

TREATMENT OF VARIOUS DISEASES BY *CANNA INDICA* L. - A PROMISING HERB

VANITA KANASE*, SUNITA VISHWAKARMA

Department of Pharmacology, Oriental College of Pharmacy, Sanpada, Navi Mumbai, Maharashtra, India.

Email: vanita.kanase@gmail.com

Received: 02 July 2018, Revised and Accepted: 21 August 2018

ABSTRACT

In recent years, ethnobotanical and traditional application of natural compounds, principally of plant origin established much attention as they are well tested for their effectiveness and generally believed to be non-toxic for human use. *Canna indica* L. is a tropical herb belonging to the family Cannaceae. It has been extensively used in a traditional remedy for the treatment of many complaints. The phytochemical analysis of *C. indica* exhibited that it contained various phytochemicals including alkaloids, cardiac glycosides, anthocyanin pigments, flavonoids, steroids, terpenoids, tannins, phlobatannins, saponins, carbohydrates, proteins, oils, and many other chemical compounds. The pharmacological studies showed that this plant exerted anthelmintic, antibacterial, antimicrobial, antiviral, antidiabetic, antidiarrheal, anti-inflammatory, analgesic, immunomodulatory, antioxidant, cytotoxic, hemostatic, hepatoprotective, molluscicidal, and other effects. This review attempts to illuminate the available literature on *C. indica* (L.) with respect to ethnobotany, chemical constituents, and summary of numerous pharmacological activities. Every part of *C. indica* has valuable properties that can serve humanity so the whole plant can be broadly studied for further research aspects.

Key words: *Canna indica*, Pharmacognosy, Chemical constituents, Pharmacology.© 2018 The Authors. Published by Innovare Academic Sciences Pvt Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>) DOI: <http://dx.doi.org/10.22159/ajpcr.2018.v11i12.28219>**INTRODUCTION**

Indian therapeutic plants are the elixir of Ayurveda and Ayurvedic treatments. Healing with medicinal plants is as old as mankind itself. When used wisely and clocking with the basic principles, they produce miraculous effects [1]. Nature's wealth utilization for health aids and the remedy, prevention, and treatment of diseases plays a big role in human civilization, with a reliance of many human populations particularly in developing countries [2]. The fact that the majority of plants from which many of the present day drugs have been derived have been sourced not only from ethnobotanical leads but also from the materia medica of the ancient "rishis" and shamanic traditions of tribal "medicine men" that dates back to thousands of years when man roamed the forests as hunter-gatherers [3]. Phytochemicals may safeguard human from a host of diseases. Phytochemicals are non-nutritive plant chemicals that have defensive or disease anticipatory properties. A plant yields these chemicals to protect itself, but recent research demonstrates that many phytochemicals can protect humans against diseases[4]. Plants have the potential to synthesize an ample variety of chemical compounds that are used to execute major biological functions and to shield against attack from predators such as insects, fungi, and herbivorous mammals [5]. *Canna indica* L. (canna lily, even though not a true lily) commonly known as Keli, the name *Canna* arises from the Greek word for a cane or reed. *Canna* is the only genus in the family Cannaceae and 19 species of flowering plants. The species have large, eye-catching foliage and horticulturists have turned it into a large-flowered and bright garden plant. In addition, it is a horticultural plant and is one of the world's richest starch sources. It extensively used as a nutritive agent and has a number of valuable pharmacological activities [6].

PLANT PROFILE**Synonyms**

Canna coccinea Mill, *Canna edulis* Ker-Gawl, *Canna lutea* Mill, *Canna achiras* Gilles [7].

Vernacular Names [8]

Languages	Names
English	African arrowroot, Canna lily, Canna Indian shot, Wild canna
Spanish	Chupa flor
French	Balisier comestible
Andes	Achira
Arabic name	Canna Hindi, Muzwardi, and Muzfahal
Kannada	Kalahu
Telugu	Krishna Tamara
Tamil	Puvalaikalvalai
Hindi	Sarvajjaya, Saka Siri, Devkali
Sanskrit	Vankelee, Devakuli
Marathi	Kardal
Konkani	KelePhool
Bengali	Sarbajaya, Kalaboti
Manipuri	Laphoorit

Taxonomical hierarchy [9]

Kingdom	Plantae - Plants
Subkingdom	Tracheobionta - Vascular plants
Super division	Spermatophyta - Seed plants
Division	Magnoliophyta - Flowering plants
Class	Liliopsida - Monocotyledons
Subclass	Zingiberidae
Order	Zingiberales
Family	Cannaceae - Canna family
Genus	<i>Canna</i> L. - canna
Species	<i>Canna indica</i> L. - Indian shot

HABITAT AND DISTRIBUTION

The *Canna* genus is native tropical and sub-tropical regions of Southern United State and South to Northern Argentina and the Philippines in settled areas, occurring in wet places and near *tikas* *Canna* settlements.

In America, wild species grow in the South of the United States, South America, from Venezuela to Argentina and India. Terrestrial plants usually live in tropical and subtropical rainforests, montane, premontane, and gallery forests. Palustrine plants grow in forest edges, wetlands, marshes, and riversides. Many taxa are nitrophilous and mostly found in humid loose soils, near streams, in uncultivated public lands or on roadsides. The plant prefers acid, neutral, and basic (alkaline) soils. It cannot grow in the shade. It needs moist soil good quality humus [10,11]. *C. indica* was the first species of this genus introduced to Europe, which was imported from the East Indies, though the species invented from the America [12] (Fig. 1).

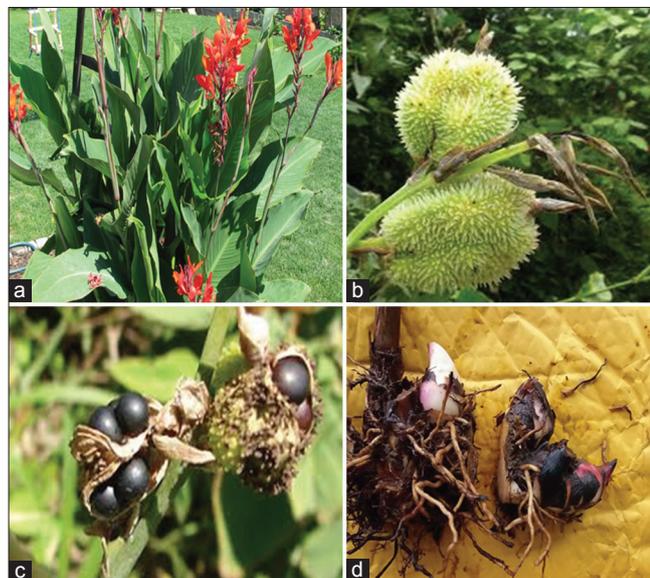


Fig. 1: (a) Plant of *Canna indica*, (b) Fruit of *Canna indica*, (c) A seed of *Canna indica*, (d) Rhizomes of *Canna indica*

PHARMACOGNOSTICAL INVESTIGATION OF *C. INDICA*

Morphology

Flowers

Flowers are red, solitary or in a pair, the diameter of the flower 4–6 cm, the bract about 1.3 cm long. Sepals are whitish green to red or purple 1–1.5 cm long. Corolla tube about 1 cm long being red or reddish 2.5–3 cm long. The staminodes are bright red. Flowers are hermaphrodite [13].

Fruits

Fruits are bright green capsules, covered by green to purple tubercles, green oblong or aid, softly echinate (spiny), and 2–2.5 cm long. Capsules about 40×25 mm, outer tepals (sepals) are persistent at the apex [13-15].

Seeds

Seeds are almost the size of a pea initially white and when mature, black with chestnut brown spots are protected with a smooth coat. Seeds are about the size of a pea [14-16].

Leaves

Leaves are lanceolate or ovate 10–30 cm long, 10–20 cm wide having large laminae up to 60 cm long. An inflorescence is waxy-glucose erect peduncle about 30 cm long with 2-flowered Cincinnati. Leaves are dark green with colorless margins and veins. They are carline, simple, alternate, and spiral. The oblong leaves have their petioles spreading downward to form a sheathing base around the stem. The lamina is pinnately, parallel veined. Leaf margins appear smooth and wavy

with an acute apex. The leaves are large and foliaceous reaching up to 65-70 cm in length and 30–35 cm in width [14-16].

Rhizomes

Young rhizomes are yellowish white or pinkish on the outside and yellowish-white within. At maturity, they turn brownish externally due to a thick outer covering. It is sympodial with Y-shaped axes, tuberous, and abundant roots growing both adaxial and abaxial from the nodes. [14-16].

Stem

Stem is a pseudostem which reaches up to 1.5–2 m in height. It is glabrous, erect, herbaceous, sturdy, and cylindrical enveloped by the sheathing leaf bases are light green [16].

Roots

The roots are thick, tubular, and creamy white with a diameter of 2–5 mm with numerous root hairs. Thinner primary and secondary lateral roots are also seen [16].

Microscopy [16-19]

Leaves

A single layered epidermis made up of rectangular cells occurs is a few layers of parenchyma cells followed by a few layers of chlorenchyma, Sclerenchyma patches occur on any side of the vascular bundle. The leaves are amphistomatic Stomatal density-2 mm.

Seeds

The epidermis is composed of a palisade layer of long and narrow cells with much-thickened walls called Malphigian cells. Micropyle is surrounded by integumentary tissue, and the micropyle itself is formed by the inner integument. The integumentary seed coat is mainly composed of 4 layers: Epidermal layer, subepidermal, vascularized, and tanniferous layer.

Stem

The uniseriate epidermis is followed by an undifferentiated ground tissue. Two to three layers of regularly arranged parenchyma cells occur below the epidermis. This is followed by 2–3 layers of chlorenchymatous tissue that formed a band. An occurrence of a few U-shaped sclerenchymatous patches at regular intermissions are below and in contact with the chlorenchymatous zone. Vascular tissue system comprises various vascular bundles scattered all over the ground tissue. Each vascular bundle is conjoint, collateral, end arch, and closed.

Rhizomes

The epidermis cell walls are scarcely cutinized. Beneath the epidermis, there is a three-layered hypodermis, which shows cells with sub polygonal outline and thick walls. The cortex is present between the hypodermis and the endodermis which is a relatively thin zone. It is mainly composed of parenchymatous tissue, starch granules, and calcium oxalate crystals.

PHYSICOCHEMICAL PROPERTIES [20]

Taste	Sweet-tasting
Nature	slightly cooling-natured
PH value (ethanol, methanol, and water)	8.0, 4.0, and 6.0%, respectively
Loss of weight on drying	4.1%
Total ash	17.98%
Acid-insoluble ash	69.2%
Water-insoluble ash	48%
Alcohol soluble extractive value	3.86%
Water-soluble extractive	6.31%

PHYTOCONSTITUENTS OF *C. INDICA*

Root

Root contains the chemical constituent's cannagenins. Rootstock contains enzymes, Triacontanal and mixture of stigmasterol, β sitosterol, campesterol, and β lectin [21].

Rhizomes

It contains alkaloid, flavonoids, phenols, sterols, saponins, gum, fat and starch. It also contains Unsaponifiable matter - 5, 8 Henicosdiene, 7- Henicosyne, 3, 15- Dihydroxy-2-octadecene, 6-Hydroxy eicosane, Tricosane, Tetracosane and essential oils of rhizome [21].

Stems

Ash: 3.14 ± 0.01 g 100/g, nitrogen free extractives: 80.43 g 100/g, calorific value: 1611.54 kJ 100g-1, crude fiber: 5.78 ± 0.08 g 100/g, crude lipid: 4.31 ± 0.11 g 100/g, crude protein: 6.34 ± 0.21 g 100/g [22].

Leaves

It contains sucrose, amino acids, sorganic acids, citric, malic, glyceric, succinic, and lactic acids, and the aspartic, glutamic, glutamine, and alanine. Leaves also contain lignin, furfural, and hemicelluloses [23].

Seeds

It contains flavonoids ($4.76 \mu\text{g/g}$) and total polyphenols ($13.79 \mu\text{g/g}$) [23].

Flowers

It contains flavonoids, phenols, lutein, β -carotene, violaxanthin, lutein, Zeaxanthin, β -Cryptoxanthin, terpenes, paraffin hydrocarbons, and a toxic red oil termed cannabiol as the major chemical constituents [24].

Six Anthocyanins-anthocyanins malvidin 3-O-(6-O-acetyl-b-D-glucopyranoside)-5-O-b-D-glucopyranoside (1), malvidin 3,5-O-b-D-digluco-pyranoside (2), cyanidin-3-O-(600-O-a-rhamnopyranosyl-b-glucopyranoside (3), cyanidin-3-O-(600-O-a-rhamnopyranosyl)-b-galactopyranoside (4), cyanidin-3-O-b-glucopyranoside (5) and cyanidin-O-b-galactopyranoside (6) [25,26] [Figure 2].

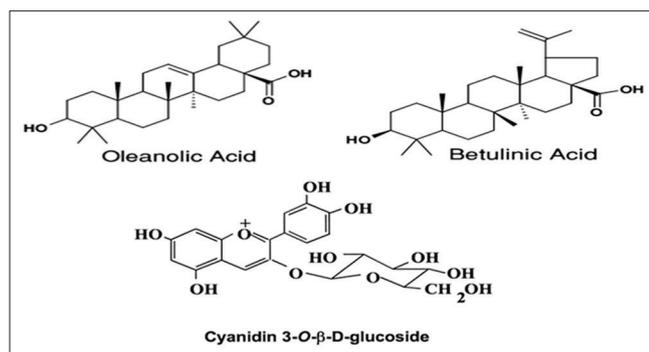


Fig. 2: (a) oleanolic acid, (b) Betulinic acid, (c) cyanidin-3-O- β -glucopyranoside

UTILIZATION

PHARMACOLOGICAL INVESTIGATION OF *C. INDICA*

AIDS/HIV1-RT inhibition

The most promising plant *C. indica* was one of the Thai traditional remedial plants used to treat AIDS tested for their human immunodeficiency virus type 1 reverse transcriptase (HIV-1 RT) inhibitor activity. Woradulayapinij *et al.* studied and reported *C. indica* rhizomes showed HIV-1 RT inhibition ratio >90% at 200 $\mu\text{g/ml}$ concentration. Further study of *C. indica* and two proteins isolated showed significant HIV-1 RT inhibition [41].

Thepouyporn *et al.* presented that a novel 10 kDa *C. indica* L. leaf protein as putative plastocyanin with anti-HIV-1 RT inhibitory activity was isolated from leaves of *C. indica* L [42].

Antibacterial effects

Abdullah *et al.* studied and reported the antibacterial effects of methanolic extract of *C. indica* leaves and flowers showed antibacterial activity against *Bacillus subtilis*. Ethyl acetate extracts of flowers and stems/barks also showed activity against *B. subtilis*, while, hexane and distilled water extracts of *C. indica* leaves, flowers, and stems / barks showed no antibacterial activity [43].

Indrayan *et al.* studied and reported the essential oil from the rhizome of *C. indica* showed good antibacterial activity against *Staphylococcus aureus* but mild activity against *B. subtilis* [44].

Anticancer/Cytotoxicity

Sunan-Chainaku *et al.* studied and reported the cytotoxicity against P388 leukemia cells showed by two pure compounds, stigmasterol and 6-beta-hydroxy stigmasta-4, 22-diene-3-one and two other toxic minor components [45].

Moshi *et al.* studied and reported the dichloromethane and ethanol extracts of the leaves of *C. indica* were evaluated for brine shrimp toxicity. Their lethal concentration 50 value was 273.9 (167.8-447.0) and >1000 $\mu\text{g/ml}$, respectively [46].

Antidiarrheal effect

Josephine *et al.* studied and reported that the antidiarrheal effect of *C. indica* methanolic extract of leaf was evaluated in castor oil-induced diarrhea, loperamide (5 mg/kg), and 50, 100, and 200 mg/kg of the extract were used and compared with a control (tween 80), while in the (charcoal meal transit) gastrointestinal transit, atropine (2.5 mg/kg), and 100 and 200 mg/kg of the extract were used and also compared with a control (tween 80). A dose of 10 mg/ml of the extract was used against acetylcholine-induced contractions in the isolated ileum models [47].

Antidiabetic effect

Purintrapiban *et al.* studied and reported the aqueous extract of *C. indica* root at doses of 0.1-0.5 mg/ml, which contains total phenolic compounds equivalent to 6-30 mg of catechin caused a dose- and time-dependent induction of 2-deoxy-[3H] glucose (2-DG) uptake activity. The induced 2-DG uptake was significantly increased within 8 h and reached a maximum of 16 h. The *C. indica* extract increased the amount of glucose transporter isoforms 1 (GLUT1) and 4 (GLUT4) at the cell surface and enhanced expression of a GLUT1 protein. Which offers a potential source of therapeutic agents for the treatment of diabetic was evaluated in cultured L8 muscle cells [48].

Anti-inflammatory effect

Chen *et al.* studied and reported that the *C. indica* ethanolic extract was found to inhibit the production of inflammatory mediators including nitric oxide (NO), prostaglandin E2, and interleukin-1 β (IL-1 β) in lipopolysaccharide-induced RAW 264.7 macrophages was investigated. In addition, the effects of *C. indica* extract in monocyte chemoattractant protein-1, high glucose-induced U937 monocytes on mRNA expressions of IL-8, and regulation of mitogen-activated protein kinase pathways were also identified [49].

Antinociceptive and anthelmintic effect

Nirmal *et al.* studied and reported that the dried coarsely powdered leaves, flowers, seeds, and rhizomes of *C. indica* were successively extracted with benzene and methanol in Soxhlet apparatus, to obtain polarity-wise fractions. The effect of benzene and methanol extracts of various parts of *C. indica* on nociceptive response using writhing test and hot plate method in mice was examined with reference to standard drug paracetamol and pentazocine. All the extracts of *Canna indica* showed significant central and peripheral analgesic activity in hot plate method and acetic acid-induced writhing test, respectively, at the dose of 50 mg/kg⁻¹ intraperitoneally. Methanolic extract of leaves of *C. indica* showed the highest increase in reaction time in hot plate method while benzene extract of leaves of *C. indica* showed the more inhibitory effect on writhing induced by acetic acid.

Table 1: Utilization

Sr. No.	Plant parts used	Traditional uses	Non-pharmacological uses
1	Rhizome	A decoction of the fresh rhizome is used as febrifuge, dropsy, dyspepsia, diuretic, antipyretic, gonorrhoea, and women with irregular menses. Macerated rhizomes are used to ease nosebleeds. Rhizome has been used with other medicinal plants for cancer treatment [29].	It is used in preparation of low fat, high-fiber dietary products in bakery industry [27]. Propagation of plant takes place by rhizome [28]. The baked rhizomes are used to make cakes, rich in starch [29].
2	Root	A decoction of the root used in the treatment of gonorrhoea and amenorrhoea. The powdered root as a cure for diarrhoea and dysentery, diaphoretic, diuretic, stimulant, and demulcent and is administered in fevers and dropsy [29].	The roots are starchy [29]. Cu ²⁺ , Zn ²⁺ , Ni ²⁺ , Pb ²⁺ , and Co ²⁺ removal from aqueous solution by acid treatment and garlic treatment [30].
3	Leaves	Leaves used for malaria and infusion of leaves used as a diuretic. Smoke from the burning leaves is said to be insecticidal. Freshly squashed leaves are used in baths against rheumatic pains and arthritis and applied to ulcers [29].	Leaves are used for wrapping up parcels and fiber obtained from the leaves is used for making paper [29]. Sugar transformation synthesis and inversion of sucrose [31].
4	Flower	The flowers were said to cure eye diseases. A decoction of flowers used for external wound bleeding [35].	It is effective in green corrosion inhibitor for mild steel in the acid medium [32]. Development of tapetum is invasive but non-plasmodial [33].
5	Seeds	Seed juice used to relieve from earaches problem [34].	The seeds are used as beads in jewelry also used in Musical rattles. A purple dye is obtained from the seed [34].
6	Whole plant	The paste of plant used for tonsillitis [34].	In more remote regions of India, cannas are fermented to produce alcohol [34]. Direct electricity recovery by an air cathode microbial fuel cell inoculated with rumen microorganisms [35]. N and P supplied throughout the plant used as biomass [36]. Phytoremediation of triazophos in a hydroponic system [37-38]. Potential tool for cadmium [39-40].

Evaluation of the anthelmintic activity of these extracts was assessed on *Pheretima Posthuma*. Results showed that the methanolic extract of rhizomes of the plant took less time to causes paralysis of the earthworms [50].

Antioxidant effects

Joshi *et al.* studied and reported that the methanolic extract of the aerial parts of the plant was studied for its *in vitro* antioxidant activity in different methods (1, 1-diphenyl-2-picryl hydrazyl [DPPH] radical scavenging assay, NO scavenging assay, hydrogen peroxide assay, and hydroxyl radical scavenging assay). Its free radical scavenging activity was estimated for various concentrations 10–100 µg/ml. At 100 µg/ml, DPPH radical scavenging assay, hydroxyl radical scavenging assay, hydrogen peroxide assay, and NO assay showed inhibition of 76.70%, 74.36%, 61.37%, and 62.84%, respectively [51].

Atrooz *et al.* studied and reported that the DPPH antioxidant activity of the *C. indica* seeds methanolic extract was 0.502 mg/g [52-54].

Srivastava *et al.* studied and reported the anthocyanins [Cyanidin-3-O-(6''-O-α-rhamnopyranosyl)-β-glucopyranoside, Cyanidin -3-O-(6''-O-α-rhamnopyranosyl)-β-galactopyranoside, Cyanidin-3-O-(6''-O-α-rhamnopyranosyl)-β-glucopyranoside, and Cyanidin-O-β-galactopyranoside] isolated from the red flowers of *C. indica* also showed good antioxidant activity. Results suggest a promising pigment source for food applications [55,56].

Hemostatic effect

Lin *et al.* studied and reported that the hemostatic effect of *C. indica* was evaluated in mice. The bleeding time (BT), clotting time (CT), and the permeability of abdominal capillary were measured. The results showed that *C. indica* significantly reduces the BT, CT, and the permeability of abdominal capillary [57].

Hepatoprotective effect

Joshi *et al.* studied and reported that liver damage protective effect against carbon tetrachloride-induced hepatotoxicity was shown by the methanolic extract of aerial parts of *C. indica* L. Histopathology demonstrated profound necrosis, lymphocytic infiltration was observed in the hepatic architecture of carbon tetrachloride treated rats which were found to obtain near normalcy in extract plus carbon tetrachloride administrated rats. Study of hydro-alcoholic extract showed a significant antioxidant and hepatoprotective activity. Results were compared with reference drug Silymarin [58,59].

Molluscicidal/Cannagenin

Hemaia *et al.* studied and reported cannagenin which had a highly synergistic with chlorophyll on the mortality of snails [60].

Tripathi *et al.* studied and reported that *C. indica* to have time and dose-dependent molluscicidal activity in a dose that was not toxic for the fish *Colisa fasciatus*, but acts as a potent molluscicidal to kill snail *L. acuminata* [61].

Studies on antioxidants enzymes

Talukdar studied and reported that the efficient scavenging of hydrogen peroxide was executed by control level activities of both ascorbate peroxidase and catalase in leaf and increased activity of only catalase in the root, preventing its accumulation at toxic concentration, and subsequent damage of membrane lipids by peroxidation. The tolerance of *C. indica* plant to copper-induced oxidative stress ensured normal growth indicating the normal dry weight of leaves and roots [62].

Surfactant-enhanced anaerobic acidogenesis of *C. indica* L. by rumen cultures

Zheng *et al.* studied and reported that a dose of a polyoxyethylene sorbitan monooleate (Tween 80) was used to enhance the anaerobic

acidogenesis of *C. indica* L by rumen culture. Pre-soaked Canna with Tween 80 gives the high production of VFA as the major acidogenic product from Canna, suggesting that the physical structure of Canna was disrupted by Tween 80 [63].

CONCLUSION

C. indica is a very useful habit for treating various types of diseases. Various studies have demonstrated that *C. indica* possesses antibacterial, antiviral, anthelmintic, molluscicidal, anti-inflammatory, analgesic, antioxidant, cytotoxic, hemostatic, hepatoprotective, anti-diarrheal, anti-diabetic, and other effects. The chemical constituents such as carbohydrates, proteins, amino acids, steroids, alkaloids, phenolics, flavonoids, tannins, and terpenoids, and other important chemical constituents are responsible for these activities. Review of the literature concluded that *C. indica* is considered to be a useful herbal medicinal plant. Therefore, there is wide scope for research in the direction of more medicinal activities of plant and to evaluate the pharmacological actions of the same in coming future.

ACKNOWLEDGMENT

We are grateful to our Principal Dr. (Mrs.) Sudha Rathod and Prof. Imtiyaz Ansari for their guidance and support as well as to Pharmacology Department Oriental College of Pharmacy, Navi Mumbai Maharashtra, India.

AUTHOR'S CONTRIBUTION

We declare that this work was done by the authors named in this article and all liabilities pertaining to claims relating to the content of this article will be borne by the authors. Miss Sunita Vishwakarma collected the data and analyzed the data. Dr. (Mrs.) Vanita Kanase proof-read the whole manuscript, and suggested the necessary changes, and helps in designing manuscript.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interests regarding the publication of this paper.

REFERENCES

- Darsini AI, Shamshad S, Paul MJ. *Canna indica* (L.): A plant with potential healing powers: A review. *Int J Pharm BioSci* 2015;6:1-8.
- Banerjee S, Mitra A. Changing landscape of herbal medicine: Technology attributing renaissance. *Int J Pharm Pharm Sci* 2012;4:47-52.
- Mitra R, Mitchell B, Agricola S, Gray C, Baskaran K, Muralitharan MS. Medicinal plants of India. *APBN* 2007;11:707-25.
- Salna K, Sreejith K, Uthiralingam M, Prince MA, Mc JM, Fleming AT. A comparative study of phytochemicals investigation of *Andrographis paniculata* and *Murraya koenigii*. *Int J Pharm Pharm Sci* 2011;3:291-2.
- Prince LM. Phylogenetic relationships and species delimitation in *Canna* (Cannaceae). In: Seberg O, Petersen G, Barfod AS, Davis J, editors. *Diversity, Phylogeny, and Evolution in the Monocotyledons*. Aarhus: Aarhus University Press; 2010. p. 307-31.
- Kessler JR. *Canna Lilies for Alabama Gardens*. Alabama Cooperative Extension System. Auburn, Alabama: Alabama A&M University and Auburn University. ANR-1315; 2007. p. 1-10.
- Al-Snafi AE. Bioactive components and pharmacological effects of *Canna indica*-an overview. *Int J Pharmacol Toxicol* 2015;5:71-5.
- Mishra S, Yadav A, Singh SK. A review of *Canna indica* Linn: Pharmacognostic and pharmacological profile. *J Harmon Res Pharm* 2013;2:131-44.
- Tanaka N. Taxonomic revision of the family cannaceae in the New World and Asia. *Makinoa Ser* 2001;1:34-43.
- DeBust TA, Peterson JE, Reddy KR. Use of aquatic and terrestrial plants for removing phosphorus from dairy wastewaters. *Ecol Eng* 1995;5:371-90.
- Neralla S, Weaver RW, Varvel TW, Lesikar BJ. Phytoremediation and on-site treatment of septic effluents in sub-surface flow constructed wetlands. *Environ Technol* 1999;20:1139-46.
- Tanaka N. Karyological analysis of the genus *Canna* (Cannaceae). *Plant Syst Evol* 2009;280:45-51.
- Khoshoo TN, Mukherjee I. Genetic-evolutionary studies on cultivated *cannas*. *Var Phenotype* 1969;36:254-70.
- Pullaiyah T. *Encyclopaedia of World Medicinal Plants*. New Delhi, India, I: Regency Publication; 2006. p. 421.
- Kirtikar KR, Basu BD. *Indian Medicinal Plants*. 2nd ed. Allahabad, IV: Lalit Mohan Basu; 1970. p. 2450-2.
- Ciciarelli MM. Life Cycle in Natural Populations of *Canna indica* L. from Argentina. Zhang X, editor. *Phenology and Climate Change*. Rijeka, Croatia: InTech; 2012. p. 101-14.
- Khoshoo TN, Mukherjee I. Genetic-evolutionary studies on cultivated *cannas*. *Theor Appl Gen* 1970;40:204-17.
- Jayakumari TR, Stephen P. Morphological and anatomical features of Queensland arrowroot (*Canna edulis* Ker.). *J Root Crops* 2009;35:164-8.
- Evangelina G, Cocucci AA. Pollination biology of *Canna indica* (Cannaceae) with particular reference to the functional morphology of the style. *Plant Syst Evol* 2011;291:49-58.
- Lamaeswari G, Ananthi T. Preliminary phytochemical screening and physicochemical characterization of *Canna indica* L. *Int J Pharm Sci Res* 2012;14:76-9.
- Kolhe NM, Nirmal SA, Pal SC. Nonpolar compounds from *Canna indica* rhizomes. *Physics Chem Technol* 2008;6:141-6.
- Mohan VR, Kalidass C. Nutritional and ant nutritional evaluation of some unconventional wild edible plants. *Trop Subtrop Agroecosyst* 2010;12:495-506.
- Bachheti RK, Rawat GS, Joshi A, Pandey DP. Phytochemical investigation of aerial parts of *Canna indica* collected from Uttarakhand India. *Int J PharmTech Res* 2013;5:294-300.
- Deming RL, Tinoi J. Determination of major carotenoid constituents in petal extract of eight selected flowering in the North of Thailand. *Chiang J Sci* 2006;33:327-34.
- Srivastava J, Vankar PS. *Canna indica* flower: New source of anthocyanins. *Plant Physiol Biochem* 2010;48:1015-9.
- Srivastava J, Vankar PS. Methylated anthocyanidin glycosides from flowers of *Canna indica*. *Carbohydr Res* 2010;345:2023-9.
- Andrade-Mahecha MM, Tapia-Bla'cido DR, Menegalli MC. Physical-chemical, thermal, and functional properties of achira (*Canna indica* L.) flour and starch from different geographical origin. *Starch J* 2012;64:348-58.
- Patel DK. Diversity of underground medicinal and aromatic plants and their Regeneration for further ex situ conservation in herbal garden. *J Biodivers Endangered Species* 2015;3:1-3.
- De Kamer HM, Maas PJ. The cannaceae of the world. *Blumea* 2008;53:247-318.
- Mahamadi C, Chapeyama R. Divalent metal ion removal from aqueous solution by acid-treated and garlic-treated *Canna indica* roots. *J Appl Sci Environ Manage* 2011;15:97-103.
- Putman EW, Hassid WZ. Sugar transformation in leaves of *Canna indica* by synthesis and inversion of sugar. *J Biol Chem Org* 2017;207:885-902.
- Mathina A, Rajalakshmi R. Corrosion inhibition of mild steel in acid medium using *Canna indica* as green corrosion inhibitor. *Rasayan J Chem* 2016;9:56-66.
- Tiwari SC, Gunning BE. Development of Ta pet urn and microspores in *Canna L.*: An example of an invasive but non-syncytial Tapetum. *Ann Bot* 1986;57:557-63.
- Nadkarni AK. *Indian Materia Medica*. 3rd ed., Vol. 1. Bombay, India: Bombay Popular Prakashan; 1991. p. 255.
- Zang GL, Sheng GP, Tong ZH, Liu XW, Teng SX, Li WW, et al. direct electricity recovery from *Canna indica* by an air-cathode microbial fuel cell inoculated with rumen microorganisms. *Environ Sci Technol* 2010;44:2715-20.
- Zhang Z, Rengel Z, Meney K. Interactive effects of N and P on growth but not on resource allocation of *Canna indica* in wetland microcosms. *Aquatic Bot* 2008;89:317-23.
- Xiao H, Cheng S, Wu Z. Microbial community variation in phytoremediation of triazophos by *Canna indica* Linn. in a hydroponic system. *J Environ Sci* 2010;22:1225-31.
- Cheng S, Xiao J, Xiao H, Zhang L, Wu Z. Phytoremediation of triazophos by *Canna indica* Linn. in a hydroponic system. *Int J Phytoremed* 2007;9:453-63.
- Cheng S, Ren F, Grosse W, Wu Z. Effects of cadmium on chlorophyll content, photochemical efficiency, and photosynthetic intensity of *Canna indica* Linn. *Int J Phytoremed* 2002;4:239-46.
- Cui X, Fang S, Yao Y, Li T, Ni Q, Yang X, et al. Potential mechanisms of cadmium removal from aqueous solution by *Canna indica* derived biochar. *Sci Total Environ* 2016;562:517-25.
- Warunya W, Noppamas S, Chanpen W. In vitro HIV Type 1 reverse

- transcriptase inhibitory activities of Thai medicinal plants and *Canna indica* L. Rhizomes. *J Ethnopharmacol* 2005;101:84-9.
42. Thepouyporn A, Yoosook C, Chuakul W, Thirapanmethee K, Napaswad C, Wiwat C. Purification and characterization of an anti-HIV-1 protein from *Canna indica* leaves. *Southeast Asian J Trop Med Public Health* 2012;43:1153-60.
 43. Abdullah E, Raus R, Jamal PA. Extraction and evaluation of antibacterial activity from selected flowering plants. *Am Med J* 2012;3:27-32.
 44. Indrayan AK, Bhojak NK, Kumar N, Shatru A, Gaura A. Chemical composition and antimicrobial activity of the essential oil from the rhizome of *Canna indica* Linn. *Indian J Chem* 2011;50:1136-9.
 45. Sunan-Chainaku. Study of cytotoxicity of the hexane crude extracted from the rhizomes of *Canna indica* L. on Cancer cells IBIDS. *Int Bibliogr Inform Diet Suppl*
 46. Moshi MJ, Innocent E, Magadula JJ, Otieno DF, Weisheit PK, Nondo RS. Brine shrimp toxicity of some plants used as traditional medicines in Kagera Region, north western Tanzania. *Tanzania J Health Res* 2010;12:63-7.
 47. Josephine OO, Cosmos OT. Evaluation of the antidiarrhoeal activity of the methanolic extract of *Canna indica* leaf (Cannaceae). *Int J Pharm Chem Sci* 2013;2:669-74.
 48. Purintrapiban J, Suttajit M, Forsberg NE. Differential activation of glucose transport in cultured muscle cells by polyphenolic compounds from *Canna indica* L. root. *Biol Pharm Bull* 2006;29:1995-8.
 49. Chen HJ, Chen CN, Sung ML, Wu YC, Ko PL, Tso T. *Canna indica* L. attenuates high glucose and lipopolysaccharide-induced inflammatory mediators in monocyte/macrophage. *J Ethnopharmacol* 2013;48:317-21.
 50. Nirmal SA, Shelke SM, Gagare PB, Jadhav PR, Dethe PM. Antinociceptive and anthelmintic activity of *Canna indica*. *Natl Prod Res* 2007;21:1042-7.
 51. Joshi YM, Kadam VJ, Kaldhone PR. In vitro antioxidant activity of methanolic extract of aerial parts of *Canna indica* L. *J Pharm Res* 2009;2:1712-5.
 52. Atrooz OM. The incorporation effect of methanolic extracts of some plants seed on the stability phosphatidylcholine liposomes. *Pak J Biol Sci* 2007;10:1643-8.
 53. Eskandarighadikolaii S, Cruz TD, Bungihan M. Antioxidant properties of fungal endophytes associated with the three medicinal plants *Gliricidia sepium*, *Canna indica* and *Gardenia jasminoides*. *J Sci Res Rep* 2015;6:661.
 54. Singh R, Bachheti RK, Saini CK, Singh U. In-vitro antioxidant activity of *Canna indica* extracts using different solvent System. *Asian J Pharm Clin Res* 2016;9:53-6.
 55. Srivastava J, Vankar PS. *Canna indica* flower: New source of anthocyanins. *Plant Physiol Biochem* 2010;48:1015-9.
 56. Srivastava J, Vankar PS. Methylated anthocyanidin glycosides from flowers of *Canna indica*. *Carbohydr Res* 2010;345:2023-9.
 57. Lin ZL, Bai'e Z, Li H, Yun C. Hemostatic effect of *Canna indica* L. *J Dali Univ* 2011;10:24-6.
 58. Joshi YM, Kadam J, Prashant RK. Investigation of hepatoprotective activity of aerial parts of *Canna indica* L. on carbon tetrachloride treated rats. *J Pharm Res* 2009;2:1712-5.
 59. Longo F, Teuwa A, Fogue KS, Spitteller M, Ngoa LS. Hepatoprotective effects of *Canna indica* L. Rhizome against acetaminophen (paracetamol). *World J Pharm Pharm Sci* 2015;4:1609-24.
 60. Motawe HM. Cannagenin: A new molluscicidal agent from *Canna indica* L. *J Herbs Spices Med Plants* 1994;2:19-26.
 61. Tripathi SM, Singh DK. Molluscicidal activity of *Punica granatum* bark and *Canna indica* root. *Braz J Med Biol Res* 2000;33:1351-5.
 62. Talukdar D. Studies on antioxidant enzymes in *Canna indica* plant under copper stress. *J Environ Biol* 2013;34:93-8.
 63. Zheng-Bo Y, Han-Qing Y, Zhen HH, Hideki H, Li YY. Surfactant enhanced anaerobic acidogenesis of *Canna indica* L. by rumen cultures. *Bioresour Technol* 2008;99:3418-23.