] Chiu YJ, Huang TH, Chiu CS, Lu TC, Chen YW, Peng WH, et al. Analgesic and antiinflammatory activities of the aqueous extract from *Plectranthus amboinicus* (Lour.) Spreng. both in vitro and in vivo. *Evid Based Compl Alt* 2012:11.
- [29] Amazing Benefits of Indian Borage Mexican Mint. Available via <https://www.organicfacts.net/health-benefits/herbs-and-spices/indian-borage-mexican-mint.html> (Accessed 4 March 2020).
- [30] *Plectranthus amboinicus* useful tropical plant Available via <http://tropical.theferns.info/viewtropical.php?id=Plectranthus+amboinicus> (Accessed 4 March 2020).
- [31] Chang JM, Cheng CM, Hung LM, Chung YS, Wu RY. Potential use of *Plectranthus amboinicus* in the treatment of rheumatoid arthritis. *Evid Based Complement Altern Med*. 2010; 7(1):115–20.
- [32] Bhatt P, Joseph GS, Negi PS, Varadaraj MC. Chemical composition and nutraceutical potential of Indian borage (*Plectranthus amboinicus*) stem extract. *J Chem* 2013.
- [33] Norazsida R, Pakeer O, Taher M. The antimalarial properties of essential oils of the leaves of Malaysian *Plectranthus Amboinicus* (Lour) Spreng in mice infected with *Plasmodium berghei*. *Int Med J Malays* 2017; 16(1).
- [34] Manimekalai K, Srinivasan P, Dineshbabu J, Guna G, Teepica Priya Darsini D. Anti-biofilm efficacy of *Plectranthus amboinicus* against *Streptococcus pyogenes* isolated from pharyngitis patients. *Asian J Pharm Clin Res* 2016; 9(4):348–54.
- [35] Chang JM, Cheng CM, Hung LM, Chung YS, Wu RY. Potential use of *Plectranthus amboinicus* in the treatment of rheumatoid arthritis. *Evid Based Complement Altern Med* 2010; 7(1):115–20.
- [36] Poppy AZH, Panal S, Denny S. Anticancer activity of B-sitasterol from *plectranthus Amboinicus* leaves: In vitro and in silico studies, *Asian J Pharm Clin Res* 2017; 10(5):306–8. doi.org/10.22159/ajpcr.2017.v10i5.16931
- [37] Ruan TZ, Kao CL, Hsieh YL, Li HT, Chen CY. Chemical Constituents of the Leaves of *Plectranthus amboinicus*. *Chem Nat Compd* 2019; 55(1):124–6.
- [38] Yu H, Iheshiulo EM, Gunupuru L. Microwave power level and exposure time alteration of compost tea efficacy, and growth of *Plectranthus amboinicus*. *Horticult Int J* 2019; 3(4):179–84.
- [39] Arumugam G, Sinniah UR, Swamy MK, Lynch PT. Encapsulation of in vitro *Plectranthus amboinicus* (Lour.) Spreng. shoot apices for propagation and conservation. *3 Biotech* 2019; 9(8):298.
- [40] Hsu KP, Ho CL. Antimildew Effects of *Plectranthus amboinicus* Leaf Essential Oil on Paper. *Nat Prod Commun* 2019; 14(7):1934578X19862903.
- [41] Itza Ortiz MF. Phytobiotic activity of *Larrea tridentata*, *Origanum vulgare* and *Plectranthus amboinicus* in Gram positive and Gram negative bacterias. *Interciencia* 2019; 44(5):298–302.

- [42] Ismayil S, Nimila PJ. Antimicrobial activity of *Plectranthus amboinicus* (Lour.) against Gram negative bacteria *Klebsiella pneumoniae* and *Shigella flexneri* and their phytochemical tests. IJHSR 2019; 9(5):304–11.
- [43] Kushali R, Priya VV, Gayathri R, Sundaram R. In vitro α -amylase and α -glucosidase inhibitory activity of isolated fraction 2 from *Plectranthus amboinicus*. DIT 2019; 12(5).
- [44] Leu WJ, Chen JC, Guh JH. Extract from *Plectranthus amboinicus* inhibit maturation and release of interleukin 1 β through inhibition of NF- κ B nuclear translocation and NLRP3 inflammasome activation. Front Pharmacol 2019; 10:573.
- [45] Shamsul M, Zahrah MA. Boiling increase antioxidant activity, total phenolic content and total flavonoid content in *Plectranthus amboinicus* leaves. GSC Biol Pharm Sci 2019; 6(3):24–30.
- [46] Hasibuan PA, Sumaiyah S. The anti-proliferative and pro-apoptotic properties of ethanol *Plectranthus amboinicus* (Lour.) Spreng. leaves ethanolic extract nanoparticles on T47D cell lines. APJCP 2019; 20(3):897.