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Nyctanthes arbor-tristis: Comprehensive review on its pharmacological, antioxidant, and anticancer activities

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ABSTRACT

Nyctanthes arbor-tristis (Oleaceae) popularly known as "Parijat" is a plant of great importance in India. It is widely used in Ayurvedic medicines. Each part of this plant has some medicinal value. It possesses extensive medicinal uses, viz., antipyretic, anti-inflammatory, anthelmintic, sedative effect, laxative, and expectorant, in rheumatism. The present review aims to perform a detailed compilation of work done on this plant mainly as a source of the antioxidant and anticancer agent as well as various pharmacological properties from 1987 to till date. All these activities possessed by plants are due to the presence of multiple phytochemicals which can act as a source of active pharmacological agents. Crude extracts, as well as pure compounds like 4-hydroxy-hexahydrobenzofuran-7-one, $\beta\beta$ -hydroxyloganin, and Arbortristoside A from seeds, a polysaccharide from leaves, and Naringenin from the stem, are reported for its anticancer and antioxidant properties. The need of the hour is to provide scientific validation of ethnomedicinal use of this plant. The present study can be used to highlight the need for research and potential development of natural therapeutic products with lesser side effects.

1. INTRODUCTION

Synthetic chemicals are widely used as medicines in the treatment of diseases encompassing various side effects. Different plants were explored as a source of bioactive agents for the treatment of ailments like cancer. The plant possesses immense biological properties due to the presence of different chemical substances which perform several important physiological functions. Among 4,22,000 flowering plants reported from the whole world, more than 50,000 plants are reported to have medicinal and pharmacological uses. A rich diversity of medicinal plants is found in India [1]. Utilization of plants for medicinal usage has been documented long back in ancient works of literature. Such documentation of prime traditional knowledge on medicinal plants provided many important drugs of the modern era. Nyctanthes arbor-tristis L. (Oleaceae) is an important medicinal plant having a lot of medicinal uses since ancient times. Different parts of this plant have been used as local and traditional medicines. Nyctanthes arbor-tristis is utilized in Ayurveda, Siddha-Ayurveda,

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Anjali Soni, Department of Biotechnology, Veer Narmad South Gujarat University, Surat, India. E-mail: anjalisoni@vnsgu.ac.in and Yunani systems of medicines as a laxative, diuretic, as anti-venoms, digestives, mild bitter tonic, and expectorant [2]. Nyctanthes arbor-tristis Linn. (Division: Magnoliophyta; Class: Magnoliopsida; Order: Lamiales; Family: Oleaceae), commonly known as Harshingar and Night jasmine [3], is a well-documented plant. It is a shrub or small tree growing to 10 m tall terrestrial woody perennial plant having 5-20 years of lifespan. It is a wellknown tree having a wide range of pharmacological activities and is widely cultivated in tropical and subtropical regions all over the world [4,5]. In India, it is distributed in the outer Himalayas and tracts of Jammu and Kashmir, Nepal to the east of Assam, Bengal, Tripura extended through the central region up to the Godavari in the South [6]. It usually grows in red and black soils, having pH of 5.6–7.5 and prefers arid and semi-arid climatic conditions [7]. Previously, the systemic position of the Nyctanthes arbor-tristis was not clear. It was placed in the Oleaceae by Bentham and Hooker. An investigation was taken to assign the best matching family by Vaishampayan and Sharma, 1983. It is being used in folk medicine for antibilious, gynecological troubles, and hepatoprotective activity since the ancient time [8]. In central India, various parts of this plant are used by the tribal people to relieve cough, hiccup, dysentery, snakebite, and sores. In addition, *N. arbor-tristis* has screened by researchers for antihistaminic,



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CNS, analgesic and anti-inflammatory, antipyretic, amoebicidal, anthelmintic, antidepressant, antiviral, antioxidant, and anticancer activities [6]. Present review reports a comprehensive collection of studies based on pharmacological, anticancer, and antioxidant activities of different plant parts of N. arbor from 1987 to till date. Reports of some important pure bioactive compounds extracted from different parts of this plant have also documented which can be investigated for their possible use as therapeutic agents in the treatment of cancer. N. arbor-tristis is wonder tree and hub of medicinal properties. The present study may provide information to different research groups to validate its ethnomedicinal uses using advance technologies and to explore the proper mechanism of action of biological compounds found in this plant. This review is prepared to document almost all pharmacological studies performed on this plant in vitro and in vivo till date and second, a detailed survey of antioxidant and anticancer activities including information regarding effective doses of crude extracts as well as isolated pure compounds in Tables 1 and 2, respectively. Isolated pure compounds like 4-hydroxy hexahydrobenzofuran-7-one which is Benzofuran derivative [9], Naringenin (5, 7, 4'-trihydroxy flavonone), a bioflavonone isolated from stem [10], Arbortristoside A and 6-β Hydroxyloganin (Iridoid glycosides) isolated from seeds [11] are reported to possess significant anticancer activities tested on different cell lines. Isolated compounds were chemically transformed to obtained derivatives, which enhance their anticancer potential. The plant is also a rich source of antioxidants which can serve as a source for agents used in cancer therapy. Highly branched polysaccharides which are present in leaves reported for dose-dependent antioxidant potential [12].

2. CONCLUSION AND FUTURE PROSPECTS

Indeed, *N. arbor* is among the wonder of medicinal plants as it has a wide variety of medicinal properties. All the pharmacological studies done so far are of a preliminary kind. These studies need identification and characterization of the bioactive compound and their molecular mechanism elucidation. Studies related to immunostimulatory, immunomodulatory, antipyretic, analgesic, anti-arthritic, hepatoprotective, antistress, anxiolytic, antiulcerogenic, hypoglycemic, and hypolipidemic activities should be checked for its toxicity level and finally for human intervention. Studies like antimalarial, antitrypanosomal, antifilarial, antileishmanial, and larvicidal activities are generally

Table 1: A detailed survey of pharmacological activities of different extracts/compounds from different parts of Nyctanthes arbor-tristis.

Plant part	Plant parts	Extracts/ pure compounds	<i>In vitro /In vivo</i> study	Geographical area of study	Studies undertaken	References
Antiviral activity	Seeds	n-Butanol fraction of 50% ethanolic extract, Arbortristoside A, and Arbortristoside C	In vitro & In vivo (Swiss albino mice)	Lucknow, India	Arbortristoside A (Iridoid glycoside) possesses antiviral activity against enveloped virus (V)	[13]
	Leaves	Ethanolic	In vivo	Tamilnadu, India	Both cellular and humoral immunity stimulation were reported. Elucidation of the exact mechanism is in progress	[14]
			(Swiss albino Rats)			
	Leaves	Aqueous	In vivo	Southwestern ghats of	Flavonol glycoside of <i>N.</i> <i>arbor</i> influences humoral and cell-mediated immune system of mice. Mechanism of immunomodulatory and probable use in immunocompromised individuals are to be investigated	[15]
			(Swiss albino male mice)	Irunelveli, Iamilnadu, India		
Immunostimulatory activity	Leaves	Water-soluble fraction Methanolic	In vivo	Madurai, Tamilnadu,	Significant enhancement of	[16]
			(Fish)	India	Immunity observed in finitsh. Investigation on active compound identification and appropriate field trials need to be ascertained for prolonged use at large scale application	
	Seeds		In vivo	Chennai, India	Possess potent Immunostimulatory and disease protective properties and can be used in aquaculture but after conducting field trials on different fish spp.	[17]
			(Fish)			

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Plant part	Plant parts	Extracts/ pure compounds	<i>In vitro /In vivo</i> study	Geographical area of study	Studies undertaken	References
	Whole plant	80% methanolic	<i>In vivo</i> (Albino Wistar rats)	Ahmedabad, India	The extract showed acute and sub- acute anti-inflammatory potential, Exact underlying mechanism of action and long-term toxicity need to be explored	[18]
Anti-inflammatory activity/ Analgesic	Leaves	β-Sitosterol isolated from Petroleum ether extract	In vivo	Ahmednagar, India	β -Sitosterol exhibits analgesic and the anti-inflammatory role which might be due to suppression of formation of prostaglandins and Bradykinins	[19]
	Stem Bark	Methanolic	In vivo (adult albino rats)	Shillong, India	Extract prevents the nociceptive component, which may be the cause of inhibition of prostaglandins and related products. The exact mechanism of action required to be studied	[20]
	Leaves	95 % ethanolic	<i>In vivo</i> (albino rats and mice)	Meerut, India	Justified its use in various inflammatory conditions as per the Ayurvedic system of medicine	[21]
	Leaves	90% ethanolic	In vivo (Rats)	Bhubaneswar, India	Showed promising result in the acute model than the chronic model. Further Human trials required to prove safety and efficacy for long-term use	[22]
Cognitive impairment	Leaves	90% Ethanolic	<i>In vivo</i> (Albino male Wistar rats)	Warangal, India	Showed acetylcholinesterase inhibitory activity, Studies are needed to ascertain the mechanism of action	[23]
Ulcerogenic activity	Leaves	Water-soluble	In vivo (Albino rats)	Meerut, India	Mechanism of action need to be established	[21]
Antipyretic	Leaves	Water-soluble	In vivo (Albino rats)	Meerut, India	Showed antipyretic effect in various type of fevers	[21]
	Leaves, Seed, Flower, Stem, and Root	50% ethanolic	<i>In vivo</i> (Balb/c mice)	Lucknow, India	Arbor-tristosides of ethanolic extracts of seeds showed significant activity	[24]
	Leaves	Aqueous	In vivo (mice)	Patiala, Punjab, India	Can be applied as an anti- immunosuppressive agent.	[25]
Immuno-modulator/ Immunorestorative activity	Seeds	Chloroform	In vivo(Fish)	Madurai, India	Phytosterols and alkaloids from chloroform extract showed the activity. Separation and identification of these active compounds should be conducted further	[26]
	Leaves	95% Ethanolic, 50% hydro-alcoholic	In vivo	Lucknow, India	Aid in the recovery of malaria. This could be a subject of further investigation for combinatorial antimalarials	[27]
Antiarthritic activity	Leaves, Stem	Ethanolic	In vivo (Male albino Wistar rats)	Coimbatore, Tamilnadu, India.	Leaves showed better activity comparative to stem extract. Further, the compound responsible for activity needs to be isolated as a modern drug.	[28]
	Fruits, Seeds, and Leaves	Water-soluble ethanolic extract	<i>In vivo</i> (Female Balb/c mice)	Lucknow, India	Leaves and Fruits extracts proven to be antiarthritic	[29]
	Leaves	95% ethanolic	<i>In vivo</i> (Wistar albino rats)	Mandsaur, India	Active toxicity constituents are to be the isolated and underlying mechanism of action is to be studied	[30]
	Leaves	Ethyl acetate	In vivo (Sprague Dawley rats)	Punjab, Lahore	Isolation of responsible phytoconstituents and confirmation of antiarthritic activity is required	[31]

(Continued)

Plant part	Plant parts	Extracts/ pure compounds	<i>In vitro /In vivo</i> study	Geographical area of study	Studies undertaken	References
	Bark	-	-	-	Hepatoprotective effect is shown	[32]
	Leaves	Water-soluble fraction of 70% ethanolic extract	In vivo (Wistar rats)	Ahmednagar, India	Leaves are found to be a hepatoprotective agent. Work going on to isolate active component responsible for hepatoprotective action	[33]
Hepatoprotective activity	Flower	Ethanolic and Aqueous	In vivo (Wistar rats)	Buldhana, India	The probable mechanism of action was proposed against CCl ₄ -induced liver toxicity. The active component responsible for hepatoprotection need to be isolated and synthesized for pharmaceuticals	[34]
	Leaves	Methanolic	<i>In vivo</i> (Albino Wistar rats)	Mumbai, India	Hepatoregenerative potential exhibited by protecting against membrane fragility and preventing the decline of glutathione level	[35]
	Flower	Petroleum ether, Chloroform, and Ethyl acetate extracts	In vitro	Rajshahi district, Bangladesh	Chloroform and Ethyl acetate extracts showed effective activity	[36]
	Leaves	Methanolic	In vitro	Gujarat, India	Showed significant activity against <i>Staphylococcus</i> epidermidis and Salmonella paratyphi A	[37]
	Leaves, Flower, Fruits, and Seeds	Ethyl acetate and Chloroform extracts	In vitro	Vellore, Tamilnadu, India	Both extracts showed better efficacy for gram harmful bacteria than gram-positive.	[38]
	Leaves	Ethanolic	In vitro	Madurai, India	Maximum antibacterial activity exhibited and so this extract would become a part of the study for bioactive drug development	[39]
	Stem bark	Petroleum ether, Chloroform, and Ethanol extracts	In vitro	Sonipat, India	Chloroform extract showed significant activity	[40]
	Root barks	Aqueous, Ethanolic, Petroleum ether, and Chloroform extracts	In vitro	Bhopal, India	Showed significant bacterial activity	[41]
Antibacterial activity	Leaves and Bark	-	In vitro	Morang district, Nepal	Potential antimicrobial activity reported	[42]
	Flower	Ethanolic extract	In vitro	Manipal, India	Moderate activity exhibited	[43]
	Leaves	Ethanolic, Methanolic, Petroleum ether, and Aqueous extracts	In vitro	Jaipur, India	Petroleum ether extract exhibited significant antimicrobial activity against tested pathogens	[44]
	Whole plant material	Aqueous, Ethanol, Benzene, Petroleum ether, and Chloroform extracts	In vitro	Dehradun, India	Broad-spectrum antimicrobial activity against a panel of bacteria	[45]
	Fruit	Petroleum ether and Methanolic extracts	In vitro	Nasik, India	The methanolic extract showed the best antibacterial activity	[46]
	Leaves	Ethanolic	In vitro	West Bengal, India	Showed moderate activity against <i>S. aureus.</i> Hence, active bio-active compounds need to be isolated and also checked for <i>In vitro</i> and <i>In vivo</i> toxicity	[47]
	Flower	Alcoholic extract utilized for the synthesis of silver nanoparticles	In vitro	Guwahati, Assam	Showed antibacterial and cytotoxic activities	[48]
	Bark	Ethanolic	In vivo	Namakkal, Tamilnadu,	Showed safe and strong activity	[49]
			(Male Wistar Albino rats)	India		
Antidiabetic activity	Leaves	50% Ethanolic	In vivo (Sprague-Dawley rats)	Tamilnadu, India	The antidiabetic effect is possibly due to the antioxidant compounds present in the extracts which neutralize the oxidative stress in diabetic condition	[50]
Antidiarrheal activity	Bark	80% methanolic	In vitro	Odisha, India	Cure of dysentery	[51]

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Plant part	Plant parts	Extracts/ pure compounds	<i>In vitro /In vivo</i> study	Geographical area of study	Studies undertaken	References
Antifilarial activity	Leaves	Ursolic acid	In vitro	West Bengal, India	May serve as a promising agent in the treatment of <i>Bancroftian</i> <i>filariasis</i>	[52]
	Leaves, Fruits	99% ethanolic	In vitro	Thiruvananthapuram, India	Leaves extract showed effective activity against malaria	[53]
	Flower	(Ethanolic) Rengyolone 1 and its acetate derivative	In vitro	Nakorn Pathom, Thailand	Possessed antiplasmodial activity. This compound further need to be studied <i>in vivo</i> for its pharmaceutical approach	[54]
	Stem bark, Leaves, Root, Seed, and Flower	50% ethanolic	In vitro and In vivo (Mouse)	Lucknow, India	Leaves extract showed both <i>in</i> <i>vitro</i> and <i>in vivo</i> activity, whereas root and seed extracts showed only <i>in vitro</i> but not <i>in vivo</i>	[55]
	Leaves	Herbal Formulation preparation (250mg powder/5 ml suspension)	<i>In vivo</i> (Human trial)	Maharashtra, India	Great improvement in the vital signs of malaria within the first week of treatment. This may prove beneficial in the long run	[56]
	Leaves	Fresh paste of leaves	<i>In vivo</i> (Human trial)	Mumbai, India	Showed significant activity against malaria and good tolerability. A standardized formulation need to be prepared	[57]
Antimalarial activity	Leaves	Ethanolic	In vitro	New Delhi, India	Hypothetically leaves of this plant possess the said activity because of iridoid glycosides present in leaves. Further continuous investigation to be done for new antimalarial drug discovery	[58]
	Seed-kernel	Iridoid glucosides	In vitro	Guwahati, India	Showed the adverse effect on parasite redox homeostatic	[59]
	Leaves	Fresh preparation of leaves paste	<i>In vivo</i> (Human trial)	Mumbai, India	Formulated paste showed a potential effect on patients. Further in-depth studies required to develop standardized pharmaceutical	[60]
Anti-leishmanicidal activity	Seeds	Iridoid glucosides	In vivo (Male golden hamsters) and In vitro	Lucknow, India	Proved to be leishmanicidal agents	[61]
Anti-trypanosomal activity	Leaves	50% ethanolic	In vitro and in vivo (Swiss mice)	Howrah, India	Significant activity observed	[62]
	Leaves, bark, roots, and seeds	Petroleum ether, Chloroform, and Methanolic	-	Pondicherry	Not much effective activity reported	[63]
Larvicidal activity	Leaves, Roots	Chloroform, Dichloromethane, and Methanolic	-	Jalgaon, India	The methanolic extract showed more effective than other extracts against mosquitos vector species. Could be a safe botanical insecticide	[64]
Anti-fungal activity	Leaves	β -sitosterol and Calceolarioside compounds from 50% ethanolic extract	In vitro	Allahabad, India	Showed effective anti-Malassezia activity. Could be a plant-based antifungal formulation.	[65]
	Flower	Zinc oxide nanoparticles synthesized using aqueous extract	In vitro	Murthal, India	Could be commercialized as an antifungal agent for agriculture purpose	[66]
Antispermatogenic effect	Bark	70% Methanolic	<i>In vivo</i> (Adult male albino rats)	Jaipur, India	Showed suppression of the spermatogenesis	[67]
Antistress activity	Fruit	Water-soluble fraction of 50% ethanolic extract	<i>In vivo</i> (Adult albino rats)	Lucknow, India	It reversed the stress-induced biochemical changes	[68]
Anti-ulcerogenic activity/ Ulcer healing property	Seeds	Arbortristiside-A and 7-O-trans-cinnamoyl- 6β-hydroxyloganin	In vivo (Rats)	Lucknow, India	Showed prevention of ulcer and ulcer healing property	[69]

(Continued)

Plant part	Plant parts	Extracts/ pure compounds	<i>In vitro /In vivo</i> study	Geographical area of study	Studies undertaken	References
Anxiolytic activity	Leaves	50% Ethanolic	In vivo	Amethi, India	Significant dose-related anxiolysis	[70]
			(Adult albino rats)		caused by the extract	
Bronchodilatory effect	Leaves	80% Ethanolic	<i>In vivo</i> (Guinea Pigs)	Dhaka, Bangladesh	Showed a direct relaxant effect. Development of new drug (bioactive molecule) for the treatment of asthma need to be studied from ethanolic extract	[71]
Hypoglycemic and hypolipidemic activity	Flower	Aqueous	In vivo (Adult male mice)	Srilanka	Proven to be safe for oral consumption that elicits promising hypoglycemic and hypolipidemic activity. The active principle requires in the future investigation	[2]
Wound healing activity	Leaves	Methanolic	In vivo (Wistar albino rats)	Vidisha, India	Folklore claim of wound healing property was justified.	[72]
Tumour necrosis factor Depleting activity	Leaves	Ethanolic	In vivo (Male Balb/c mice)	Lucknow, India	It could be useful in inflammatory rheumatic disease, inflammatory bowel disease, improvement in cardiac function in a patient with septic shock, and might help in problem associated with exogenous TNF administration in different carcinomas.	[73]
Membrane stabilizing activity	Tubular calyx of flowers	Crocetin (A carotenoid aglycone)	In vitro	Thane, India	Represented good membrane stabilizing activity	[74]
Commercial application	Flower corolla	Aqueous	-	Amravati, India	Eco-friendly, dyeing, and painting agent on silk and cotton	[75]
Prevention of initial lung injury	Leaves	Water-soluble fraction of ethanolic extract	In vivo (MaleSwiss mice)	Lucknow, India	Showed bypassing of silica- induced initial lung injury	[76]
Tranquillizing, antihistaminic and Purgative activity	Leaves	Water-soluble portion of alcoholic extract	In vivo	Meerut	Showed the presence of activity	[77]
	I C			I yalmayy and		[70]
Therapeutic efficacy against Caecal amoebiasis	Leaves, Stem, Flowers, Seeds, and Roots	fractions	(Rats)	Lucknow and Dehradoon	of amoebicidal activity in vitro	[78]
Stimulation of Acetylcholinesterase activity	Leaves, Flowers	Aqueous	In vivo (Swiss albino mice)	Patiala, India	The adverse effect of malathion on Acetylcholinesterase enzyme activity could be antegonized	[79]
	Doule	Defeelence of here	In stine	Ahmadnagar India	Betra laws other entry of a fload	[00]
Mast cell stabilizing and bronchodilatory activity	Daix	chloroform, ethyl acetate, and ethanolic extracts	(Male Swiss mice)	Anneuragai, india	showed mast cell stabilizing and potent bronchodilatory effects. Further investigation on the active molecule and its toxicity should be conducted before developing into the proper drug.	[00]
Bio-medical application	Flower	The ethanolic extract used in the synthesis of gold nanoparticles	In vitro	Guwahati, (Assam) India	A potential source of reducing agent as gold nanoparticles synthesized which may have application in Contrasting agent in bio-imaging may cross the cytotoxicity barrier	[81]
	Seeds	Aqueous	-	Howrah, West Bengal	Low cost and abundance make seed extract a potential source of nanomaterials to explore its various catalytic and biomedical application	[82]
Inhibition of mild steel corrosion	Leaves	Acid extract	-	Tamilnadu, India	Leaves are good corrosion inhibitors	[83]

Table 2: Different extracts from various parts of Nyctanthes arbor-tristis showing antioxidant and anticancer activities.

Plant part	Extract/Compound	Activity	IC ₅₀ / Major Observations	Reference
	Methanolic extract	Anti-lipid peroxidation	19-24 µg/ml, moderate exercise	[84]
Ţ	Aqueous extract	Antioxidant	Deficient activity	[85]
	Acetone fraction of ethanolic extract (NEA)	Antioxidant	More antioxidant potential than standard (BHT)	[86]
	Butanolic fraction of ethanolic extract	Antioxidant	10.71 mg/ml	[87]
Leaves	Methanolic extract and Flavonoid fraction	Antioxidant	Strong reducing power and DPPH scavenging activities	[88]
	Polyphenols extracted from leaves	Antioxidant	Role in oxidative stress	[89]
	Methanolic extract	Antioxidant	Free radical scavenger	[90]
	Methanolic extract	Anticancer	A-549 cancer cell line	[91]
	Petroleum ether, Chloroform, and Ethyl acetate extracts	Cytotoxic	14.88, 12.62 and 12.79 $\mathrm{LC}_{\mathrm{50}}$ respectively for Brine Shrimp	[36]
	Dry flower aqueous extract	Antioxidant	76.48% Radical Scavenging Activity	[92]
	Dry flower methanolic extract	Antioxidant	High Phenolic Content	[93]
Flower	Ethanolic extract	Antioxidant	The most effective organic solvent	[94]
	Hydroalcoholic extract	Antioxidant	Role in oxidative stress	[95]
	Phenolic fraction	Antioxidant	12.10 µg/ml	[96]
	Ethanolic, Hexane, Ethyl acetate, n-Butanol, aqueous and insoluble part extract	Anticancer	Ethyl acetate and ethanolic extracts showed significant phenolic content	[97]
Leaves and Stem	Successive extraction using hexane and ethanol, respectively	Cytotoxic	193.17 μg/ml	[12]
Stem, leaves, and Fruits	Methanolic extract	 a. Cytotoxicity by stem, leaf, and fruits extract, respectively. 	a. Antiproliferative activity 82%, 71%, and 48% at 30, 30, and 15 $\mu g/ml$ and	[8]
		b. Anti-oxidant activity by fruit extract	b. Maximum Antioxidant activity of fruit was 93.8% at 1,000 mg/ml	
Leaves,	Aqueous/Methanolic/	Antioxidant	Most effective Methanolic stem extract	[98]
Stem, Flower, and Root	Ethyl acetate/Hexane			

cured effectively with some herbal formulation or paste preparations and crude extracts. One should go for combinatorial formulation with some other similar medicinal property containing plant for better results. Overall, a significant number of in vitro antioxidant studies provide substantial evidence that N. arbor and its ethanolic fraction of acetone (NEA), butanolic extract, and dried extracts of plant parts are effective against the carcinogenic process. Phenolic acid and flavonoids, Naringenin, a bioflavone, should be studied In vitro and in vivo for its anticancer activity and further steps for molecular chemistry and molecular docking analysis to gain an insight into its molecular interactions with cellular component would give the path for designing drug and then finally human trials against human cancers. Only a few references were found explaining the molecular mechanism of isolated compounds. Hence, rest of the study on the antioxidant and anticancer activity should be undertaken for research to address responsible phytoconstituents and its mechanism of actions which would support the said therapeutic action and then in vivo study will give the lead for drug development. Further research should focus on how genetic variability and environmental factors influence on its anticancer property attributed to N. arbor. Moreover, molecular marker-assisted selection study to improve desired traits; use of plant tissue culture technique and recombinant technology can be undertaken to increase the production of bioactive molecules.

REFERENCES

- 1. Uniyal SK, Singh KN, Jamwal P, Lal B. Traditional use of medicinal plants among the tribal communities of Chhota Bhangal, Western Himalaya. J Ethnobiol Ethnomed 2006;2(14):1–8.
- Rangika BS, Dayananda PD, Peiris DC. Hypoglycemic and hypolipidemic activities of aqueous extract of flowers from *Nyctanthes* arbor-tristis L. in male mice. BMC Complement Altern Med 2015;15(1):1–9.
- 3. Kiew R, Bass P. *Nyctanthes* is a member of the Oleaceae. Proc Indian Acad Sci (Plant Sci.) 1984;93(3):349–58.
- Rani C, Chawla S, Mangal M, Mangal AK, Kajla S, Dhawan AK. *Nyctanthes arbor-tristis* Linn. (Night Jasmine): a sacred ornamental plant with immense medicinal potentials. Indian J Tradit Knowl 2012;11(3):427–35.
- Agrawal J, Pal A. Nyctanthes arbor-tristis Linn—a critical ethnopharmacological review. J Ethnopharmacol 2013;146(3):645– 58.
- 6. Jain PK, Pandey A. The wonder of Ayurvedic medicine—*Nyctanthes arbor-tristis*. Int J Herbal Med 2016;4(4):9–17.
- 7. Latha PG, Suja SR, Shyamal S, Rajasekharan S. Some hepatoprotective garden plants. Nat Prod Radiance 2005;4(4):278–9.
- Kumari TDS, Madhuri TDS, Charya MAS, Rao KS. Antioxidant and anticancer activities of *Nyctanthes arbor-tristis*. Int J Pharm Pharm Sci 2012;4(4):452–4.
- Khatune NA, Islam ME, Rahman MAA, Mossaddik MA, Haque ME. In vivo cytotoxic evaluation of a new Benzofuran derivative isolated from Nyctanthes arbor-tristis L on Ehrlich Ascite carcinoma cells (EAC) in mice. J Med Sci 2003;9(2):169–73.

- Kanno S, Tomizawa A, Hiura T, Osanai Y, Shouji A, Ujibe M, et al. Inhibitory effects of Naringenin on tumor growth in human cancer cell lines and sarcoma S-180-implanted mice. Biol Pharm Bull 2005;28(3):527–30.
- 11. Pandeti S, Sharma K, Bathula SR, Tadigoppula N. Synthesis of novel anticancer iridoid derivatives and their cell cycle arrest and caspase-dependent apoptosis. Phytomedicine 2014;21(3):333–9.
- Chidi BB, Pandeya S, Gharti KP Bharti L. Phytochemical screening and cytotoxic activity of *Nyctanthes*. Indian Res J Pharm Sci 2015;2(2):205–17.
- Gupta P, Bajpai SK, Chandra K, Singh KL, Tandon JS. Antiviral profile of *Nyctanthes arbor-tristis* L. against encephalitis causing viruses. Indian J Exp Biol 2005;43:1156–60.
- Kannan M, Singh AJAR, Kumar TTA, Jegatheswari P, Subburayalu S. Studies on immuno-bioactivities of *Nyctanthes arbor-tristis* (Oleaceae). Afr J Microbiol Res 2007;1:88–91.
- Kannan M, Singh AJAR. An Immuno-Pharmacological investigation of Indian Medicinal Plant *Nyctanthes arbor-tristis* Linn. World Appl Sci J 2010;11(5):495–503.
- Devasree LD, Binuramesh C, Michael RD. Immunostimulatory effect of water-soluble fraction of *Nyctanthes arbor-tristis* leaves on the immune response in Oreochromis mossambicus (Peters). Aquac Res 2014;45(10):1581–90.
- Kirubakaran CJW, Subramani PA, Michael RD. Methanol extract of *Nyctanthes arbor-tristis* seeds enhances non-specific immune responses and protects Oreochromis mossambicus (Peters) against Aeromonas hydrophila infection. Res Vet Sci 2016;105:243–8.
- Bhalerao AR, Desai SK, Serathia BR, Vartak KM, Doshi GM. Acute and subacute models of inflammation of *Nyctanthes arbor-tristis* and *Maharasnadi ghan*. Int J Pharmacol Res 2011;1(1):14–24.
- Nirmal SA, Pal SC, Mandal SC, Patil AN. Analgesic and antiinflammatory activity of β-sitosterol isolated from *Nyctanthes arbortristis* leaves. Inflammopharmacology 2012;20(4):219–24.
- Kakoti BB, Pradhan P, Borah S, Mahato K, Kumar M. Analgesic and anti-inflammatory activities of the methanolic stem bark extract of *Nyctanthes arbor-tristis* Linn. BioMed Res Int 2013;2013:1–6.
- Saxena RS, Gupta B, Saxena KK, Srivastava VK, Prasad DN. Analgesic, antipyretic and ulcerogenic activity of *Nyctanthes arbortristis* leaf extract. J Ethnopharmacol 1987;19(2):193–200.
- Pattanayak C, Datta PP, Prasad A, Panda P. Evaluation of antiinflammatory activity of *Nyctanthes arbor-tristis* leaves. Int J Med Pharm Sci 2013;3(9):18–25.
- Phanindhra B, Raju BA, Vikas G, Anusha R, Deepika D. Effect of *Nyctanthes arbor-tristis* leaf extract against scopolamine-induced cognitive impairment in rats. Herva Pol 2015;60(4):34–49.
- Khan ZK, Manglani A, Shukla PK, Puri A, Saxena RP, Tandon JS. Effect of plant extracts and iridoid glucosides from *Nyctanthes arbor-tristis* against systemic candidiasis in mice. Int J Pharmacogn 1995;33(4):297–304.
- Bhatia A, Kaur J. Nyctanthes arbor-tristis leaves extract as antagonizer of immunotoxic effects of chemical pesticides (experimental study). Int J Environ Stud 2001;58(2):197–215.
- Kirubakaran CJW, Alexander CP, Michael RD. Enhancement of non-specific immune responses and disease resistance on oral administration of *Nyctanthes arbor-tristis* seed extract in *Oreochromis mossambicus* (Peters). Aquac Res 2010;41(11):1630–9.
- Agrawal J, Shanker K, Chanda D, Pal A. *Nyctanthes arbor-tristis* positively affects immunopathology of malaria-infected mice prolonging its survival. Parasitol Res 2013;112:(7):2601–9.
- Thomas S, Nirmala JG, Narendhirakannan RT. Free radical scavenging activities of *Nyctanthes arbor-tristis*. L on adjuvant induced arthritis in rats. Br J Pharm Res 2013;3:536–47.
- Rathore B, Paul B, Chaudhury BP, Saxena AK, Sahu AP, Gupta YK. Comparative studies of different organs of *Nyctanthes arbor-tristis* in modulation of cytokines in murine model of arthritis. Biomed Environ Sci 2007;20(2):154–9.

- Goyal S, Sheth NR, Srivastava DN. Comparative evaluation of *Nyctanthes arbor-tristis* and *Alstonia scholaris* leaves extracts in Freund 's complete adjuvant induced arthritis in rats. Int J Pharm Biol Arch 2013;4(5):903–8.
- Uroos M, Abbas Z, Sattar S, Umer N, Shabbir A, Rehman S, Sharif A. *Nyctanthes arbor-tristis* Ameliorated FCA-induced experimental arthritis: a comparative study among different extracts. Evid-Based Complement Altern Med 2017;2017:1–13.
- Puri A, Saxena R, Saxena RP, Saxena KC, Srivastava V, Tandon JS. Immunostimulant activity of *Nyctanthes arbor-tristis* L. J Ethnopharmacol 1994;42(1):31–7.
- Deshmukh RD, Pokharkar RD, Takate SB, Gite VN. Amelioration of CCL₄-induced hepatosuppression by *Nyctanthes arbor-tristis* Linn leaves in Wistar albino rats. Pharmacologyonline 2007;1:203–8.
- 34. Wagh AE, Yeotkar US, Nimbhorker MG, Deshmukh TA, Patil VR. Hepatoprotective activity of *Nyctanthes arbor-tristis* (l.). Orient Pharm Exp Med 2010;10(2):111–5.
- Vishwanathan M, Juvekar AR. Hepatoregenerative effect of *Nyctanthes arbor-tristis* Linn. on acetaminophen-induced oxidative damage in rats. Int J PharmTech Res 2010;2(2):1291–7.
- Khatune NA, Mosaddik MA, Haque ME. Antibacterial activity and cytotoxicity of *Nyctanthes arbor-tristis* flowers. Fitoterapia 2001;72(4):412–4.
- Mahida Y, Mohan JSS, Dubard R, Linn N. Screening of plants for their potential antibacterial activity against Staphylococcus and Salmonella spp. Nat Prod Radiance 2007;6(4):301–5.
- Priya K, Ganjewala D. Antibacterial activities and phytochemical analysis of different plant parts of *Nyctanthes arbor-tristis* (Linn.). Res J Phytochem 2007;(4):61–7.
- Sathiya M, Parimala P, Muthuchelian K. Preliminary Phytochemical Screening and Antibacterial Studies on the Ethanolic Leaf Extract of *Nyctanthes arbor-tristis* Linn. Ethnobot Leaf 2008;12:337–42.
- Manisha V, Neha S, Satish S. Antimicrobial activity of stem bark extracts of *Nyctanthes arbor-tristis* Linn. (Oleaceae). Int J Pharmacogn Phytochem Res 2009;1(1):12–4.
- 41. Verma NS, Dwivedi S, Panigrahi D, Gupta SK. Anti-bacterial activity of root bark of *Nyctanthes arbor-tristis* Linn. Int J Drug Discov Herbal Res 2011;1(2):61–2.
- Satyal P, Paudel P, Poudel A, Setzer WN. Chemical composition and biological activities of essential Oil from leaf and bark of *Nyctanthes arbor-tristis* L. from Nepal. Open Access J Med Aromat Plants 2011;3(1):1–4.
- Srinivasan KK, Goomber A, Kumar SS, Thomas AT, Joseph A. Phytochemical, antioxidant and antimicrobial study of flowers of Nyctanthes arbor-tristis Linn. Pharmacologyonline 2011;2:16–21.
- Vyas A, Sarin R. Analysis of the phytochemical content and antimicrobial activity of *Nyctanthes arbor-tristis*. Int J Pharma Bio Sci 2013;4(1):201–6.
- Aggarwal SG, Goyal S. Nyctanthes arbor-tristis against pathogenic bacteria. J Pharmacogn Phytochem 2013;2(3):124–7.
- Shinde PR, Sali VA, Patil PS, Bairagi VA. Assessment of pharmacognostic, phytochemical and antibacterial potential of fruit of *Nyctanthes arbor-tristis* Linn. J Pharmacogn Phytochem 2014;2(6):203–12.
- Show S, Banerjee S, Chakraborty I, Sikdar M. In vitro Comparision between antibacterial activity of *Catharanthus roseus* and *Nyctanthes arbor-tristis* on antibiotic-resistant *Staphylococcus aureus* strain. Indo Am J Pharm Res 2014;3(2):1746–51.
- 48. Gogoi N, Babu PJ, Mahanta C, Bora U. Green synthesis and characterization of silver nanoparticles using alcoholic flower extract of *Nyctanthes arbor-tristis* and *in vitro* investigation of their antibacterial and cytotoxic activities. Mater Sci Eng C 2015;46:463–9.
- Suresh V, Jaikumar S, Arunachalam G. Antidiabetic activity of ethanol extract of stem bark of *Nyctanthes arbor-tristis* Linn. Res J Pharm Biol Chem Sci 2010;1(4):311–7.

- 50. Husain A, Tiwari U, Sharma V, Kumar A, Rais N. Effect of *Nyctanthes arbor-tristis* Linn. leaves against streptozotocin-induced oxidative stress in rats. Int J Pharma Prof Res 2010;1(1):10–3.
- Panda SK, Patra N, Sahoo G, Bastia AK, Dutta SK. Anti-diarrheal activities of medicinal plants of Similipal Biosphere Reserve, Odisha, India. Int J Med Aromat Plants 2012;2(1):123–34.
- 52. Saini P, Gayen P, Kumar D, Nayak A, Mukherjee N, Mukherjee S, Pal BC, Babu SPS. Antifilarial effect of ursolic acid from *Nyctanthes arbor-tristis*: molecular and biochemical evidences. Parasitol Int 2014;63(5):717–28.
- Simonsen HT, Nordskjold JB, Smitt UW, Nyman U, Palpu P, Joshi P, Varughese G. *In vitro* screening of Indian medicinal plants for antiplasmodial activity. J Ethnopharmacol 2001;74(2):195–204.
- Tuntiwachwuttikul P, Rayanil K, Taylor WC. Chemical constituents from the flowers of *Nyctanthes arbor-tristis*. Sci Asia 2003;29:21–30.
- 55. Misra P, Pal NL, Guru PY, Katiyar JC, Tandon JS. Antimalarial activity of traditional plants against erythrocytic stages of *Plasmodium berghei*. Int J Pharmacogn 1991;29(1):19–23.
- Ghiware NB, Nesari TM, Gond NY. Clinical validation of *Piper* nigrum and Nyctanthes arbor-tristis formulation for antimalarial activity. J Res Edu Indian Med 2007;13(1):33–8.
- Karnik S, Tathed P, Antarkar D, Godse C, Vaidya R, Vaidya A. Antimalarial activity and clinical safety of traditionally used Nyctanthes arbor-tristis Linn. Indian J Tradit Knowl 2008;7(2):330–4.
- Kumari P, Sahal D, Jain SK, Chauhan VS. Bioactivity guided fractionation of leaves extract of *Nyctanthes arbor-tristis* (Harshringar) against P falciparum. PLoS One 2012;7(12):1–7.
- Shukla AK, Patra S, Dubey VK. Iridoid glucosides from *Nyctanthes* arbor-tristis result in increased reactive oxygen species and cellular redox homeostasis imbalance in Leishmania parasite. Eur J Med Chem 2012;54:49–58.
- Godse CS, Tathed PS, Talwalkar SS, Vaidya RA, Amonkar AJ, Vaidya AB, Vaidya ADB. Antiparasitic and disease-modifying activity of *Nyctanthes arbor-tristis* Linn. in malaria: an exploratory clinical study. J Ayurveda Integr Med 2016;7(4):238–48.
- Tandon JS, Vandita S, Guru PY. Iridoids: a new class of leishmanicidal agents from *Nyctanthes arbor-tristis*. J Nat Prod 1991;54(4):1102–4.
- 62. Talakal TS, Dwivedi SK, Sharma SR. *In vitro* and *in vivo* antitrypanosomal potential of *Nyctanthes arbor-tristis* leaves. Pharma Biol 2000;38(5):326–9.
- Mathew N, Anitha MG, Bala TSL, Sivakumar SM, Narmadha R, Kalyanasundaram M. Larvicidal activity of *Saraca indica*, *Nyctanthes arbor-tristis*, and *Clitoria ternatea* extracts against three mosquito vector species. Parasitol Res 2009;104(5):1017–25.
- 64. Patil SV, Patil CD, Salunkhe RB, Salunke BK. Larvicidal activities of six plants extracts against two mosquito species, *Aedes aegypti* and *Anopheles stephensi*. Trop Biomed 2010;27(3):360–5.
- 65. Mishra RK, Mishra V, Pandey A, Tiwari AK, Pandey H, Sharma S, Pandey AC, Dikshit A. Exploration of anti-Malassezia potential of *Nyctanthes arbor-tristis* L. and their application to combat the infection caused by Mala s1 a novel allergen. BMC Complement Altern Med 2016;16(1):1–14.
- Jamdagni P, Khatri P, Rana JS. Green synthesis of zinc oxide nanoparticles using flower extract of *Nyctanthes arbor-tristis* and their antifungal activity. J King Saud Univ Sci 2018;30(2):168–75.
- Gupta RS, Kachhawa JBS, Sharma R. Antispermatogenic effects of Nyctanthes arbor-tristis in male albino rats. Physiology 2006;261–73.
- 68. Tripathi S, Tripathi PK. Antistress activity of *Nyctanthes arbor-tristis* fruits in rats. Mol Clin Pharmacol 2013;4(1):53–8.
- Mishra V, Shukla A, Pandeti S, Barthwal MK, Pandey HP, Palit G, Narender T. Arbortristoside-A and 7-O-trans-cinnamoyl-6βhydroxyloganin isolated from *Nyctanthes arbor-tristis* possess anti-ulcerogenic and ulcer-healing properties. Phytomedicine 2013;20(12):1055–63.
- Tripathi S, Tripathi PK, Vijayakumar M, Rao CV, Singh PN. Anxiolytic activity of leaf extract of *Nyctanthes arbor-tristis* in experimental rats. 2010;457–63.

- Sopi RB, Khan MFH. Bronchodilatory effect of ethanolic extract of the leaves of *Nyctanthes arbor-tristis*. Pharmacogn Res 2013;5(3):169– 72.
- Bharti M, Saxena RC, Baghel OS, Saxena R, Apte KG. Wound healing activity of leaf of *Nyctanthes arbor-tristis* (Linn.). J Health Sci 2007;2(10):111–4.
- Paul BN, Saxena AK. Depletion of tumor necrosis factor-c in mice by Nyctanthes arbor-tristis. J Ethnopharmacol 1997;56:153–8.
- Gadgoli C, Shelke S. Crocetin from the tubular calyx of *Nyctanthes* arbor-tristis. Nat Prod Res 2010;24(17):1610–5.
- 75. Deshmukh A, Dongre S. Natural yellow colour from Corolla of *Nyctanthes arbor-tristis* Linn . for dyeing and painting on cotton and silk for value addition. Biolife 2015;3(1):353–7.
- Paul BN, Prakash A, Kumar S, Yadav AK, Mani U, Saxena AK, Sahu AP, Lal K, Dutta KK. Silica induced early fibrogenic reaction in lung of mice ameliorated by *Nyctanthes arbor-tristis* extract. Biomed Environ Sci 2002;15:215–22.
- Saxena RS, Gupta B, Lata S. Tranquilizing, antihistaminic and purgative activity of *Nyctanthes arbor-tristis* leaf extract. J Ethnopharmacol 2002;81:321–5.
- Chitravanshi VC, Singh AP, Ghoshal S, Krishna Prasad BN, Srivastava V, Tandon JS. Therapeutic action of *Nyctanthes arbor-tristis* against caecal amoebiasis of rat. Pharm Biol 1992;30(1):71–5.
- Verma N, Kaur J, Bhatia A. Stimulation of acetylcholinesterase activity with *Nyctanthes arbor-tristis* leaves extract in the malathion-treated immunosuppressed mice. Int J Environ Stud 2001;58(5):645–54.
- Nirmal SA, Pal SC, Mandal SC. Mast cell stabilizing and bronchodilatory activity of *Nyctanthes arbor-tristis* bark. Phytother Res 2012;2(1):234–42.
- Das RK, Gogoi N, Bora U. Green synthesis of gold nanoparticles using *Nyctanthes arbor-tristis* flower extract. Bioprocess Biosyst Eng 2011;34(5):615–9.
- Basu S, Maji P, Ganguly J. Rapid green synthesis of silver nanoparticles by aqueous extract of seeds of *Nyctanthes arbor-tristis*. Appl Nanosci 2016;6(1):1–5.
- Saratha R, Vasudha VG. Inhibition of mild steel corrosion in 1N H₂SO₄ medium by acid extract of *Nyctanthes arbor-tristis* leaves. E-J Chem 2015;5(1):14–23.
- Kumar KCS, Müller K. Medicinal plants from Nepal; II. Evaluation as inhibitors of lipid peroxidation in biological membranes. J Ethnopharmacol 1999;64(2):135–9.
- Dasgupta N, De B. Antioxidant activity of some leafy vegetables of India: a comparative study. Food Chem 2007;101(2):471–4.
- Rathee JS, Hassarajani SA, Chattopadhyay S. Antioxidant activity of Nyctanthes arbor-tristis leaf extract. Food Chem 2007;103(4):1350–7.
- Akki KS, Krishnamurthy G, Naik HSB. Phytochemical investigations and *in vitro* evaluation of *Nyctanthes arbor-tristis* leaf extracts for antioxidant property. J Pharm Res 2009;2(4):752–5.
- Sasikumar JM, Mathew GM, Darsini DTP. Comparative studies on antioxidant activity of methanol extract and flavonoid fraction of *Nyctanthes arbor-tristis* leaves. EJEAFChe 2010;9(1):227–33.
- Meghashri S, Gopal S. Biochemical characterization of radical scavenging polyphenols from *Nyctanthes arbor-tristis*. J Pharm Bioallied Sci 2012;4(4):341.
- Savarimuthu MJ, Kalirajan A, Padmalatha C, Singh AJAR. *In vitro* antioxidant evaluation and total phenolics of methanolic leaf extracts of *Nyctanthes arbor-tristis* L. Chin J Nat Med 2013;11(5):484–7.
- Kumari TDS, Charya MAS. Phytochemistry, anti-cancer and antiinflammatory activities of solvent leaf extracts of *Nyctanthes arbortristis*. Int J Pharm Sci Res 2017;8(4):1654–63.
- Vankar PS. Antioxidant activity of the flower of *Nyctanthes arbortristis* L. Int J Food Eng 2008;4(8).
- Nagavani V, Rao RKV, Ch RK, Rao RT. *In-vitro* screening of *Nyctanthes* arbor-tristis flowers for antioxidant activity and identification of polyphenols by RP-HPLC. Pharmacologyonline 2010;2:57–78.
- 94. Mishra AK, Upadhyay R, Chaurasia JK, Tiwari KN. Comparative antioxidant study in different flower extracts of *Nyctanthes arbor-*

tristis (L.) (Oleaceae): an important medicinal plant. Brazil J Bot 2016;39(3):813-20.

- Hussain A, Ramteke A. Flower extract of *Nyctanthes arbor-tristis* modulates glutathione level in hydrogen peroxide treated lymphocytes. Pharmacogn Res 2012;4(4):230.
- Pandey RS. Anti-oxidant activity of Nyctanthes arbor-tristis Linn. Asian J Pharm Life Sci 2012;2(2):360–4.
- Khanapur M, Avadhanula RK, Setty OH. *In vitro* antioxidant, antiproliferative, and phytochemical study in different extracts of *Nyctanthes arbor-tristis* flowers. BioMed Res Int 2014;2014: 1–10.
- Thakur MK, Jaiswal P. The investigation on total phenolic content and *In vitro* antioxidant potential of different plant parts of *Nyctanthes arbor-tristis* (night jasmine). Int J Pharm Sci Res 2017;8(8):3547–51.

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