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Review Article

**ETHNOBOTANICAL AND PHYTO PHARMACOLOGICAL
ACTIVITIES OF MADAGASCAR PERIWINKLE
(*CATHARANTHUS ROSEUS*) - A DETAILED REVIEW****V. SHOBA**

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Abstract:

Catharanthus roseus (L.) G. Don known as "The Madagascar periwinkle". It is a popular ornamental plant found in gardens and homes across the warmer parts of the world. It is a tropical and subtropical plant belonging to the family Apocynaceae. This review highlights the marvelous properties of this plant. Alkaloids were the major phytochemical constituent of the above medicinal plant and have different types possessing various medicinal uses. The pharmacology of the plant was found to be associated mostly especially with the alkaloids that occupies almost most of the parts of the plant. Present review, focusing on the ethnobotanical and pharmacological activities of medicinal plants (*Canthranthus roseus*) resides in its secondary metabolites of various human diseases and vector control connections.

Keywords: *Catharanthus roseus*, Apocynaceae, pharmacological activities, secondary metabolites.

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INTRODUCTION:

Medicinal plants are a natural gift for human beings disease free and healthy life [1]. The herbal products today are considered to be safer to human and environment in India has different parts of several medicinal plants or their extracts are used for the treatment of various diseases[2] [3]. Herbal medicines have not gained much importance due to the deficient in of scientific facts for their mechanism of exploit [4]. According to the World Health Organization state that traditional medicine is used in plant parts such as a leaf, stem, bark, and flowers estimated to be used medicine by 80% of the population most of developing countries [5]. In India, medicinal plants are widely used by all sections of people both directly as folk medicines in different indigenous systems of medicine like Siddha, Ayurveda and Unani and indirectly in the pharmaceutical preparations [6]. India has about 4.5 million plant species and among them, several thousands have been claimed to possess medicinal properties against human diseases. Although traditional medicinal healers have used medicinal plants for treatment of ailments for hundreds of years, there has always been a lingering question in scientific circles about their therapeutic efficacy. As a consequence, the pharmacological activity of many medicinal plants has been studied, even though the vast majority of medicinal plants remain to be studied for their phytochemical components and pharmacological effects. World health organization [5] have been prepared a list of 21000 medicinal important plant one such plant is *Catharanthus roseus* (L).

Catharanthus roseus belonging to family Apocynaceae, the plant is used to treat the disorders such as Antimicrobial, antioxidant, anticancer [7-12], lymphoblastic leukemia [13], and possess antibacterial [14, 15], antiviral and anti-inflammatory activities [16], anti-fertility [17], anti-helminthic activity [18], hypolipidemic activity [19], antifungal [20], ulcer [21]. The activity of glucokinase, malate dehydrogenase, succinate dehydrogenase was increased gradually in the streptozotocin-induced diabetic rats treated with *C. roseus* extracts [22, 23].

The hepatic enzyme such as hexokinase was significantly increased and glucose 6-phosphatase, fructose 1, 6-bisphosphate activity came to normal level in *C. roseus* treated animals [24]. The increase in serum insulin level and restoration of β cells were evident in aqueous extract treated rats [25]. Treatment of diabetic animals with extracts resulted in significant decrease in serum LDL level; the reduced level of LDL may possibly occur due to the presence of flavonoids in the ethanol extract of *C. roseus* [21]. The increased level of protein was decreased by the treatment of *C. roseus* in alloxan-induced diabetic rats. Therefore extensive studies are carried out to screen plants as insect growth control agents. Over the past decades, better attention has been focused on the bioactivity of Phytochemicals for their potential as pesticides [26]. It causes human mortality and morbidity alongside giant economic loss. Roughly all tropical regions of the planet area unit expertise the recovery and reoccurrence of 1 of the world's an outsized quantity deadly diseases, ie. Malaria and India is not any omission[27].

Taxonomy, habit and habitat of *Catharanthus roseus*

Medicinal plants are the traditional source of drugs [28]. *Catharanthus roseus* (L.) G. Don of the family Apocynaceae is one of the most widely investigated medicinal plants (Fig 1). It is a perennial, evergreen herb, 30-100 cm height that was originally native to the island of Madagascar. It has been widely cultivated for hundreds of year and can now be found growing wild in most warm regions of the world. The leaves are glossy, dark green (1-2 inch long), oblong-elliptic, acute, rounded apex; flowers fragrant, white to pinkish purple terminal or axillary cymose clusters; follicle hairy, many seeded, 2-3 cm long; seeds oblong, minute, black. The plant is commonly grown in gardens for beddings, borders and for mass effect. It blooms throughout the year and is propagated by seeds or cuttings. The bloom of natural wild plants are pale pink with a purple eye in the center, but horticulturist has developed varieties (more than 100) with color ranging from white to pink to purple [29].

Table 1. *C. roseus* Classification

Kingdom	Plantae
Class	Magnoliopsida
Order	Gentianales
Family	Apocynaceae
Genus	<i>Catharanthus</i>
Species	<i>roseus</i>



Figure 1: *Catharanthus roseus* (L.) plant

Table 2: Pharmacological activities of *Catharanthus roseus*

S. No	Pharmacological activities	References
1	Anti-cancer	[8,11,33,38,45,46,58]
2	Anti-diabetics	[19,20,22,23,24]
3	Hypoglycemic	[3,23,60]
4	Hypertension	[21,36,42,60]
5	Anti-helminthic	[14,47]
6	Anti-diarrheal	[14,48]
7	Anti-oxidant	[6,30,49,50,51,52]
8	Anti-allergic	[52,53]
9	Anti-inflammatory	[35,52,53]
10	Anti-microbial	[5,7,10,17,55,56]
11	Biochemical	[19,20,54,59]
12	Wound Healing	[61]

Morphology characteristics of *Catharanthus roseus*

Catharanthus roseus is an evergreen subshrub or herbaceous plant growing to 1 m tall. The leaves are oval to oblong, 2.5- 9.0 cm. long and 1- 3.5 cm. broad glossy green hairless with a pale midrib and a short petiole about 1- 1.8 cm. long and they are arranged in the opposite pairs. The flowers are white to dark pink with a dark red center, with a basal tube about 2.5- 3 cm. long and a corolla about 2-5 cm. diameter with five petal-like lobes. The fruit is a pair of follicles about 2-4 cm. long and 3 mm broad[30].

History of Introduction and Spread

C. roseus has been introduced into new habitats worldwide mostly to be used as an ornamental and a medicinal plant. It was brought into cultivation in the first half of the 18th century in Paris from seeds collected in Madagascar, and was later distributed from European botanical gardens to the tropics as an ornamental. In the West Indies, it appears in herbarium collections made in 1882 in the Virgin Islands, in 1885 in Puerto Rico, and in 1910 in the Dominican Republic (US National Herbarium)[31].

C. roseus cultivation

The genus comes from Madagascar and has been cultivated with ornamental aim because it produces flowers of pink or white colour for most of the year [32]. As an ornamental and medicinal plant, *C. roseus* is cultivated in tropical and subtropical regions of the world [33]. The climatic conditions and the soil properties of some European countries are, however unfavorable for the cultivation of *C. roseus*. It may be grown only as an annual plant in greenhouses and in plastic tunnels but in that cases the content of dimeric indole alkaloids was observed to be very low [34].

Potentially bioactive chemical constituents

C. roseus posses carbohydrate, flavinoid, saponin, Terpenoids, protein and alkaloids[9]. Alkaloids are the most potentially active chemical constituents of *Catharanthus roseus*. More than 400 alkaloids are present in the plant, which are used as pharmaceuticals, agrochemicals, flavor and fragrance, ingredients, food additives and pesticides. The alkaloids like actineo plastidemic, Vinblastin, Vincristine, Vindesine, Vindeline Tabersonine etc. are mainly present in aerial parts whereas ajmalicine, vinceine, vineamine, raubasin, reserpine, catharanthine etc are present in roots and basal stem. Rosindin is an anthocyanin pigment found in the flower of *C. roseus*. Terpenes or terpenoids indole alkaloids have been identified as active anti-cancer, anti-inflammatory and anti-bacterial anti-protzoal and anti-malarial agents in many pharmacological studies [35-38].

Pharmacological activities of *Catharanthus roseus*

The present interest in this plant is due to the fact that it is a source of chemotherapeutic agents with activity against several kinds of cancer [39] and also it produces a great variety of terpenoid indole alkaloids, most of them with pharmacological activity [40]. Vinblastine and vincristine are perhaps the most important alkaloids with anti-cancerous property [36]. Vinblastine is used against several forms of cancer like Hodgkin's disease, while vincristine is used in the treatment of leukemias [41]. This plant also produces antihypertensive agents such as ajmalicine and serpentine, which are used to overcome heart arrhythmias [41]. These agents improve blood circulation in brain [42]. Some of the terpenoid indole alkaloids are used in the treatment of anxiety (serpentine), arterial hypertension (ajmalicine) [43] and similar other disorders. Vincristine and vinblastine alkaloids are found to be useful in the treatment of various types of lymphoma and leukemia [44, 45]. It has been used in traditional medicine as a hypoglycemic agent [22].

Catharanthus alkaloids are anti-tumoral drugs widely used in the treatment of malignant diseases. This review summarizes different aspects of their pharmacology (mechanism of action, resistance, clinical pharmacokinetics) as well as information on their uses in the clinical setting [46]. Traditionally, the plant has been used for relieving muscle pain, depression of the central nervous system and wasps stings. It is used in the cases of nose bleed, bleeding gums, mouth ulcers and sore throats. It has also been used internally for the treatment of the loss of memory, hypertension, cystitis, gastritis, enteritis, diarrhoea and the raised blood sugar levels [47]. Its application ranges widely from the prevention of cancer, cancer treatment, anti-diabetic, stomachic etc [48]. From the Traditional period itself, the plant has been used to cure diabetes and high blood pressure as it was believed to promote the insulin production or to increase the body's usage of the sugars from the food in case of diabetes [22]. During the period of 1950s, *C. roseus* was found to possess a large number of chemicals in the alkaloid class. Alkaloids are the bitter-tasting plant compound that contains mostly of nitrogen many of them was found to possess pain relieving or the anti-cancer properties. Especially two major alkaloids in *C. roseus* such as vinblastine and vincristine was developed into the prescriptions for the anticancer drugs [49]. The absolute levels of vinblastine and vincristine are considered to be far too low in order to explain the activity of crude extracts of *Catharanthus* [50, 51].

Helminthes infections are the chronic illness, affecting human beings and cattle. *Catharanthus roseus* was found to be used from the traditional period as an anti-helminthic agent [18]. The anti-diarrheal activity of the plant ethanolic leaf extracts was tested in the wistar rats with castor oil as a experimental diarrhea inducing agent in addition to the pretreatment of the extract. The anti-diarrheal effect of ethanolic extracts *C. roseus* showed the dose dependant inhibition of the castor oil induced diarrhea [52]. Asheesh Kumar [53] were investigated the anti-oxidant activity of *Catharanthus roseus*. The anti-oxidant potential of the ethanolic extract of the roots of the two varieties of *C. roseus* namely rosea (pink flower) and alba (white flower) was obtained by using different system of assay same medicinal plant *Pisonia alba* [54] ethnobotanical reviews focused important of plants. The result obtained proved that the ethanolic extract of the roots of Periwinkle varieties has exhibited the satisfactory scavenging effect in the entire assay in a concentration dependent manner but *C. roseus* was found to possess more anti-oxidant activity than that

of *C. alba* [55]. The flower petals, seeds and other parts of *Catharanthus roseus* exhibit anti-oxidant properties. Thus phenolic compounds have redox properties that act as reducing agents, hydrogen donors, singlet oxygen quenchers or metal chelators. It has multiple applications in foods, cosmetics and pharmaceutical industries. Besides anti-oxidant activity, these compounds exhibit anti-allergic, anti-inflammatory, anti-microbial, anti-thrombotic, cardio protective and vasodilatory effects [56, 57].

Other pharmacological uses of *C. roseus* include wound healing, analgesic, vasodilatory and hypoglycaemic [58]. Yogesh Patel [19] were done a study to find out the Hypolipidemic activity of *Catharanthus roseus* (Linn.). Mostly the pharmacological activity of medicinal plants resides in its secondary metabolites which are comparatively smaller molecules in contrast to the primary molecules such as proteins, carbohydrates and lipids. These natural products provide clues to synthesize new structural types of anti-microbial and anti-fungal chemicals that are relatively safe to man [10, 59]. In recent years much attention has been devoted to natural anti-oxidant and their association with health benefits. Plants are potential sources of natural antioxidants and produce various anti-oxidative compounds that have therapeutic potentials. Anti-oxidant-based drug formulations are used for the prevention and treatment of many complex diseases. Similar plants have so many disease cures and recovery acting traditional and now a day. Hence, in this review monitoring plant conservation and awareness develop modern life[60-62].

Economic Values

The world market consumed 5-10 kg of vincristine and vinblastine in the early 1990s, with a total value of US\$25-50 million. In 2005 the market was estimated at US\$150-300 million. In 1991 the world market consumed 3-5 t of ajmalicine, with a total value of US\$4.5-7.5 million. Two anti-cancer medicines, Oncovin® and Velban®, derived from *C. roseus*, are sold for a total of US\$100 million per year [10, 63].

CONCLUSION:

Catharanthus roseus is one of the best studied medicinal plants. Medicinal plant is the most exclusive source of life saving drugs for majority of the world's population. They continue to be an important therapeutic aid for alleviating the ailments of human kinds. The search for defence mechanism, longevity and remedies to relieve pain and discomfort drove early man to explore these immediate natural surroundings. It led to the use of plants, animal

products and minerals etc., and the development of a variety of therapeutic agents. Today, there is a renewal interest in traditional medicine and an increasing demand for more drugs from plant sources because green medicine is safe and more dependable than costly synthetic drug, many of which have adverse side effects. *Catharanthus roseus* was investigated from the ancient time for their phytochemical components and their therapeutic effect. The plant contains enormous phytochemical constituents of various medicinal applications. This review may be help made to investigate medicinal plants and health professionals, scientists and scholars operational in the field of pharmacology and therapeutics to develop various drugs synthesis and build new remedies various diseases. The plants also possess various properties such as anti-cancerous, anti-diabetic, anti-helminthic, anti-diarrheal, anti-microbial etc. Hence, most work could be done on the above plant to reveal the unknown mysteries which would help the need of the present pharmaceutical world.

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REFERENCES:

1. Ravisankar, N., et al., *Antioxidant activities and phytochemical analysis of methanol extract of leaves of Hypericum hookerianum*. Int J Pharm Pharm Sci, 2014. **6**(4): p. 456-460.
2. Elujoba, A.A., O. Odeleye, and C. Ogunyemi, *Traditional medicine development for medical and dental primary health care delivery system in Africa*. 2005.
3. Agrawal, D.K., M.S. Lodhi, and S. Panwar, *Are EIA studies sufficient for projected hydropower development in the Indian Himalayan region?* Current Science, 2010: p. 154-161.
4. Gayathri, G. and M. Gayathri, *Preliminary qualitative phytochemical screening and in vitro hypoglycemic potential of Acanthus ilicifolius and Evolvulus emerginatus*. Int J Pharm Pharm Sci, 2014. **6**(6): p. 362-5.
5. Organization, W.H., *The world health report 2002: reducing risks, promoting healthy life*. 2002: World Health Organization.
6. Srinivasan, D., et al., *Antimicrobial activity of certain Indian medicinal plants used in folkloric medicine*. Journal of ethnopharmacology, 2001. **74**(3): p. 217-220.

7. Jaleel, C.A., et al., *Triadimefon induced changes in the antioxidant metabolism and ajmalicine production in Catharanthus roseus (L.) G. Don.* Plant Science, 2006. **171**(2): p. 271-276.
8. Tamizhazhagan, V., et al., *Antioxidant properties of Pisonia alba plant leaf extract.* International Journal of Zoology and Applied Biosciences, 2017. **2**(6): p. 311-314.
9. Tamizhazhagan, V., et al., *Preliminary screening of phytochemical evaluation selected plant of Pisonia alba.* IJ Biol. Research, 2017. **2**(4): p. 63-66.
10. Patil, P.J. and J.S. Ghosh, *Antimicrobial activity of Catharanthus roseus—a detailed study.* British Journal of Pharmacology and Toxicology, 2010. **1**(1): p. 40-44.
11. Sain, M. and V. Sharma, *Catharanthus roseus (An anti-cancerous drug yielding plant). A Review of Potential Therapeutic Properties.* Int. J. Pure App. Biosci, 2013. **1**(6): p. 139-142.
12. Mothana, R.A., et al., *Studies of the in vitro anticancer, antimicrobial and antioxidant potentials of selected Yemeni medicinal plants from the island Soqatra.* BMC Complementary and Alternative Medicine, 2009. **9**(1): p. 7.
13. Ahmad, N.H., R.A. Rahim, and I. Mat, *Catharanthus roseus aqueous extract is cytotoxic to Jurkat leukaemic T-cells but induces the proliferation of normal peripheral blood mononuclear cells.* Tropical life sciences research, 2010. **21**(2): p. 101.
14. Ibrahim, M., S. Mehjabeen, and M.L. Narsu, *Pharmacological evaluation of Catharanthus roseus.* International Journal of Pharmaceutical Applications, 2011. **2**(3): p. 165-173.
15. Vipasha, S., et al., *Traditional Indian Herb Catharanthus roseus Used as Cancer Treatment: A Review.* Int J Pharmacogn Phytochem Res, 2016. **8**(12): p. 1926-1928.
16. Marcone, C., A. Ragozzino, and E. Seemuller, *Dodder transmission of alder yellows phytoplasma to the experimental host Catharanthus roseus (periwinkle).* European journal of forest pathology, 1997. **27**(6): p. 347-350.
17. Shaik, A., P.R. Yalavarthi, and C.K. Bannoth, *Role of Anti-fertility Medicinal Plants on Male & Female Reproduction.* Journal of Complementary and Alternative Medical Research, 2017. **3**(2): p. 1-22.
18. Agarwal, S., et al., *Evaluation of in-vitro anthelmintic activity of Catharanthus roseus extract.* Int J Pharm Sci Drug Res, 2011. **3**(3): p. 211-3.
19. Patel, Y., et al., *Evaluation of hypolipidemic activity of leaf juice of Catharanthus roseus (Linn.) G. Donn. in guinea pigs.* Acta Pol Pharm, 2011. **68**(6): p. 927-935.
20. Patharajan, S., et al., *Catharanthus roseus: Detoxification and Hepatic Protection of Aflatoxin B1, in Catharanthus roseus.* 2017, Springer. p. 331-348.
21. Karthikeyan, J., et al., *Medicinal plants and diabetes mellitus: A review.* Journal of Pharmacognosy and Phytochemistry, 2017. **6**(4): p. 1270-1279.
22. Singh, S.N., et al., *Effect of an antidiabetic extract of Catharanthus roseus on enzymic activities in streptozotocin induced diabetic rats.* Journal of Ethnopharmacology, 2001. **76**(3): p. 269-277.
23. Ahmed, M.F., et al., *Antidiabetic activity of Vinca rosea extracts in alloxan-induced diabetic rats.* International Journal of Endocrinology, 2010. **2010**.
24. Jayanthi, M., et al., *Study of antihyperglycemic effect of Catharanthus roseus in alloxan induced diabetic rats.* Int J Pharm Pharm Sci, 2010. **2**(4): p. 114-116.
25. Natarajan, A., et al., *Effect of aqueous flower extract of Catharanthus roseus on alloxan induced diabetes in male albino rats.* IJPSSDR, 2012. **4**(2): p. 150-153.
26. Lakshmanan, S., S. Thushimanan, and V. Tamizhazhagan, *Antifeedant, larvicidal and oviposition Detergent activity of Pongamia pinnata and Ceiba pentandra against pod borer larvae of Helicoverpa armigera (Noctuidae: Lepidoptera).* Indo American Journal of Pharmaceutical Sciences, 2017. **4**(2): p. 180-185.
27. Tamizhazhagan, V., et al., *Pest potential of Pisonia alba extracts and fractions against mosquito-borne disease (Diptera: Culicidae).* 2017.
28. Herb, M.M., *Somatic Embryogenesis in Swertia chirata Buch. Ham. ex Wall.—A Multipotent Medicinal Herb.* Asian Journal of Biotechnology, 2011. **8**(2): p. 186-198.
29. Junaid, A., et al., *Somatic embryo proliferation, maturation and germination in Catharanthus roseus.* Plant cell, tissue and organ culture, 2006. **84**(3): p. 325-332.
30. Aruna, M.S., et al., *Catharanthus Roseus: ornamental plant is now medicinal boutique.* Journal of Drug Delivery and therapeutics, 2015. **5**(3): p. 1-4.
31. De Padua, L., N. Bunyapraphatsara, and R. Lemmens, *Plant resources of South-East Asia.* Vol. 12. 1999: Backhuys Publ.
32. Loyola-Vargas, V.M., R.M. Galaz-Ávalos, and R. Kú-Cauich, *Catharanthus biosynthetic*

- enzymes: the road ahead*. Phytochemistry Reviews, 2007. **6**(2-3): p. 307-339.
33. Malviya, N., Jain, S., & Malviya, S. A. P. N. A. (2010). Antidiabetic potential of medicinal plants. *Acta Pol Pharm*, *67*(2), 113-118.
 34. Pietrosiuk, A., M. Furmanowa, and B. Łata, *Catharanthus roseus: micropropagation and in vitro techniques*. Phytochemistry Reviews, 2007. **6**(2-3): p. 459-473.
 35. Mahato, S.B. and S. Sen, *Advances in triterpenoid research, 1990–1994*. Phytochemistry, 1997. **44**(7): p. 1185-1236.
 36. Mukherjee, A.K., et al., *Advances in cancer therapy with plant based natural products*. Current medicinal chemistry, 2001. **8**(12): p. 1467-1486.
 37. Krishnaiah, D., R. Sarbatly, and A. Bono, *Phytochemical antioxidants for health and medicine a move towards nature*. Biotechnology and Molecular Biology Reviews, 2007. **2**(4): p. 97-104.
 38. Asase, A., G.A. Akwetey, and D.G. Achel, *Ethnopharmacological use of herbal remedies for the treatment of malaria in the Dangme West District of Ghana*. Journal of ethnopharmacology, 2010. **129**(3): p. 367-376.
 39. Schmeller, T. and M. Wink, *Utilization of alkaloids in modern medicine*, in *Alkaloids*. 1998, Springer. p. 435-459.
 40. Jacobs, D.I., et al., *The Catharanthus alkaloids: pharmacognosy and biotechnology*. Current medicinal chemistry, 2004. **11**(5): p. 607-628.
 41. Shanks, J.V., et al., *Quantification of metabolites in the indole alkaloid pathways of Catharanthus roseus: implications for metabolic engineering*. Biotechnology and bioengineering, 1998. **58**(2-3): p. 333-338.
 42. Moreno, P.R., R. van der Heijden, and R. Verpoorte, *Cell and tissue cultures of Catharanthus roseus: a literature survey*. Plant cell, tissue and organ culture, 1995. **42**(1): p. 1-25.
 43. Kruczynski, A. and B.T. Hill, *Vinflunine, the latest Vinca alkaloid in clinical development: a review of its preclinical anticancer properties*. Critical reviews in oncology/hematology, 2001. **40**(2): p. 159-173.
 44. Farnsworth, N., G. Svoboda, and R. Blomster, *Antiviral activity of selected Catharanthus alkaloids*. Journal of pharmaceutical sciences, 1968. **57**(12): p. 2174-2175.
 45. Svoboda, G.H. and D.A. Blake, *The phytochemistry and pharmacology of Catharanthus roseus (L.) G. Don*. The catharanthus alkaloids, 1975: p. 45-83.
 46. Leveque, D., J. Wihlm, and F. Jehl, *Pharmacology of Catharanthus alkaloids*. Bulletin du cancer, 1996. **83**(3): p. 176-186.
 47. Desisa, D., *A preliminary economic evaluation of medicinal plants in Ethiopia: trade, volume and price*. 2001.
 48. Eguale, T. and M. Giday, *In vitro anthelmintic activity of three medicinal plants against Haemonchus contortus*. International Journal of Green Pharmacy (IJGP), 2009. **3**(1).
 49. Duflos, A., A. Kruczynski, and J.-M. Barret, *Novel aspects of natural and modified vinca alkaloids*. Current Medicinal Chemistry-Anti-Cancer Agents, 2002. **2**(1): p. 55-70.
 50. El-Sayed, A. and G.A. Cordell, *Catharanthus alkaloids. XXXIV. Catharanthamine, a new antitumor bisindole alkaloid from Catharanthus roseus*. Journal of natural products, 1981. **44**(3): p. 289-293.
 51. El-Sayed, A., G.A. Handy, and G.A. Cordell, *Catharanthus Alkaloids, XXXVIII. Confirming Structural evidence and antineoplastic activity of the bisindole alkaloids leurosine-N^b-oxide (pleurosine), roseadine, and vindolicine from Catharanthus roseus*. Journal of natural products, 1983. **46**(4): p. 517-527.
 52. Hassan, K.A., et al., *In vivo antidiarrheal activity of the ethanolic leaf extract of Catharanthus roseus Linn.(Apocyanaceae) in Wistar rats*. African Journal of Pharmacy and Pharmacology, 2011. **5**(15): p. 1797-1800.
 53. Kumar, A., et al., *Analysis of antioxidant activity of Catharanthus roseus (L.) and its association with habitat temperature*. Asian J Exp Biol Sci, 2012. **3**(4): p. 706-13.
 54. Tamizhazhagan, V. and K. Pugazhendy, *Ethnobotanical and Phytopharmacological review of Pisonia alba Span*. Asian J Pharm Clin Res, 2017. **10**(5): p. 69-71.
 55. Bhat, N.A., A. Bhardwaj, and B. Tiwari, *Anti-Dermatophytic Activity Of Catharanthus Roseus L.(Leaves)*.
 56. Jacob, R.A., *The integrated antioxidant system*. Nutrition research, 1995. **15**(5): p. 755-766.
 57. Kabesh, K., et al., *Phytochemical analysis of Catharanthus roseus plant extract and its antimicrobial activity*. Int J Pure Appl Biosci, 2015. **3**(2): p. 162-72.
 58. Hasegawa, P.M., et al., *Plant cellular and molecular responses to high salinity*. Annual review of plant biology, 2000. **51**(1): p. 463-499.
 59. Kalimuthu, K., S. Vijayakumar, and R. Senthilkumar, *Antimicrobial activity of the biodiesel plant, Jatropha curcas L*. International Journal of Pharma and Bio Sciences, 2010. **1**(3): p. 1-5.

60. Kasote, D.M., et al., *Significance of antioxidant potential of plants and its relevance to therapeutic applications*. International journal of biological sciences, 2015. **11**(8): p. 982.
61. Panche, A., A. Diwan, and S. Chandra, *Flavonoids: an overview*. Journal of nutritional science, 2016. **5**.
62. Szymanska, R., P. Pospisil, and J. Kruk, *Plant-derived antioxidants in disease prevention*. Oxidative medicine and cellular longevity, 2016. **2016**.
63. Singh, K., B. Swanson, and J. Singh. *Development of supply chains for medicinal plants: a case study involving the production of vinca rosa by small farmers in the Patna District of Bihar India*. in *Workshop on Building New Partnerships in the Global Food Chain*, Chicago. 2005.