REVIEW ARTICLE

ARUNDO DONAX L.: A SCIENTIFIC UPDATE

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ABSTRACT

Arundo donax L. belongs to the family Poaceae. It has been found in the Mediterranean, North Africa, India and Pakistan. It grows in hilly locations in India. It grows up to 2100-2440 m in the Himalayas. Commonly, *A. donax* L. is known as Giant Reed in English and Narakata in Hindi. Traditionally it is used in the treatment of dropsy and cancer. It is the active ingredient of an Ayurveda formulation, "Virataradi Kashaya," which is used in the treatment of urinary calculi, retention of urine and abdominal pain in homeopathy *A. donax L. is* used for the treatment of allergic rhinitis. *A. donax* L. contains many beneficial phytoconstituents such as protein, fat, total carbohydrate, fibers, lignin, α-cellulose, hemicelluloses, alkaloids (tryptamine, bufotenidine, gramine and arundamine), etc. *A. donax* L. has been found to possess many pharmacological properties like antibacterial and antifungal effects, anthelmintic effects, antifeedant activity, antiproliferative effect, effect on milk production and fattening performance, central nervous effect, hypotensive effect, antispasmodic effect, anti-acetylcholine effect, uterine stimulant effect and neuromuscular blocking activity. It is an essential ingredient of herbal expectorants. This review might be a vital tool for researchers who seek to work in this area.

Keywords: *A. donax* L., Narakata, urinary calculi, gramine, arundamine, antispasmodic effect

INTRODUCTION

Plants are closely related to human health care systems. Studies on phytochemicals obtained from various medicinal plants indicate that many health problems can be treated well by using them[1]. *A. donax* L. is an ancient grass mentioned in Ayurvedic literature, "Indian Materica Medica" (*Bhavpraksh Nighantu*). It is used in treating a burning sensation of the body, herpes, improving breast milk in a lactating woman, skin diseases, and condition of burning urination[2].

Taxonomy

Arundo donax L. is the scientifically correct name for this plant. Among the three species that make up the genus Arundo, the largest and most aggressive of these species is *A. donax* L. (Arundineae) (Fig. 1). Other recognized varieties of *A. donax* are *A. donax* var. variegata Vilm and *A. donax* var. versicolor (Mill.) Kunth[3]. *A. donax* L. is known by many names in different parts of world (Table I). In India *A. donax* L. is identified by different local names (Table II).

Kingdom : Plantae

Phylum : Spermatophyta

Subphylum : Angiospermae

Class : Monocotyledonae

Order : Cyperales

Family : Poaceae

Genus : Arundo

Species : *Arundo donax*

Preferred Scientific Name : *Arundo donax* L.

Synonyms : *Donax arundinaceus*, *Donax sativa*, *Arundo bengalensis*

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Fig. 1: *A. donax* L. plant[4]

Table I: International common names of *A. donax* L.[3]

English	Wild cane; Giant cane; Bamboo reed; Spanish reed
Spanish	Cañacomún; Carizo; Caña de Castilla; Carrizo
French	Grandroseau; Canne de Provence
Arabic	Qala; Ghab
Chinese	Luzhu
Portuguese	Canapalustre; Canno de reino

Table II: General names of *A. donax* L. in India[4]

Hindi	Baranal, baru, Doka, Nal, naldura
Kannada	Baaladakaddi, Bileelaaladakaddi, Hulagiluhullu
Malayalam	Oodappullu
Marathi	Nal
Nepali	Thulonarka
Sanskrit	Nala, Dhamana, Potagala
Tamil	Koraikkuccu, Caravanam, Korukachi
Telugu	Adavikikkasagadi, Adavikikasa-Gaddi, Kaki Veduru

Distribution

The *A. donax* L. plant is indigenous to the Old World's tropics and temperate zones. The native range is assumed to be Asiatic (i.e., temperate and tropical Asia[7]) despite the widespread belief that it originated in the Mediterranean region[5] or warmer regions of the Old World[6]. It has become naturalized and invasive in many locations, including those with similar conditions to its original range, such as the sub-tropical United States, southern Africa, Mexico, South America, the Pacific and the Caribbean islands[8].

Description

It is a tall, upright, perennial grass that resembles a cane or reed. *A. donax* L. is 2-10 m in height, and it is one of the tallest herbaceous grasses. It has a sturdy root system and penetrates deeply into the soil[9]. Spreading horizontal rhizomes produce clusters of cane-like, hollow, multi-stemmed clumps that can cover a wide area. Each node can be anywhere from 12 to 30 cm in length and the culms can grow to a diameter of 1 to 4 cm with walls that are 2 to 7 mm thick. In their second year of development, they typically send out a limb or two, usually a single lateral branch from a node[10]. At maturity, the culm's exterior tissue, which is silicaceous in composition, develops a pale yellow color and becomes hard and brittle. The heart-shaped, hairy-tufted bases of the 2 to 6 cm-wide (5.1- to 15.2-cm-wide) leaves, which are broadest at the base and narrow at the tip, clasp the stem broadly and extend to 70 cm or more in length. The leaf arrangement is uniform and alternating along the culm, although it is two-ranked. While the culms can stay green year-round, they typically lose their color and go into a semi-dormant state throughout the winter or during dry spells. The flowers bloom from March to September. These are cream to brown and are born in substantial plume-like panicles 30-65cm in length at the very top of the stems. The spikelets, which are the individual flowers, each consisting of florets and the florets diminish in size down the length of the spikelet. Above the glumes and between the florets, the rachilla, the spikelet's segmented central shaft, becomes

glabrous and disarticulates. The glumes, which are not uniform in length but are as long as the spikelets, are membranous, have three nerves, and are thin, slim, and pointy. Lemmas are the more prominent outer bract that serve to enclose the florets along with the palea. There is an inward tapering that culminates in fine teeth[3].

Traditional uses

The effect of *A. donax* L. on the evolution of western music may be traced back at least 5,000 years, making this species an essential part of western cultural history. To this day, reeds for woodwind instruments[9] continue to be harvested from *A. donax* L. culms, the cane from which the first panpipes and syrixes were made. Only a few regions in France and the states of Texas and California in the United States have been actively cultivating cane for woodwind reeds. Ancient Egyptians began using it for lining underground grain storage circa 5000 BC. By 400 AD, its leaves were used to wrap mummies long before anyone realized its musical potential.

A. donax L. was utilized commercially to produce energy[10], fiber, crude shelters, livestock fodder, basket-work, paper pulp, fishing rods, trellises, garden fences, building and roofing material, erosion control or bank stabilization and arrows. It is primarily grown for its aesthetic value or as a privacy screen, while it is also sometimes employed as an erosion control measure[11,12].

Decoctions of *A. donax* L. rhizomes are employed as an emollient and diuretic[13] in the Ayurvedic medical system. It is a remedy for high body temperature, urinary incontinence, scabies and rabies. An ayurvedic medicine called “Trinpanchmula kwath”[14] contains this as one of its main ingredients. The dropsy treatment involves the application of the rhizome. It is used to treat cancer by heating its roots with honey. Also, condylomata and indurations of the breast benefited after treatment with *A. donax* L. Infusions made from the roots have been utilized for various medical purposes, including sudorific, diaphoretic, emollient, depurative, and diuretic[15-19]. In addition to its usage as a hemostatic, *A. donax* L. is also applied to toothache[18], pertussis[19], and cystitis[20]. To alleviate symptoms of allergic rhinitis, *A. donax* L. is often recommended by homeopaths.

A. donax L. is a plant of therapeutic value. Stem, leaves and fruits are used in the management of menstrual pain[21,22], decoction of root is used as abortifacient[23], leaves are used in the treatment of otitis, as an emmenagogue, vulnerary[24], treatment of fracture-dislocation[25], worm infestation[26], to provide a lossless urine transfer[27], as febrifuge[28], asanti-asthmatic[29], as depurative[30], as lactifuge[31], in treatment of hemorrhoids[32], as analgesic and anti-inflammatory[33], in treatment of bronchitis, as anti-diarrhoeic, calculolithic[34], sedative in gastralgia[35], hypertension[36], cold, fever[37], improving perspiration[38], haemostatic[39], arthritis[40], abdominal pain, wounds[41], gastro-intestinal[42], antiepistactic[43], emostatic[44] and heat-cleaning[45]. It is also used in veterinary medicine as a diuretic and urinary antiseptic in cows[46] and to reduce horses’ stomach flatulence[47].

The plant exhibits many physicochemical characteristics (Table III) and has been found to contain many chemical constituents (Table IV).

Table III: Physicochemical characteristics[48]

1	Ash value	3.00- 6.14%
2	Silicates	1.16- 1.31 %
3	Total extractives	11.16- 18.30%
4	Dichloromethane	0.46 -0.37%
5	Ethanol	4.18-9.10%
6	Hot water	6.61-6.70%

PHARMACOLOGICAL EFFECTS

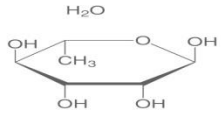
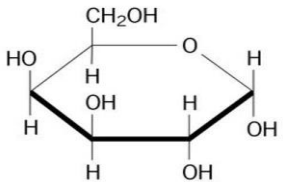
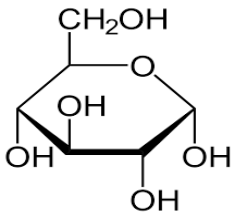
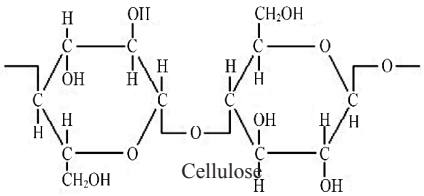
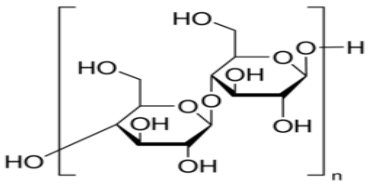
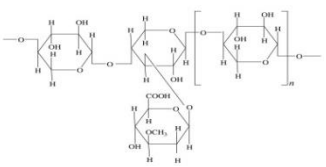
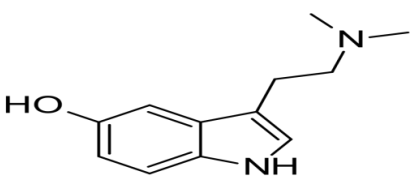
Antimicrobial effects

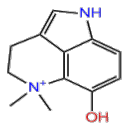
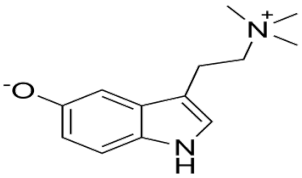
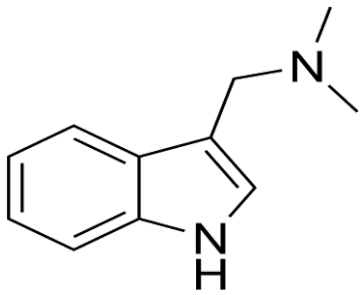
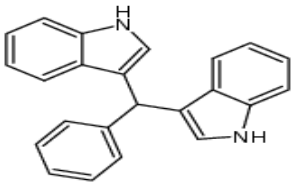
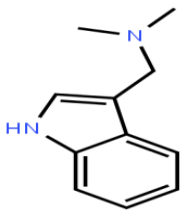
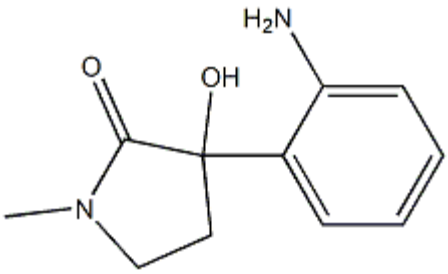
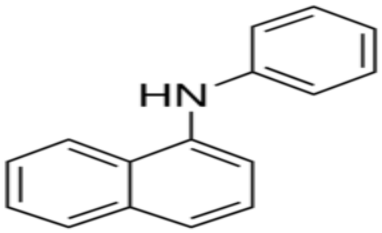
Methicillin-resistant *Staphylococcus aureus* (MRSA) was inhibited by a 128 g mL^{-1} concentration of *A. donax* aqueous extract. A significant dose-dependent antibiofilm efficacy was revealed by its reed nodes, both in inhibiting the formation of MRSA biofilms and destroying existing biofilms. Thus, the reed of the plant has been used to obtain fresh lacerations and in the treatment of biofilm-related illnesses[48].

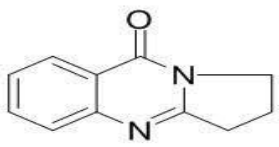
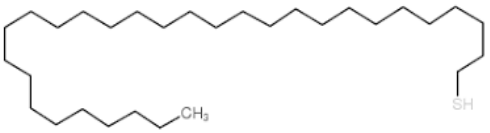
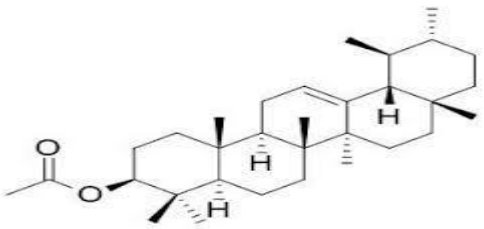
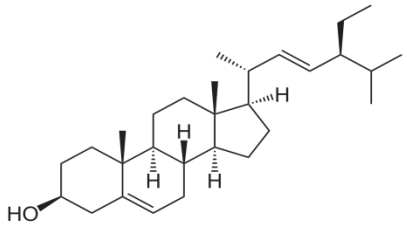
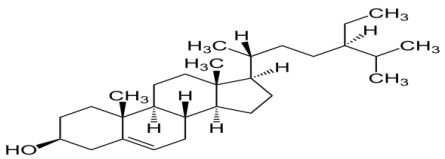
Anthelmintic effects

The effectiveness of *A. donax* L. extract against *H. contortus* was examined, as well as the efficacy of the chloroform and petroleum ether extracts. The anthelmintic effects of *A. donax* L. (25-50 mg mL^{-1}) were observed. After being exposed to the plant extract at 50 mg mL^{-1} concentration for 10 h, 56.7% of *Haemonchus contortus* died. Within 2 h of treatment with Levamisole (the drug used as a standard), all of the worms exposed to the drug had died. However, the plant’s anthelmintic effects varied with both dosage and duration of use. Ovicidal effects on the insects were measured for these plant extracts over time and across various doses. *A. donax* L. showed ovicidal action with an LC_{50} of 200. 1 µg mL^{-1} in an egg

Table IV: Chemical constituents

S. No.	Chemical constituent		Structure	Reference
1.	**Sugars and Celluloses**	Rhamnose		42
		Galactose		35
		Glucose		34
		Cellulose		38
		α-cellulose		40
		Hemicellulose		37
2	**Indole-3-alkylamine bases**	Bufotenine		38, 39

		Dehydro-bufotenine		40
		Bufotenidine		30
3	**Alkaloids**	Gramine		28
		Bisindole		35
		Donaxine		36
		Donaxaridine		40
		N-phenylnaphthylamine		28

		Deoxyvasicinone		27
4	**Triterpenes**	Triacontane		30
		α-Amyrin acetate		31
		Triacontanol		47
5	**Sterols**	Stigmasterol		38
		β-Sitosterol		31, 32

hatch test, and its crude powder reduced the number of fecal eggs by 50.5% in sheep naturally infected with gastrointestinal nematodes[49].

Antifeedant activity

A. donax L. possesses efficacy against anti-boll weevil i.e. *Anthonomus grand* [31]. Bioassays demonstrated that while sterols had some antifeedant activity; however, the isolates of tricin and tricontanol have shown far more potent results[50, 51].

Antiproliferative effect

A. donax L. was utilized to treat malignancies in conjunction with *Cynodon dactylon* L. and *Spartium junceum* L. due to its antiproliferative properties[52]. Purified from the *A. donax* L. rhizomes was a lectin that inhibited the growth of human cancer cell lines while stimulating the proliferation of human peripheral blood mononuclear cells. Gel filtration chromatography established that the molecular weight of natural lectin was 32 kDa. The lectin from the *A. donax* L. (ADL) plant was stable up to 55 °C,

was most active between pH 7.0 and 9.0 and contained 2.1% carbohydrates[53].

Effect on milk production and fattening performance

The foliage of *A. donax* L. harms milk production and fattening efficiency because it is poorly digested. DM digestibility was found to be about 47-52 %, and OM digestibility was reported to be around 54-56 %, with a range of 48-51 %. Components were reported being galactagogue[54, 55]. *A. donax* L. increases milk production in cows. However, a previous study[56] revealed a more excellent DM digestibility of 69%. Lambs benefited more from fresh giant reed forage than giant reed hay[57] when it came to gaining weight. Rahmani sheep had an easier time digesting fodder. It has giant reed silage compared to berseem or reed hay[58].

Central nervous effect

The amino acids (such as tryptamine, bufotenine, and N-DMT) found in *A. donax* L. rhizome given a significant neurological effect. There were supposedly no psychotropic effects from them. Instead of producing psychedelic effects[59]; 50 mg of rhizome extract elicited minor but long-lasting allergic symptoms, such as impaired vision, watery and swollen eyes, conjunctivitis, and rashes[60].

Effect on blood pressure

Injection of bufotenine (0.2-0.5 mg kg^{-1}; derived from ethanolic rhizome extract of *A. donax* L.) caused a reduction in blood pressure. It was a precipitous decline followed by a slow ascent. After the initial dose, hypotension lasted from half an hour to an hour and a half, and tachyphylaxis was observed after repeated injections of the same dose[61].

Effect on skeletal muscle

Isolated rectus abdominis muscle from frogs was shown to have its spasm inhibited by the alkaloid when exposed to 5 µg mL^{-1} of acetylcholine. No effect on muscle was seen due to KCl. Regression curves were used to determine the ED_{50} by comparing the inhibitory impact of d-tubocurarine. Alkaloid and d-tubocurarine ED50 values were found to be 1.40 and 1.05 µg mL^{-1}, respectively[62].

Effect on smooth muscle

The effect of smooth muscle was studied using dog intestine, guinea pig loop, guinea pigs and albino rat's uterus and tracheal dog. The alkaloid caused spasms when tested *in vivo* and tachyphylaxis when dosed repeatedly. Histamine release was suspected to be to blame for this phenomenon. Alkaloid doses between 1 and 10 µg mL^{-1} were sufficient to produce muscular relaxation. Spasm-inducing actions of drugs were blocked above 20 µg mL^{-1} of alkaloids. Therefore, the spasmolytic effect is generic. When the uterus of an isolated guinea pig was subjected to the medication, it spasmed more frequently and more persistently than the uterus of the animals. This spasm was only observed up to 20 pg mL^{-1} in guinea pigs and 10 pg mL^{-1} in albino rat uterus. We did not observe any signs of tachyphylaxis. The medication prevented the AcCh-induced spasm in larger doses. The stimulating activity of the alkaloid may have been the basis for the plant extract's (rhizomes) use "as a stimulator of menstrual discharge" in traditional medical systems[63].

Neuromuscular blocking activity

Bufotenidine's neuromuscular blocking activity was documented utilizing isolated frog rectus abdominis muscle and sciatic nerve preparation in albino rats, a rabbit head drop method and intravenous treatment in chicks. D-Tubocurarine, the gold standard in this field, was employed as a reference point. The frog rectus muscular spasms caused by acetylcholine (5 g mL^{-1}) were inhibited by bufotenidine, while the spasms induced by potassium chloride (1 mg mL^{-1}) were unaffected. Spasmolytic ED_{50} values for bufotenidine and D-Tubocurarine against acetylcholine were 1.4 and 1.05 g mL^{-1}, respectively (derived using log dose-percentage inhibition curves). D-Tubocurarine and bufotenidine caused a lowering of rabbits' heads in the dose of 0.45 and 5.2 mg kg^{-1}, respectively. When administered intravenously through the alar vein, both drugs caused paralysis of flaccid muscle in chicks. The recovery from neostigmine was accelerated from both drugs. Additionally, these drugs blocked tetanic response in albino rats. Recovery from this block, brought on by the lack of drugs, began after 10–15 minutes and was nearly complete after 45 minutes. By 15-18 minutes after the administration of drugs, the neuromuscular blockade was wholly reversed, demonstrating the antidepolarizing effect of these medicines. The data demonstrate that bufotenidine effectively blocks neuromuscular transmission. Bufotenidine was about as effective as D-tubocurarine *in vitro* but about ten times less *in vivo*[64].

CONCLUSION

Numerous traditional applications have been developed for the plant. Traditional medicine practitioners have relied on it to treat various illnesses for centuries. Its primary application is in the therapy of gastrointestinal diseases like ulcerative colitis. It has a wide variety of chemical constituents that are effective in various

disorders. The plant has great potential benefits and may be an excellent traditional source for researchers to explore its therapeutic activity for the treatment of humanity.

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OBITUARY

IDMA MOURNS THE SAD DEMISE OF PROF. SUKHDEV SWAMI HANDA, EDITORIAL ADVISORY BOARD MEMBER, INDIAN DRUGS

A Tribute to Prof Sukhdev Swami Handa by Dr Indu Pal Kaur, Professor & Chairperson, UIPS

We all at the University Institute of Pharmaceutical Sciences (UIPS), Panjab University, Chandigarh, fail to find words to express our heartfelt sorrow at the hapless demise of Professor Sukhdev Swami Handa, former Chairperson and faculty at UIPS, who bid adieu to his wonderful life-sojourn of 82 years recently on 7th March 2023.

All of us remember Prof. Handa Sir very fondly for being a passionate teacher, great researcher, motivational mentor, able administrator and, above all, a thorough gentleman, always immaculately dressed. Prof. Handa's specialized areas of research included, quality control and standardization of medicinal plants and their products, liver-protecting phytoactives, anti-inflammatory plant products, anticancer agents from plants, and therapeutically active alkaloid N oxides from plants.

After serving UIPS at Panjab University for around 26 years as Lecturer, Reader, Professor and Head/Chairman (1985-1988), Prof. Handa held the prestigious assignment of serving the Indian Institute of Integrative Medicines (IIIM, CSIR) at Jammu, as its Director, from 1995-2000. He has also been associated with International Centre for Science United Nations Industrial Development Organization (ICS-UNIDO) as Senior Specialist. Prof. Handa was also instrumental in establishing the Ranbaxy Herbal Drug Research Centre as a Consultant to Ranbaxy Laboratories, Ltd., Gurgaon. He also served as a Scientific Adviser, on Board of Directors and as a Consultant to Zandu Pharmaceutical Works, Mumbai, and a Pharmaceutical Consultant to Glaxo Smith Kline (GSK), Asia-Pacific, for quite long.

His professional achievements are quite unparalleled and pharmaceutical contributions galore. His footprints will always be our companions on every journey that UIPS undertakes.

We salute Hon'ble Sir, who will continue to serve as a beacon for the profession of pharmacy in decades to unfold...