JOURNAL OF NUTRACEUTICALS AND HEALTH
2023, VOL. 1, ISSUE 1, pp. 17-21
https://doi.org/10.61577/jnh.2023.100004

RESEAPRO JOURNALS

REVIEW

OPEN ACCESS

Health-promoting properties of *Plectranthus amboinicus*: a comprehensive review

Luciana Gama de Mendonça and Rafael Audino Zambelli

Department of Food Engineering, Food Biomaterials Laboratory, Federal University of Ceará, Fortaleza, Ceará, Brazil

ABSTRACT

Plectranthus amboinicus, known as Cuban oregano or Indian borage, is a botanical species with various health benefits. This comprehensive analysis aims to clarify the scientific foundations of *P. amboinicus* as a phytotherapeutic agent, focusing on its botanical traits, phytochemical composition, and applications in healthcare. *P. amboinicus* is a perennial herbaceous plant recognized for its fleshy, fragrant leaves and adaptability to diverse ecological environments. Its historical use in different cultures for medicinal and culinary purposes is well-documented and demonstrates its significance as a valuable botanical resource. *P. amboinicus* has a complex chemical composition containing multiple bioactive compounds. Phenolic compounds, such as carvacrol and thymol contribute to its antioxidant and antimicrobial properties. Essential oils, terpenes, and other phytoconstituents further enhance its therapeutic potential. The applications of *P. amboinicus* in healthcare are extensive. It is efficient in alleviating respiratory issues, gastrointestinal disorders, and skin conditions. Its antioxidant and anti-inflammatory properties support its relevance in modern healthcare. *P. amboinicus* presents a compelling subject for botanical research and holds promise for promoting health and well-being. A comprehensive understanding of its safety profile and potential adverse effects is crucial, especially in therapeutic contexts. Ongoing scientific investigations and clinical trials are necessary to validate its therapeutic scope and ensure its judicious integration into health-promoting protocols.

KEYWORDS

Health benefits; Phytochemical composition; *Plectranthus amboinicus*; Therapeutic potential

ARTICLE HISTORY

Received 06 October 2023; Revised 01 November 2023; Accepted 07 November 2023

Introduction

Herbal medicines are known to have a range of health-promoting activities [1]. *Plectranthus amboinicus*, a well-recognized member of the Lamiaceae family, shares its family with commercially significant genera like *Plectranthus, Salvia, Ocimum,* and *Mentha*, known for their diverse ethnobotanical benefits. *P. amboinicus*, commonly referred to as Indian borage, is a succulent herb distinguished by its fleshy leaves and distinctive oregano-like flavor and aroma. It holds significance in both culinary science and medicine. Its leaves contain essential oils and bioactive compounds, which render it to be a valuable resource in traditional and contemporary herbal medicine. This plant also has a well-documented history in traditional remedies and exhibits therapeutic potential in conditions such as influenza, bronchitis, and epilepsy [2-4]. It has a relieving action against various symptoms such as coughs, sore throats, and nasal congestion. Additionally, it offers relief from discomfort caused by animal and insect bites and serves as a natural stimulant for breast milk production [5-7].

P. amboinicus naturally thrives in tropical and warm regions, including those of Africa, Asia, and Australia. It exhibits distinct physical characteristics such as vibrant, succulent heart-shaped leaves with scalloped edges. It can reach heights of around 50 cm, and its horizontal stems can measure up to 180cm. The leaves of *P. amboinicus* contain an ample amount of essential oils comprising a diverse range of bioactive compounds. Notable constituents include Carvacrol, Thymol, β-Caryophyllene, α-Humulene, γ-Terpinene, p-Cymene, α-Terpineol, β-Selinene, along with various phytocompounds like flavonoids, cinnamic derivatives, and terpenes [8]. Carvacrol and Thymol are well-known for their anti-inflammatory properties, which are valuable in mitigating inflammation-related health issues. Extensive research supports the antibacterial properties, strong antioxidant capabilities, and hydrophobic characteristics of Carvacol [9]. Furthermore, these compounds exhibit potent antioxidant capabilities, which help in combating harmful free radicals and oxidative stress within the body [10]. Certain constituents, such as β-Caryophyllene, may also contribute to the anticancer effects of the plant. The presence of flavonoids, cinnamic derivatives, and terpenes further augments its therapeutic potential [11]. The rich phytochemical profile of *P. amboinicus* warrants further investigation for its utility in both traditional and modern healthcare practices [5]. In this regard, this article provides a comprehensive overview of *P. amboinicus* as a therapeutic plant.

Phytochemical Composition

The essential oil derived from *P. amboinicus* is composed of several volatile constituents. These constituents can be categorized into distinct chemical groups, namely oxygenated monoterpenes, monoterpene hydrocarbons, oxygenated sesquiterpenes, and sesquiterpene hydrocarbons [5]. These compounds are mostly responsible for its characteristic aroma and therapeutic attributes [12-14]. Its leaves contain over 100 bioactive substances, including phenolic acids (e.g., rosmarinic acid, chlorogenic acid, caffeic acid, hydroxycinnamic acid, and p-coumaric acid), flavonoids

***Correspondence:** Dr. Rafael Audino Zambelli, Department of Food Engineering, Food Biomaterials Laboratory, Federal University of Ceará, Fortaleza, Ceará, Brazil, e-mail: zambelli@ufc.br

(including quercetin, luteolin, apigenin, and guanine), carotenoids, steroidal glycosides, alkaloids, saponins, tannins, and phytosterols [14-16].

The phytochemical composition can vary based on factors such as geographical location, growth conditions, and plant age. The composition of essential oils is subject to various factors, including geographical location, growing conditions, and extraction methods [17]. Variations in soil composition, climate, altitude, and environmental conditions can lead to differences in phytochemicals [18]. Growing conditions, such as soil quality and sunlight exposure, can influence oil development, and stressors like drought can prompt the plant to produce different compounds [19]. The age of the plant at harvest also plays a role in the essential oil's composition [20]. The timing of harvest can affect constituents [21]. Extraction techniques can yield varying results [22]. Genetic variations within *P. amboinicus* populations lead to distinct oil profiles [23,34]. Environmental factors, such as light intensity and temperature, influence essential oil quality and composition in the Lamiaceae family. Higher light intensity can affect the relative concentration of specific compounds, while others may decrease [25].

Gas chromatography analysis has revealed carvacrol and thymol to be the primary components, each constituting over 20% of the oil's composition in the Indian variety [26]. The essential oil derived from the dried leaves of *P. amboinicus* originating from the Comoros Archipelago, have shown the major constituents to be carvacrol, camphor, Δ-3-carene, λ-terpinene, O-cymene, and α-terpinene [27]. In Colombian *P. amboinicus*, the essential oil contains a total of fifteen different compounds, with carvacrol as the predominant constituent, constituting 75.9% of the composition. Other significant compounds include α-bergamotene, p-cymene, α-humulene, 4-terpineol, caryophyllene oxide, β-guaiene, 1-octen-3-ol, α-muurolene, caryophyllene, 3-hexen-2-ol, γ-terpinene, isothymol, 2-carene, and β-bisabolene [28]. In Uganda, phytochemical analysis of aqueous extracts has identified various chemical compounds, including tannins, saponins, flavonoids, steroid glycosides, and polyuronides. Gas chromatography-mass spectrometry analysis further revealed that linalool was the most abundant compound, followed by nerol acetate, geranyl acetate, and carvacrol [29]. Essential oil from Thai *P. amboinicus* is characterized by oxygenated monoterpenes as the primary constituents, followed by monoterpene hydrocarbons, sesquiterpene hydrocarbons, and oxygenated sesquiterpenes [30].

Anti-Inflammatory Properties

Inflammation is a complex biological process that occurs in response to tissue injuries or exposure to pathogens. Its primary goal is to restore normal tissue structure and function. This process is essential for the defense mechanisms of the organisms. Acute inflammation is a well-regulated, transient response that serves as a beneficial mechanism when dealing with infectious pathogens such as bacteria or viruses. During acute inflammation, immune cells are recruited to the site of injury or infection, and various chemical signals coordinate the immune response. This process aids in eliminating harmful agents, initiating tissue repair, and contributing to the overall healing process [31,32]. In contrast, chronic inflammation is a persistent and undesirable phenomenon. Unlike acute inflammation, which has a clear purpose and resolution, chronic inflammation can persist in the body for extended periods. Prolonged inflammation can lead to the development of various inflammatory diseases, including rheumatoid arthritis, cardiovascular diseases, and autoimmune disorders. In chronic inflammation, the immune system may fail to resolve the issue effectively, which causes continuous tissue damage and dysfunction [33]. Under typical circumstances, when the body encounters acute inflammatory stimuli, a series of coordinated cellular and molecular responses take place to address imminent injury or infection and restore tissue equilibrium. However, when acute inflammation is not properly controlled, it can transition into a chronic state, contributing to the development and perpetuation of various chronic inflammatory disorders [34]. Inflammation can stem from various causes, categorized as infectious or non-infectious factors. When the body experiences tissue damage, a complex chemical signaling cascade is initiated to facilitate tissue repair. These signaling molecules induce the migration of white blood cells (leukocytes) from the bloodstream to the specific injury sites. At the site of injury, these activated leukocytes release cytokines, which regulate various aspects of the inflammatory response [35].

Research into the medicinal potential of *Plectranthus* has primarily focused on a subset of 62 species. Scientific investigations have provided evidence that these species possess therapeutic properties, including analgesic and anti-inflammatory effects [36]. These therapeutic applications have been recognized in addressing a range of inflammation-related conditions affecting the skin, infections, the digestive system, and respiratory disorders [4]. Quercetin, present in *P. amboinicus* extract, has demonstrated effectiveness in preventing acute liver injury induced by difenoconazole exposure. This compound acts as an anti-inflammatory, antioxidant, antiaggregant, and hepatoprotective agent. The plant is also enriched with flavonoids and caffeic acid, which further contribute to its remarkable antioxidant and anti-inflammatory properties [37,38]. The anti-inflammatory effect of the plants has been shown in many reports. A significant reduction in paw edema was observed following the administration of hexanoic extract from *P. amboinicus*, especially at higher doses [10]. In another study, an aqueous extract of *P. amboinicus* was subjected to evaluation for its impact on AP-1 binding activities, a cellular process associated with inflammation. The extract exhibited inhibition in DNA-binding activities related to AP-1, with increased inhibition at higher concentrations, and demonstrated no significant toxicity to human fibroblast cell line Detroit 551 [39]. Terpenoid derivatives, known for their diverse biological activities, further enhance the pharmacological potential of *P. amboinicus*. Cinnamic compounds, recognized for their anti-inflammatory and antioxidant properties, add to the plant's medicinal value. These phytocompounds found in *P. amboinicus* leaves support both its traditional use in ethnobotanical medicine and its potential in the development of novel anti-inflammatory and chemotherapeutic agents [40]. The leaves of *P. amboinicus* also have a long history of use in traditional folk medicine due to their easy accessibility for collection and preparation, as well as their analgesic and antimicrobial property that alleviate pain and inhibit harmful microorganisms [41,42].

https://doi.org/10.61577/jnh.2023.100004

Antioxidant Capabilities

An imbalance between pro-oxidant and antioxidant substances in the body characterizes oxidative stress. This imbalance can harm essential macromolecules, including lipids, proteins, and DNA, and lead to their degeneration. Oxidative stress can induce various forms of DNA damage, such as single- and double-stranded DNA breaks and modifications to DNA bases. These DNA lesions have significant consequences, such as disruption of the accurate interpretation of genetic information, which potentially leads to permanent alterations in the genetic material. These genetic changes play critical roles in carcinogenesis and mutagenesis [43,44].

A comprehensive study investigated the antioxidant activity in sixteen distinct *Plectranthus* species using three well-established *in vitro* assays: DPPH (2,2-diphenyl-1-picrylhydrazyl), ABTS (2,2-azinobis (3-ethylbenzothiazoline 6-sulfonate)), and FRAP (ferric reducing antioxidant power using 2,4,6-tripyridyl-s-triazine). The extracts of *P. amboinicus*, *P. barbatus*, and *P. argentatus*, along with the 90% methanol extracts of *P. caninus, P. fruticosus subsp. james,* and *P. argentatus*, exhibited the highest antioxidant activity in the DPPH assay. About 50% of the DCM (Dichloromethane) extracts showed potent antioxidant activity, exceeding even L-ascorbic acid, a well-known reference compound. These findings highlight the remarkable antioxidant potential present in various *Plectranthus* species, which could have significant implications for their utilization in diverse applications, from pharmaceuticals to functional foods. The ethanolic extract and the ethyl acetate fraction obtained from the leaves of *P. amboinicus* have demonstrated significant antioxidant properties in reducing paw edema. These findings show that the relative potency of these extracts reached 83.37% and 88.66%, respectively. This substantial antioxidant activity highlights the therapeutic potential of *P. amboinicus* and its constituents in addressing inflammatory conditions [45]. Further exploration and utilization of these plant-derived antioxidants hold the potential to contribute to the development of novel antioxidant-based therapies and dietary supplements [46].

Anticancer Potential

Cancer poses a significant challenge to human health and ranks among the leading causes of mortality, closely following cardiovascular diseases. This devastating disease is primarily characterized by uncontrolled cell growth, often attributed to the activation of tumor suppressor genes, which promote unchecked cell proliferation while inhibiting the apoptotic mechanisms of the body. Malignant tumors result from the delicate balance of cell adhesion receptors. These receptors facilitate tissue-specific cell attachments and are essential for maintaining proper cell-to-cell connections. However, the development of cancer often involves the down-regulation of these receptors, disrupting normal cellular adhesion. Conversely, there is an up-regulation of cell adhesion receptors that enhance cell motility, contributing to the progression of malignancy. The complex mechanisms underlying cancer initiation and progression encompass various factors, including genetic mutations, chromosomal aberrations, dysregulated signaling pathways, and altered gene expression or activity. Epigenetic changes, affecting DNA residues and gene expression, may also contribute to cancer development [47,48].

The ethanolic extract of *P. amboinicus* (Lour.) Spreng leaves contain various flavonoid compounds, all of which exhibit remarkable anticancer and antioxidant activity. These compounds are known to neutralize harmful free radicals within the body and reduce oxidative stress [49]. The aqueous extract obtained from *P. amboinicus* inhibits the growth of Sarcoma-180 and Ehrlich ascite carcinoma cells by over 70% possibly due to the presence of phenolic compounds. The phytocompounds of *P. amboinicus*, such as diterpenoids, sesquiterpenoids, monoterpenoids (carvacrol), terpenoids (β-sitosterol), caffeic acid, and cinnamic derivatives, possess chemotherapeutic effects [10]. The essential oil from *P. amboinicus* leaves exhibits high IC50 values of 22.5 µg/mL on the breast carcinoma cell line (MCF-7) and 24.5 µg/mL on the Hepatocellular carcinoma cell line (HepG2), indicating its potential anticancer activity [49]. The hexane fraction from the ethanolic extract of the leaves shows cytotoxic effects against human breast cancer MCF-7 cells, with an IC50 value of 8.85 µ g/mL, while the chloroform fraction is more active, with an IC50 value of 2.46 µg/mL. Mass spectrometer analysis indicates that (7-acetoxy-6-hydroxyroyleanone) present in the essential oil of *P. amboinicus* possesses greater cytotoxic activity against MCF-7 cells [50]. A significant reduction in the percentage of viable cells was observed as the concentration of the *P. amboinicus* extract increased. Notably, the IC50 value, representing the concentration at which 50% of the cells were inhibited, was determined to be 53.0 µg/ml for *P. amboinicus*. This data indicates that the plant extract possesses notable cytotoxicity against oral cancer cells [1].

Conclusions

P. amboinicus, known for its succulent aromatic leaves and adaptability to various environments, has a rich history of use across cultures as a valuable botanical resource. Its phytochemical complexity, which includes phenolic compounds like carvacrol and thymol, along with essential oils and terpenes, imparts antioxidant, anti-inflammatory, anticancer, and therapeutic properties. The health applications of *P. amboinicus* are extensive, with documented benefits in treating respiratory, gastrointestinal, and dermatological conditions, supported by its antioxidant and anti-inflammatory capabilities. It stands as a compelling subject for ongoing botanical research and holds great promise in enhancing health and well-being. Rigorous scientific investigations and clinical trials are imperative to validate its broad therapeutic potential and facilitate its prudent incorporation into health-improving protocols.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

1. Leo CM, Sathish MR, Harini PAH, Nachiammai N. Anticancer effect of Plectranthus amboinicus and Glycyrrhiza glabra on oral cancer cell line: an in vitro experimental study. Asian Pac J Cancer Prev. 2023;24(3):881-887.
2. Janakiraman D, Somasundaram C. Evaluation of anti-inflammatory effect of Plectranthus amboinicus leaf extract an in vitro study. J Adv Pharm Educ Res. 2014;4(2):88-92.
3. Alasbahi RH, Melzig MF. Plectranthus barbatus: A review of phytochemistry, ethnobotanical uses and pharmacology - Part 1. Planta Med. 2010;76(7):653-661.
4. Lukhoba CW, Simmonds MSJ, Paton AJ. Plectranthus: a review of ethnobotanical uses. J Ethnopharmacol. 2006;103(1):1-24.
5. Arumugam G, Swamy M, Sinniah U. Plectranthus ambinicius (Lour.) Spreng: Botanical, phytochemical, pharmacological and

https://doi.org/10.61577/jnh.2023.100004

nutrition significance. Molecules. 2016;21(4):369-375.
6. Khare RS, Banerjee S, Kundu K. Coleus aromaticus Benth.-a nutritive medicinal plant of potential therapeutic value. Int J Parma Bio Sci. 2011;2(3):488-500.
7. Damanik R, Wahlqvist M, Wattanapenpaiboon N. Lactagogue effects of Torbangun, a Bataknese traditional cuisine. Asia Pac J Clin Nutr. 2006;15(2):267-274.
8. Vasconcelos SECB, Melo HM, Cavalcante TTA, Júnior FEAC, de Carvalho MG, Menezes FGR, et al. Plectranthus amboinicus essential oil and carvacrol bioactive against planktonic and biofilm of oxacilin and vancomycin-resistant Staphylococcus aureus. BMC Complement Altern Med. 2017;17(1):462-470.
9. Dudai N, Putievsky E, Ravid U, Palevitch D, Halevy AH. Monoterpene content in Origanum syriacum as affected by environmental conditions and flowering. Physiol Plant. 1992;84(3):453-459.
10. Yang J, Zhong C, Yu J. Natural monoterpenes as potential therapeutic agents against atherosclerosis. IJMS. 2023;24(3):2429-2435.
11. Gurgel APAD, da Silva JG, Grangeiro ARS, Oliveira DC, Lima CMP, da Silva ACP, et al. In vivo study of the anti-inflammatory and antitumor activities of leaves from Plectranthus amboinicus (Lour.) Spreng (Lamiaceae). J Ethnopharmacol. 2009;125(2):361-363.
12. Dhifi W, Bellini S, Jazi S, Bahloul N, Mnif W. Essential oils' chemical characterization and investigation of some biological activities: a critical review. Medicines. 2016;3(4):25-37.
13. Sharmeen JB, Mahomoodally FM, Zengin G, Maggi F. Essential oils as natural sources of fragrance compounds for cosmetics and cosmeceuticals. Molecules. 2021;26(3):666-678.
14. Memar MY, Raei P, Alizadeh N, Aghdam AM, Kafil HS. Carvacrol and thymol: strong antimicrobial agents against resistant isolates. Rev Med Microbiol. 2017;28(2):63-68.
15. Stasińska-Jakubas M, Hawrylak-Nowak B, Wójciak M, Dresler S. Comparative effects of two forms of chitosan on selected phytochemical properties of Plectranthus amboinicus (Lour.). Molecules. 2023;28(1):376-382.
16. Wadikar DD, Patki PE. Coleus aromaticus: A therapeutic herb with multiple potentials. J Food Sci Technol. 2016;53(1):2895-2901.
17. Hassani MS, Zainati I, Zrira S, Mahdi S, Oukessou M. Chemical composition and antimicrobial activity of plectranthus amboinicus (lour) spring. essential oil from the archipelago of comoros. J Essent Oil-Bear Plants. 2012;15(4):637-644.
18. Bhatt P, Joseph GS, Negi PS, Varadaraj MC. Chemical composition and nutraceutical potential of indian borage (Plectranthus amboinicus) stem extract. J Chem. 2013;2013(1):82-92.
19. Carneiro FB, Júnior ID, Lopes PQ, Macêdo RO. Variation in the amount of β-caryophyllene in essential oil of Plectranthus amboinicus (Lour.) Spreng. Lamiaceae under different conditions of cultivation. Rev Bras Farmacogn. 2010;20(4):600-606.
20. Alshallash KS, Mohamed MF, Dahab AA, El-Salam HSA, El-Serafy RS. Biostimulation of Plectranthus amboinicus (Lour.) spreng. with different yeast strains: morphological performance, productivity, phenotypic plasticity, and antioxidant activity. Horticulturae. 2023;8(10):887-896.
21. Alves FAR, Morais SM, Sobrinho ACN, da Silva INC, Martins CG, Silva AAS, et al. Chemical composition, antioxidant and antifungal activities of essential oils and extracts from Plectranthus sp. against dermatophytes fungi. Rev Bras Saúde Prod Anim. 2018;19(1):105-115.
22. Maldaner J, Oliveira MN, Santos DA, Garcia PT, Silva SYS, Silva SC, et al. Chemical and thermal profile of Plectranthus amboinicus essential oil for its application as a bioherbicide. Scientia Plena. 2021;17(11).
23. Bezerra RCF, Oliveira Neto FB, da Silva FFM, Bertini LM, Alves LA. Seasonal effect in essential oil composition and antioxidant activity of Plectranthus amboinicus leaves. Biosci J. 2017;33(6):1608-1616.
24. Bandeira JM, Barbosa FF, Barbosa LMP, Rodrigues ICS, Bacarin MA, Peters JA, et al. Essential oil composition of four Plectranthus species. Rev Bras Plantas Med. 2011;13(2):157-164.
25. Mofikoya OO, Makinen M, Janis J. Chemical Fingerprinting of conifer needle essential oils and solvent extracts by ultrahigh-resolution fourier transform ion cyclotron resonance mass spectrometry. ACS Omega. 2020;5(18):10543-10552.
26. Jaramillo-Colorado BE, Vega-Díaz R, Pino-Benítez CN. Volatile chemical composition of Colombian Plectranthus amboinicus (Lour.) Spreng essential oil and its biocidal action against Tribolium castaneum (Herbst). Rev Colomb Cienc Hortic. 2022;16(1):134-143.
27. Priya VN, Vinitha UG, Muthuraman MS. Preparation of chitosan-based antimicrobial active food packaging film incorporated with Plectranthus amboinicus essential oil. Biocatal Agric Biotechnol. 2021;34(2):102-108.
28. Senthilkumar A, Venkatesalu V. Chemical composition and larvicidal activity of the essential oil of Plectranthus amboinicus (Lour.) Spreng against Anopheles stephensi: a malarial vector mosquito. Parasitol Res. 2010;107(1):1275-1278.
29. Asiimwe S, Borg-Karlsson AK, Azeem A, Mugisha KM, Namutebi A, Gakunga NJ. Chemical composition and Toxicological evaluation of the aqueous leaf extracts of Plectranthus amboinicus Lour. Spreng. Int J Pharm Sci Invent. 2014;3(2):19-27.
30. Hsu KP, Ho CL. Antimildew Effects of Plectranthus amboinicus Leaf essential oil on paper. Nat Prod Commun. 2019;14(7):1934578X19862903.
31. Kaplanski G, Marin V, Montero-Julian F, Mantovani A, Farnarier C. IL-6: a regulator of the transition from neutrophil to monocyte recruitment during inflammation. Trends Immunol. 2003;24(1):25-29.
32. Chiu YJ, Huang TH, Chiu CS, Lu TC, Chen YW, Peng WH, et al. Analgesic and anti-inflammatory activities of the aqueous extract from Plectranthus amboinicus (Lour.) Spreng. Both In Vitro and In Vivo. Evid Based Complement Alternat Med. 2012;2012(1):508-516.
33. Chen L, Deng H, Cui H, Fang J, Zuo Z, Deng J, et al. Inflammatory responses and inflammation-associated diseases in organs. Oncotarget. 2018;9(6):7204-7218.
34. Zhou Y, Hong Y, Huang H. Triptolide attenuates inflammatory response in membranous glomerulo-nephritis rat via downregulation of NF-κB signaling pathway. Kidney Blood Press Res. 2016;41(1):901-910.
35. Jabbour HN, Sales KJ, Catalano RD, Norman JE. Inflammatory pathways in female reproductive health and disease. Reproduction. 2009;138(6):903-919.
36. Santos LA, Menezes JDS, Rufino LRA, Oliveira NDMS, Fiorini JE. Determination of the antimicrobial activity in the hydroalcoholic extract of the plant Plectranthus ornatus Codd (Bilberry Chinese). Rev Méd Minas Gerais. 2014;24(4):448-453.
37. Bhat UH, Bhat R. Quercetin: a bioactive compound imparting cardiovascular and neuroprotective benefits: scope for exploring fresh produce, their wastes, and by-products. Biology. 2021;10(7):586-592.
38. Simonetti P, Gardana C, Pietta P. Plasma levels of caffeic acid and antioxidant status after red wine intake. J Agric Food Chem. 2001;49(12):5964-5968.
39. Chen YS, Yu HM, Shie JJ, Cheng TJR, Wu CY, Fang JM, et al. Chemical constituents of Plectranthus amboinicus and the synthetic analogs possessing anti-inflammatory activity. Bioorg Med Chem. 2014;22(5):1766-1772.
40. Barbosa MO, Wilairatana P, Leite GML, Delmondes GA, da Silva LYS, Júnior SCA, et al. Plectranthus species with anti-inflammatory and analgesic potential: a systematic review on ethnobotanical and pharmacological findings. Molecules. 2023;28(15):5653-5660.
41. Cruz MG, Lopes Junior ML, Freitas MCC, Freitas ACGDA, Santos LDS, Corrêa MJC, et al. Levantamento etnobotânico de plantas medicinais na comunidade Guajará de Carapajó, Cametá-pa. Open Sci Res. 2022;7(1):1408-1431.
42. Farias OT, Nascimento LC, Oliveira FS, Santos MDR, Bruno RLA. Essential oil of andiroba (Carapa guianensis Aubl.) and copaiba

https://doi.org/10.61577/jnh.2023.100004

(Copaifera langsdorffi Desf) on health and physiology of seeds macassar bean (Vigna unguiculata L. Walp). Rev Bras Plantas Med. 2016;18(1):629-635.
43. Srinivas US, Tan BW, Vellayappan BA, Jeyasekharan AD. ROS and the DNA damage response in cancer. Redox Biol. 2019;25(1):101084.
44. Wang H, Wang DH, Yang X, Sun Y, Yang CS. Colitis-induced IL11 promotes colon carcinogenesis. Carcinogenesis. 2021;42(4):557-569.
45. El-Hawary RH, El-Sofany AR, Abdel-Monem RS, Ashour SS. Phytochemical screening, DNA fingerprinting, and nutritional value of Plectranthus amboinicus (Lour.) Spreng. Pharmacogn J. 2012;4(1):10-13.
46. Sako KB, Makhafola TJ, Antonissen R, Pieters L, Verschaeve L, Elgorashi EE. Antioxidant, antimutagenic and antigenotoxic properties of Plectranthus species. S Afr J Bot. 2023;161(1):113-125.
47. Li BT, Smit EF, Goto Y, Nakagawa K, Udagawa H, Maziéres J, et al. Trastuzumab deruxtecan in HER2-mutant non–small-cell lung cancer. N Engl J Med. 2022;386(3):241-251.
48. Chaft JE, Rimner A, Weder W, Azzoli CG, Kris MG, Cascone T. Evolution of systemic therapy for stages I–III non-metastatic non-small-cell lung cancer. Nat Rev Clin Oncol. 2021;18(9):547-557.
49. Manurung K, Sulastri D, Zubir N, Ilyas S. In silico Anticancer activity and in vitro antioxidant of flavonoids in Plectranthus amboinicus. Pharmacogn J. 2020;12(6):1573-1577.
50. Almaki A, Abutaha N, Al-Doaiss AA, Mohammed AZ, Wadaan MA. Cytotoxicity, in vivo toxicity, and chemical composition of the hexane extract of Plectranthus amboinicus (Lour.) Spreng. Environ Sci Pollut Res Int. 2021;28(35):48141-48153.

https://doi.org/10.61577/jnh.2023.100004