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REVIEW ARTICLE

PHYTOCHEMICAL AND PHARMACOLOGICAL PROFILE OF *IPOMOEA AQUATICA*

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ABSTRACT

Ipomoea aquatica (*I. aquatica*) (*Convolvulaceae*) is commonly grown green leafy vegetable found throughout India, Ceylon, Tropical Asia, Africa, and Australia. Traditionally, *I. aquatica* used as carminative agent and lessens inflammation, and is useful in fever, jaundice, biliousness, bronchitis, liver complaints, etc., *I. aquatica* is a rich source of vitamins, minerals, proteins, fibers, carotenes, and flavanoids with many health benefits. The objective of this review is to highlight the pharmacognostical, phytochemical, and pharmacological information of this plant.

Key words: *Convolvulaceae*, *Ipomoea aquatica*, pharmacology, phytoconstituents

INTRODUCTION

Knowledge of herbs has been handed down from generation to generation for thousands of years. The revival of interest in natural drugs started in last decade mainly because of the wide spread belief that green medicine is healthier than synthetic products. In the recent past, there has been a tremendous increase in the use of plant-based health products in developing as well as developed countries resulting in an exponential growth of herbal products globally. According to WHO, about 80% of the population in the world rely on the traditional medicine for the treatment of various

diseases.^[1] However, due to over population, urbanization, and continuous exploitation of these herbal reserves, the natural resources along with their related traditional knowledge are depleting day by day.^[2]

In the present era of drug development and discovery of newer drug molecules, many plant products are evaluated on the basis of their traditional uses. In this regard, one of the many plants which are being evaluated for their therapeutic efficacies is *Ipomoea aquatica* (*I. aquatica*) (*Convolvulaceae*) which is a perennial herb found throughout India, Ceylon, Tropical Asia, Africa, and Australia.^[3]

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I. aquatica used as carminative agent and lessens inflammation, and is useful in fever, jaundice, biliousness, bronchitis, and liver complaints in Unani system of medicine.^[4]

I. aquatica is a commonly grown green leafy vegetable which is a rich source of vitamins, minerals, proteins, fibers, carotenes, and flavanoids with many health benefits.^[5] The aim of this review is to highlight the traditional uses, pharmacognostical, phytochemical, and pharmacological investigation carried out on the plant so that more pharmacological studies could be conducted to investigate the unexploited potential.

PLANT PROFILE

I. aquatica (synonym: *Ipomoea reptans* Linn.) belongs to family *Convolvulaceae* is a perennial herb found throughout India, Ceylon, Tropical Asia, Africa, and Australia.^[3] It is supposed to be originated in China.^[5] The plant is grown wildly as weed in India and USA,^[6] whereas in South East Asia such as Malaysia, China, Hong Kong, Singapore, and Indonesia, the plant is grown commercially.^[7]

Taxonomic classification

Kingdom: Plantae (plants)

Subkingdom: Tracheobionta (vascular plants)

Superdivision: Spermatophyta (seed plants)

Division: Magnoliophyta (flowering plants)

Class: Magnoliopsida (dicotyledons)

Subclass: Asteridae

Order: Solanales

Family: *Convolvulaceae* (morning glory family)

Genus: *Ipomoea* L. (morning glory)

Species: *I. aquatica* Forsk (swamp morning glory).^[8]

Vernacular names

Sanskrit: Kadambi, Kalaka, Kalambi, Kalambika, Kalashaka, Kechuka, Nadika, Pattashaka, Pechu, Pechuli, Shataparna, Shradhashaka, Vishvarochana^[4]

Hindi: Kalmisag, Karmi, Patuasaga^[4]

Gujarati: Nalanibhaji^[4]

English: Water spinach, Chinese water spinach, water morning glory, swamp cabbage^[4]

Punjabi: Ganthian, Nali, Nari^[4]

Marathi: Nadishaka^[4]

Bengal: Kalmisak, Nalike, Patushaka^[4]

Tamil: Koilangu, Sarkareivalli^[4]

Telugu: Tutikura^[4]

Urdu: Narikaka^[4]

Sind: Naro.^[4]

Botanical description

I. aquatica is a perennial glabrous herb having long, prostrate, hollow stem. Leaves are 5-12.5 cm long and 3.2-7.5 cm broad, acute, cordate or hastate with rounded or acute lobes, and having 3.8-12.5 cm long petiole. Flowers are infundibuliform, solitary or 3-4 in cymes; peduncles 1.3-10 cm long, usually 1-5 flowered; bracts small, linear-lanceolate; and pedicels 2.5-5 cm long. Flowers consists of five free sepals, five united pale purple petals, unequal five stamens with spiny pollens, and 2-celled glabrous ovary with 2 ovules in each cell. Fruits are capsular with 1-4 seeds, capsules 8 mm long, ovoid, and minutely pubescent. Seeds are 3-sided, 4.5-5.5 mm long, 3.5-4.5 mm wide, and 2.5-3.5 mm thick. Two ventral faces usually flat, less often slightly concave, back arched, ventral view outline broadly elliptic or ovate to nearly round, and lateral view outline depressed ovate.^[4,6,9,10]

Composition

The leaves of *I. aquatica* contain the following: Moisture 90%, carbohydrate 4.3%, protein 3%, fat 0.4%, fiber 0.9%, mineral matter 2%, nicotinic acid 0.6 mg/100 g, riboflavin 120 mg/100 g, vitamin C 137 mg/100 g, and vitamin E 11 mg/100 g.^[6]

Traditional uses

I. aquatica used as carminative agent and lessens inflammation, and is useful in fever, jaundice, biliousness, bronchitis, and liver complaints in Unani system of medicine;^[4] used in nervous and general debility of female in Assam;^[4] dried juice has purgative properties;^[3,6] stem and leaves used in febrile delirium in Cambodia while in Burma, the juice is used as an emetic in cases of arsenic or opium poisoning.^[4] It is used also for piles, leucoderma, leprosy, and as anthelmintic.^[3,6] It is effectively used against nosebleed and high blood pressure.^[11] It is supposed to possess an insulin-like principle according to indigenous medicine in Sri Lanka.^[12]

PHARMACOGNOSTICAL STUDIES

Macroscopic characters of leaf

The leaves of *I. aquatica* were simple, opposite, ovate-oblong shape; having acute apex, reticulate venation, and glabrous surface. The base of leaves usually dilated, cordate to hastate. Leaves have entire margin and long petiole. Leaf was pale green in color, with a characteristic odor and taste.^[13]

Microscopic characters of leaf

Transverse section of leaf of *I. aquatica* showed typical dorsiventral structure. Epidermis was single layered with cuticle. Lamina was differentiated in to two layers, spongy and

palisade tissues. There were three layers of palisade cells found below upper epidermis. Midrib portion consists of epidermis as seen in lamina; collenchyma cells present below and in upper layer of epidermis and vascular bundle consists of xylem and phloem. A unicellular trichomes, paracytic stomata, and rosetts of calcium oxalate crystals found in the lamina and midrib portion of leaf.^[13]

Powder characters of leaf

The powder of leaves showed presence of unicellular trichomes, paracytic stomata, rosettes of calcium oxalate crystals, epidermal cells, and xylem vessels.^[13]

Leaf constants

Average stomatal number at upper and lower epidermis was, respectively, 300/square mm and 366/square mm. Stomatal index at upper and lower epidermis was, respectively, 14.52 and 17.46. Vein-islet number, vein-termination number, and palisade ratio were 41.33/square mm, 25.34/square mm, and 7.42, respectively.^[13]

Physiochemical parameters

Total ash 4.41% w/w, acid-insoluble ash 2.62% w/w, water-soluble ash 0.53% w/w, alcohol soluble extractive 21.92% w/w, water soluble extractive 17.06% w/w, ether soluble extractive 3.94% w/w, and loss on drying 3.20% w/w.^[13]

Phytochemical studies

A very little phytochemical work has been carried out with the plant *I. aquatica*.

Alanine, glutamine, and glucose were detected from stem; β -carotene was detected in fruits;

and hentri-acontane, β -sitosterol, and glucoside of β -sitosterol in seeds of *I. aquatica*.^[6,14]

β -carotene, xanthophyll, taraxanthin, nicotinic acid, riboflavin, vitamin A, vitamin B1, vitamin C, vitamin E, anthocyanins, 3'-methoxy quercetin, 4'-methoxy quercetin, fat, protein, carbohydrate, calcium, phosphorus, iron,^[6,14] and 7-O- β -D-glucopyranosyl-dihydroquercetin-3-O- α -D-glucopyranoside (DHQG)^[15] were detected from leaves of *I. aquatica*. Seven aliphatic pyrrolidine amides with branched and linear saturated C15-C19 acyl moieties were detected in stem and leaves of *I. aquatica* and one of the compounds was characterized as 1-(14-methylhexadecanoyl) pyrrolidine.^[16,17]

N-trans and N-cis feruloyltyramines (cinnamoyl- β -phenethylamine, N-caffeoyl- β -phenethylamine);^[18] 1-hexadecanoylpyrrolidine; and 1-octadecanoylpyrrolidine^[19] were detected in *I. aquatica*.

Chlorophyll, more than 2% of total carotenoids of which 16 carotenoids were identified of which lutein was the major carotenoid with β -carotene, violaxanthin, neoxanthin a, neoxanthin b, antheraxanthin, mutatoxanthin, cryptoxanthin, lutein epoxide, zeaxanthin, flavoxanthin, auroxanthin, etc., were detected from *I. aquatica*.^[20,21]

The oil of *I. aquatica* contained 58 volatile components of which 49.14% were terpenoid and the main components were phytol (37.08%), palmitic acid (10.99%), (z)-3-hexen-1-ol (5.7%), alpha-humulene (2.28%), n-hexacosane (2.25%), and bis (2-ethyl-hexyl) sebacate (2.17%).^[22]

Amino acids such as aspartic acid, threonine, serine, glutamic acid, proline, glycine, alanine, leucine, tyrosine, lysine, histidine, and arginine;^[23] minerals such as sodium, potassium, calcium, iron, magnesium, and zinc;^[24] sugars such as glucose, fructose, sucrose,^[25] and starch;^[7] and organic acids such as malic acid, citric acid, and oxalic acid^[25] were detected in *I. aquatica*.

Polyphenols such as myricetin, quercetin, luteolin, apigenin, and kaempferol were detected in *I. aquatica*.^[26-28]

PHARMACOLOGICAL STUDIES

Anti-diabetic activity

The comparative anti-diabetic activity of methanolic and aqueous extracts of banana (*Musa sapientum*) flowers, Pipino (*cucumis sativus*) fruit, and leaves of Ampalaya (*Momordica charantia*), Kangkong (*I. aquatica*), Kamote (*Ipomoea batatas*), Makopa (*Syzygium malaccense*), Mango (*Mangifera indica*), and Tangled (*Adnropogon citrates*) showed that aqueous extracts of banana flowers were most potent than other extracts. The comparative potencies of the other plants' aqueous extracts were: Tangled leaves more than pipino fruits more than kangkong leaves more than makopa leaves more than ampalaya leaves more than kamote leaves. The mango leaves did not exhibit anti-diabetic activity. The methanolic extract of makopa leaves was the most anti-diabetic followed by kangkong and mango leaves. The methanolic extracts of banana flower and kamote, ampalaya and tangled leaves exhibited low anti-diabetic potentials.^[29]

A boiled whole extract of *I. aquatica* showed an oral hypoglycemic effect in healthy, male, Wistar rats after a glucose challenge. There was a significant reduction in the serum glucose concentrations with both single (33%, $P < 0.0027$) and multiple (25%, $P < 0.02$) doses. The optimum dose was 3.4 g/kg, while the optimum activity was given 2 h after the administration of the extract.^[30]

Investigation has been carried out to evaluate the effect of *I. aquatica* (leafy stem) aqueous and dichloromethane/methanol extracts on the glucose absorption using a rat intestinal preparation *in situ*. Extracts orally tested at the dose of 160 mg/kg exerted a significant inhibitory effect on glucose absorption when compared with control animals. The most pronounced effect was observed with the aqueous extract. Both plant extracts inhibited the gastrointestinal motility, suggesting that the inhibition of glucose absorption was not due to the acceleration of intestinal transit.^[31]

An aqueous extract of *I. aquatica* showed the oral hypoglycemic effect as similar to that of drug tolbutamide in reducing the blood sugar levels of Wistar rats. Glucose level of the *I. aquatica* leaves aqueous extract-treated group was 47.5% lower than that of the control group treated with distilled water. The tolbutamide treated group showed a mean blood glucose level which was only 33.8% lower than that of the control group. However, statistical analysis indicated that the blood glucose levels of the *I. aquatica* treated group were not significantly different from that of the tolbutamide treated group.^[32]

I. aquatica showed oral hypoglycemic activity in streptozotocin-induced diabetic Wistar rats,

and Type II diabetic patients. Experimental diabetes was induced with streptozotocin in Wistar rats. In addition to the standard feed given to both test and control groups, the test was fed with the shredded leaves of *I. aquatica* (3.4 g/kg) for 1 week. Type II diabetic patients were subjected to a glucose challenge before and after a single dose of blended *I. aquatica*. Patients acted as their own controls. The results revealed that consumption of the shredded, fresh, edible portion of *I. aquatica* for 1 week, effectively reduced the fasting blood sugar level of streptozotocin-induced diabetic rats ($P = 0.01$). When subjected to a glucose challenge, the Type II diabetic subjects showed a significant reduction ($P = 0.001$) in the serum glucose concentration 2 h after the glucose load. However, it was not significantly reduced at 1 h ($P < 0.09$) post-glucose load. There was a 29.4% decrease in the serum glucose concentration of the diabetic patients when treated with the plant extract.^[33]

The methanol extracts of the leaves of *I. aquatica* showed potent hypoglycemic activity with different doses as 200 mg/kg and 400 mg/kg body weight of Swiss albino mice. But more activity was observed in case of 400 mg/kg body weight dose.^[34]

Anti-oxidant activity

The methanol extracts of the leaves of *I. aquatica* showed potent free radical-scavenging activity with IC_{50} value (concentration of extracts that inhibits the formation of DPPH radicals by 50%) of 4.4 $\mu\text{g/ml}$ in 1, 1-diphenyl-2-picrylhydrazyl (DPPH) free radical-scavenging assay.^[34] A free radical-scavenging anti-oxidant was isolated from *I. aquatica* leaves.^[35]

A free radical-scavenging activity of three carotenoids purified from *I. aquatica* by thin layer chromatography, namely violaxanthin, lutein, and β -carotene, was carried out by measuring the ability to scavenge 2,2-diphenyl-1-picrylhydrazyl (DPPH) radicals and 2,2-azobis-3-ethylbenzthiazoline-6-sulfonic acid radicals and by measuring their ability to inhibit red blood cell hemolysis and lipid peroxidation. It was found that the three carotenoids, in the range of 0-8 $\mu\text{g/mL}$, possessed significant anti-oxidant activity which increased in a concentration-dependent manner. Among them, violaxanthin, a 5,6-epoxycarotenoid, presented the excellent scavenging capacity, and the IC_{50} values were 8.77, 3.38, 5.06, and 4.25 $\mu\text{g/mL}$ for each assay, respectively. β -Carotene showed highest scavenging percentage in DPPH free radical assay, whereas violaxanthin was most efficient in the other three assays. The relationship between structure and anti-oxidant activities *in vitro* was complex, epoxidation of the 5, 6-ring may improve the anti-oxidative activities of the carotenoid in the four detected assays *in vitro* except the quenching of DPPH radicals.^[36]

The comparative anti-oxidant studies of 95% ethanol and water extract of stem and leaves of *I. aquatica* revealed that the ethanol extract of stem had the highest radical-scavenging activity, followed by ethanol extract of leaf. The ethanol extract of stem showed a positive effect in DPPH staining with 6.25 mg dry matter/mL, whereas all other fractions showed no effect at the same dilution. This fraction also had the highest content of the total phenolic compounds, as well as the highest reducing power and ferric thiocyanate activity. Ethanol extract of leaf had the highest amount of flavonoids.^[37]

The methanol extract of stem and leaf showed anti-oxidant activity, membrane stabilizing potential, and cytotoxicity. The anti-oxidant activity of the methanol extract increased in a concentration-dependent manner that was studied with DPPH radical, nitric oxide radical, and *in vivo* anti-oxidant enzyme activity assays. In DPPH radical-scavenging assays, the IC_{50} values of the extracts were 33.188 and 672.376 ($\mu\text{g/mL}$) for the stem and leaf, respectively. The plant inhibited the nitric oxide radicals generated from sodium nitroprusside with IC_{50} of 142.52 and 156.99 ($\mu\text{g/mL}$) for the stem and leaf, respectively, as opposed to 0.0161 ($\mu\text{g/mL}$) for vitamin C. The total poly-phenolic constituents could be contributory to the anti-oxidant activity observed. The plant extracts are less toxic (half of the lethal dose (LC_{50}) = 160.8664 and 111.419 $\mu\text{g/mL}$) for the leaf and stem, respectively, when compared to the reference standard (potassium dichromate, LC_{50} = 44.20 $\mu\text{g/mL}$). The extracts also showed significant membrane stabilizing activity.^[38]

The aqueous extract of *I. aquatica* showed the anti-oxidant effect on ethanol-treated rats (18% ethanol 5 ml/100 g body weight for 45 days). *I. aquatica* extract (33.4 g/kg body weight/day) was given for 45 days. Silymarin (0.1 g/kg body weight/day) was given as a reference drug once daily for 45 days. Levels of serum marker enzymes (Aspartate transaminase (AST), Alanine transaminase (ALT), and alkaline phosphatase (ALP), superoxide dismutase, catalase, lipid peroxidase, and lipid profiles were significantly changed. The extract was found to be utilized in alcoholic liver diseases to reduce morbidity and mortality.^[39]

Methanol extract of the flowers of *I. aquatica* showed potent anti-oxidant activity with *in vitro* models such as DPPH (1,1-Diphenyl-2-Picryl-Hydrazyl) free radical-scavenging activity, β -carotene linoleate model system, reducing power assay, and scavenging of hydrogen peroxide (H_2O_2). Methanol extract of flowers at 400 μ g/mL concentration showed maximum DPPH radical-scavenging activity (85.17%) and while at 100 μ g/mL concentration showed maximum H_2O_2 scavenging (54.55%) activity. Reducing power of methanol extract of flower was also dose dependent. The IC_{50} of methanol extract of flower for DPPH radical and H_2O_2 radical was found to be 20.89 μ g/mL and 60.25 μ g/mL, respectively.^[40]

Callus from the leaves of *I. aquatica* showed significant anti-oxidant activity after 1 month but not showed metal chelating activity. The callus was initiated on Murashige and Skoog's media supplemented with various combinations of plant growth regulators. Highest percentage of callus response was obtained in combination of α -naphthalene acetic acid (1.5 mg/L) with kinetin (0.5 mg/L). The half maximal effective concentration (EC_{50}) value of callus extract was 38 ± 3.05 and 54 ± 3.60 in DPPH and lipid peroxidation assay methods, respectively, as against 58 ± 2.6 and 64 ± 1.2 in *in vivo* plant material.^[41]

Extract of *I. aquatica* exhibited high anti-oxidant properties. Its hydrophilic-oxygen radical absorbance capacity and DPPH scavenging activity being 341.92 ± 1.32 and 37.67 ± 2.63 μ mol Trolox equivalent/gram of dry weight (TE/g DW), respectively. The total polyphenol content was estimated to be

12.56 ± 0.08 mg Gallic acid equivalent/gram of dry weight (mg GAE/g DW), and moisture content was found to be 85%. The extract also exhibited anti-bacterial activities against several spoilage and pathogenic bacteria.^[42]

Anti-cancer activity

Crude methanolic extract (CME) of *I. aquatica* leaves, its column fraction (CF), and isolated purified bioactive compound i.e. 7-O- β -DHQG showed *in vitro* cytotoxic properties. DHQG showed cytotoxicity toward cell cultures with CTC_{50} values (concentration of the sample required to kill 50% of the cells) of 387 mg/ml against normal vero cell line, whereas 156 and 394 mg/ml, against Hep-2 and A-549 cell lines, respectively. The CME and CF gave CTC_{50} values ranging from 41 to 332 mg/ml *in vitro*, 46 to 114 mg/ml in Hep-2, and 44 to 230 mg/ml in A-549 cell lines. The CME was more potent than that of DHQG probably due to synergistic effects resulting from the combination of anthocyanins and other phenolic compounds. Presence of sugar moiety in DHQG may be attributed to its low activity, probably due to steric hindrance by addition of sugar moieties.^[15]

The comparative anti-proliferative activities of 95% ethanol and water extract of stem and leaves of *I. aquatica* revealed that the water extract of stem had the highest anti-proliferative activity with an EC_{50} of 661.40 ± 3.36 μ g dry matter/mL followed by ethanol extracts of stem and leaf. The water extract of leaf had the lowest anti-proliferative activity ($EC_{50} > 1000$ μ g dry matter/mL).^[37]

Extract of *I. aquatica* showed anti-mutagenic effect on Trp-P2-induced mutagenicity to

Salmonella Typhimurium TA98 and anti-tumor activity to mouse myeloma cell line P-388.^[42]

Anti-inflammatory activity

The methanol and aqueous leaf extracts of *I. aquatica* showed significant anti-inflammatory effect with carrageenin-induced rat paw edema model. The percentage inhibition of paw edema with methanolic leaf extracts (200 mg/kg), aqueous leaf extracts (200 mg/kg), and standard (indomethacin 5 mg/kg) was 55.07%, 49.27%, and 63.76%, respectively. The percentage inhibition of paw edema with methanolic leaf extracts (400 mg/kg), aqueous leaf extracts (400 mg/kg), and standard was 81.17%, 76.47%, and 89.41%, respectively. The results impacted that methanol leaf extracts have potential anti-inflammatory activity compared to aqueous leaf extracts. Pre-treatment with a single dose of *I. aquatica* produced significant dose-dependent anti-inflammatory effects on carrageenin-induced rat hind paw edema.^[43]

Anti-arthritic activity

The methanol leaf extract of *I. aquatica* showed significant anti-arthritic potential. Methanol leaf extract at 200 and 400 mg/kg, both the dose significantly ($P < 0.05$) decreased the paw thickness at the end of 30-day treatment. In acute phase inflammation, both the doses showed the almost same potency while in chronic phase, methanol leaf extract of 400 mg/kg exhibited more potency than the low dose of 200 mg/kg.^[44]

Anti-microbial activity

The methanolic and aqueous leaf extracts of *I. aquatica* showed anti-microbial activity against Gram-positive and Gram-negative

microorganisms. The methanolic leaf extract of *I. aquatica* showed bigger zone of inhibition (15-25 mm) than aqueous leaf extract of *I. aquatica* (08-19 mm) in agar disc diffusion method.^[43]

Anti-ulcer activity

The ethanolic extract of *I. aquatica* showed potent anti-ulcer activity along ulcer-healing effect. Ethanolic extract of *I. aquatica* was found to be effective with 200 mg/kg (68.72%) and 400 mg/kg (62.13%) in aspirin induced ulcer model and significantly reduced free and total acidity. It was found that anti-ulcer effect of *I. aquatica* may be due to its cytoprotective effect rather than anti-secretory activity.^[45]

Nootropic activity

The methanol leaf extract of *I. aquatica* showed nootropic effect in rat hippocampus. The treatment with 200 and 400 mg/kg of methanol leaf extract, for 30 days in neonatal and young adult age groups of rat, significantly increased acetylcholine content in their hippocampus as compared to age-matched controls. Increase in acetylcholine content in their hippocampus may be the neuro-chemical basis for their improved learning and memory.^[46]

Center nervous system depressant and anti-epileptic activity

The methanol extract of the leaves of *I. aquatica* exhibited center nervous system (CNS) depressant and anti-epileptic activities in various animal models such as pentobarbitone sleeping time and hole-board exploratory behavior for sedation tests and strychnine-, picrotoxin-, and pentylenetetrazole-induced convulsions in mice. Methanol extract of the leaves (200 and 400 mg/kg, p.o.), like

chlorpromazine hydrochloride (1 mg/kg, i.m.), produced a dose-dependent prolongation of pentobarbitone sleeping time and suppression of exploratory behavior. Methanol extract of the leaves (200 and 400 mg/kg) produced dose dependent and significant increases in onset to clonic and tonic convulsions and at 400 mg/kg, showed complete protection against seizures induced by strychnine and picrotoxin but not with pentylenetetrazole. The extracts did not produce any toxic effect in 14 days acute oral toxicity test.^[47]

Anxiolytic activity

The methanol:acetone extract of leaves of *I. aquatica* (MAE-IA) exhibited anxiolytic activity in elevated plus maze, light:dark apparatus, and hole-board apparatus models. Its ability to influence ketamine-induced sleep was also assessed in mice. The MAE-IA (200 and 400 mg/kg orally) increased time spent in open arm of elevated plus maze, time spent in lit area of light:dark apparatus, and number of head poking in the hole-board apparatus. The extract also increased duration of ketamine-induced sleep.^[48]

Hypolipidemic activity

The methanol leaf extract of *I. aquatica* showed significant hypolipidemic activity in hyperlipidemic rats. Hypolipidemic effects were evaluated with the single, daily oral dosing of 200 and 400 mg/kg of methanol leaf extract of *I. aquatica* in Swiss albino rats for 30 days. On day 30, the concentrations of plasma total cholesterol, total lipid, free fatty acid, phospholipid, and triglycerides in rats treated with methanol leaf extract of *I. aquatica* at 200 and 400 mg/kg were significantly decreased ($P < 0.05$), accompanied with

significantly decreased concentrations of liver, kidney, and heart total cholesterol and triglyceride ($P < 0.05$). These results indicated that methanol leaf extract of *I. aquatica* largely improved the lipid profiles in the hyperlipidemic rats.^[49]

Diuretic activity

The methanol extract of *I. aquatica* showed good diuretic activity in Swiss albino mice. The excretion of electrolytes and urine volume was higher in methanol extract-treated mice than that of standard diuretic, furosemide.^[50]

Prostaglandin inhibitory activity

N-trans and N-cis feruloyltyramines, isolated from Indonesian medicinal plant, *I. aquatica*, showed inhibition of *in vitro* prostaglandin synthesis.^[18]

Scorpion venom anti-dote activity

I. aquatica extract showed scorpion venom anti-dote activity against fibroblast cell lysis after Heterometrus laoticus scorpion venom treatment. The venom was pre-incubated with plant extract for 30 min and further treated to confluent fibroblast cells for 30 min. More than 40% efficiency (test/control) was obtained from cell treatment with venom pre-incubated with extracts of *I. aquatica*.^[51]

CONCLUSION

From the above description, it may be concluded that *I. aquatica* could be a useful natural herb having rich source of vitamins, mineral, carotenoids, and flavanoids which comprises its utility as nutraceutical food and it can be used to cure many fatal diseases such as cancer, diabetes, etc., Many unrevealed applications

of this herb remain un-investigated in relatively newer areas of its function. Thus, further phytochemical and biological studies would be carried out on *I. aquatica* in order to elucidate their active principles and mechanisms of action of the active constituents.

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