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Review Article

WOODFORDIA FRUTICOSA (L.) KURZ: A HIGH DEMAND THREATENED PLANT WITH POTENTIAL MEDICINAL VALUES

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ABSTRACT
Woodfordia fruticosa is a high demand medicinal plant for pharmaceutics and dye industries. The plant is distributed in North-eastern India. This review highlights the spectacular properties of this plant. Flowers of *W. fruticosa* have been used traditionally in the treatment of dysentery, diarrhea, other bowel complaints, internal haemorrhages, leucorrhoea and menorrhagia. Externally, powdered flower is sprinkled over foul ulcers and wounds for diminishing their discharge and promoting granulations. *W. fruticosa* is also reported to have DNA topoisomerase inhibitor, antibacterial, antifertility, antipeptic ulcer, free radical scavenging, and hepatoprotective activity. *W. fruticosa* is a medicinal plant used to treat a wide range of disorders including diabetes.

Keywords: *W. fruticosa, Hepatoprotective Acitivity, DNA Topoisomerase Inhibitor, Antipeptic Ulcer*

INTRODUCTION
North East is the part of India which covers states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim. These states are rich in biodiversity and house many valuable medicinal plants. *Woodfordia fruticosa* (L.) Kurz. (syn. *Woodfordia floribunda* Salisb.) is a medicinal plant commonly known with different vernacular names from various parts of India as well as world wherever it is found; Dhataki, Dhawai flower, Fire flame Bush, Shiranjitea, are some of the popular common names of *W. fruticosa* (Kaur *et al.*, 2010).
The use of medicinal plants in curing diseases is as old as human civilization. The World Health Organization (WHO) has long recognized and drawn the attention of many countries to the ever increasing interest of the public in the use of medicinal plants and their products in the treatment of various ailments. These plants which are found in our environment enjoy wide acceptability through the population and serve as cheaper alternatives to orthodox medicine (Baravalia *et al.*, 2012).
Woodfordia fruticosa belongs to family Lythraceae and is locally known as Dhavdi (Gujarat, India). All parts of this plant possess valuable medicinal properties viz. anti-inflammatory, anti-tumor, hepatoprotective and free radical scavenging activity, but its flowers are in maximum demand. The flowers are being used in the preparation of Ayurvedic fermented drugs called '*arista*' and '*asava*', and are very popular in the Indian subcontinent as in other South Asian countries (Kores *et al.*, 1993).
Traditional Indian ayurvedic preparations like, '*arista' and 'asava'* are believed to be general health tonics in nature, having overall health stimulating properties via ameliorating and/or delaying one or other systemic disorders. Of the 18 *aristas* mentioned in the Indian Ministry of Health and Family Welfare's monograph (CCRIMH, 1978), 17 have been found to contain *W. fruticosa*. According to the Indian systems of medicine, flowers of this plant have pungent, acrid, cooling, toxic, alexiteric properties and are used as a sedative and as an antihelminthic. These flowers are also useful in fever, thirst, blood diseases, dysentery, toothache, leprosy, leucorrhea, and menorrhagia. *Charaka* and *Sushruta* used sweetened decoction of flowers for fever, haemothermia, persistent dysentery; included *Dhaataki* in conception-promoting group of herbs (Khane, 2007). Powder of *Dhaataki* flowers, mixed with honey, was prescribed for leucorrhoea. Dried flowers are powdered and dusted over ulcers and wounds to eliminate discharge and promote granulation. The dried flowers are an astringent tonic in disorders of the haemorrhoids, mucous membranes and in derangements of the liver and also considered a safe stimulant in pregnancy (Kirtikar *et al.*, 1992).

This plant has attracted many researchers in the modern times too. However, there is a paucity of sufficient and authentic literature to explore the information for further studies of this medicinally important plant. Most of the research papers highlight the ethno botanical significance and characterization of the phyto-constituents showing potent medicinal activities. Each drug is unique in its own physical and chemical characteristics which separate it from various other closely related drugs. Standardization and validation of the physico-chemical properties of a drug is essential to maintain its integrity and purity. A very few reports are available on the conservation of the plant. This review focuses on the *in vitro* conservation and plant regeneration methods using various explants under artificial conditions.

Botanical Name

Woodfordia fruticosa (L.) Kurz.

Family

Lythraceae

Vernacular Names

➢	Bengali	:	Dawai, Dhai, Dhai phul
➢	Gujarati	:	Dhavdi, Dhavadina
➢	Hindi	:	Dhataki, Dhatri, Dhaura,Dhawai, Dhawala
➢	Kannada	:	Tamrapushpi
➢	Malayalam	:	Tatiripuspi
➢	Marathi	:	Ddhayati,Dhavada
➢	Oriya	:	Dhobo, Jaliko, Harwari
➢	Sanskrit	:	Agnijwala, Dhataki, Dhauri
➢	Tamil/Telugu	:	Dhataki,
➢	Nepali	:	Dhangera
➢	Bihar	:	Dawai, Dhai
➢	Jammu & Kashmir	:	Thawi, Thai

It is widely used in Ayurvedic formulations and patents like Liv-52 (Shanker *et al.,* 2013). *Woodfordia fruticosa* a high demand medicinal plant for Pharmaceutics and dye industries is gradually depleting from its natural habitat hence need first, to assess for its distribution and easy means for cultivation either in-situ or ex- situ. Oil based flower extract has always been recommended for open wounds. It is used in menorrhagia and leucorrhoea; another constituent isolated was woodfordin C (12) with antitumor activity (Cho *et al.*, 1990).

Description

a)Macroscopic

Flower, about 1.2 cm long, occurs as single or in bunches of 2-15, calyx 1.0-1.6 cm long, ridged and glabrous, bright red when fresh but fades on drying, with ampanulate base and oblique apex having 6 triangular and acute teeth, each tooth being, 2-2.5 mm long, 6, very minute accessory sepals attached outside at the juncture of calyx tooth and deeper in colour, petals 6, attached inside the mouth of calyx-tube, shightly longer than calyx tooth, alternating with calyx-tooth pale rose or whitish, thin, papery, lanceolate, acuminate, stamens 12, united at the base, about 1.5-2 cm long, filament filiform, curved at the apex, keeping anthers inside calyx-tube , anthers dorsifixed brown, almost rounded or broadly ovate, carpels 2, united, ovary superior, style filiform, longer than ovary and stamens, taste astringent.

b)Microscopic

Transverse section of sepal shows, single layered cuticularised epidermis, provided with both glandular and covering trichomes multicellular, long, consisting of a stalk and a globose, thin-walled, multicellular head, covering trichomes, unicellular thick-walled broad at base and pointed at the apex, ground tissue consisting of thin-walled, parenchymatous cells. Surface view of petal shows thin-walled, parenchymatous cells, provided with very few sparsely distributed covering trichomes; transverse section of filament shows epidermis consisting of single layered tangentially elongated cells, covered with a very thick-cuticle; ground tissue consisting of thin walled parenchymatous cells with intercellular spaces,

surrounding a central vascular cylinder of spirally thickened vessels. Transverse section of anther shows, single layered epidermis, covered with cuticle followed by several layers of thickened cells, surrounding both the pollen-sacs having numerous pollen grains, roughly tetrahedral with three pores, measuring 12-16 µ approximately; central region consisting of thin-walled cells embodying vascular bundles.

Distribution

Woodfordia fruticosa is a plant of Indian origin and distributed in Madagascar, Pakistan, India, Yunnan, China, Nepal, Bhutan, Myanmar, Thailand, Laos, and Indonesia. *Woodfordia fruticosa* has been recorded amongst the IUCN red list of threatened plants. It has been categorized as lower risk or 'Least concerned' (LC) plant species (IUCN, 2015). The major threats are the flowers are traded for use in ayurvedic formulations and the species is grown in numerous gardens (IUCN, 2015). The plant is distributed in most part of the country having stony/ rocks and slopes of hills with less population restricted to very limited areas. In North-eastern India it is having its occurrence in Tenga and Salari to Nafra areas of East Kameng district, Kawlkuth areas in Mizoram and limited northern parts of West Bengal adjacent to South Sikkim (Shanker *et al.*, 2013).

Plants of *Woodfordia fruticosa* are distributed in an altitudinal range of 1243 msl to 1478 msl in very limited areas of Arunachal Pradesh, Mizoram and West Bengal. In Arunachal Pradesh it is found in West Kameng district on the way to Nafra from Bomdila the district Headquarter of West Kameng between 27°19.552' - 27°19.793' N and 092°26.486' - 092°27.327' and near Tenga towards Nag Mandir, Jamiri on way to Bomdila from the entry point of West Kameng district between 27°12.538' N and 092°34.109' E in West Kameng district of Arunachal Pradesh. Only single plant was observed during 2003 near Papu Hill in Papumpare district only. In Mizoram it was found only at Kawlkuth area on route to Champhai from Aizawl in Champhai district. Population density per unit area of $1m^2$ is 8.5 plants in west Kameng district of Arunachal Pradesh, 5.08 plants in Kwalkuth areas of Mizoram and 3.36 plants in North Bengal (Shanker *et al.*, 2013).

Medicinal Properties and Anti-Fertility Activity

Anti-fertility activity of dried flowers of *Woodfordia fruticosa* is studied with various solvents and individually with water and aqueous alcohol (50:50). Antifertility activity of successive alcoholic, individual aqueous and individual hydro-alcoholic extracts was studied in female albino rats. Among all the three extracts tested, successive alcoholic extract showed maximum abortifacient activity of 43%, which was found to be statistically significant ($P < 0.05$). Individual aqueous and individual hydro-alcoholic extract, though, showed moderate activity of 12% and 20%; however, it was not statistically significant (Khushalani *et al.*, 2006).

Immuno-Active Constituents

Fermentation of both preparations- '*asava'* and '*arista'*) is brought about by the addition of a source of sugar with *dhataki* flowers. Dhataki is fermentation initiator and *jaggery* is used as a source of sugar in *asava* and *arista* preparation. The use of *Woodfordia* flowers in model preparations resulted in a substantial increase of the inhibition of both human complement activity and chemi-luminescence generated by zymosan-stimulated human polymorpho-nuclear leukocytes. It was established that the increased biological activity was not due to microbial interference, but to immuno-active constituents released from the *Woodfordia* flowers. Experiments performed with yeasts isolated from commercial Nimba arishtas showed, in agreement with empirical findings, significantly raised alcohol content upon addition of *Woodfordia* (Kroes *et al.*, 1993).

Antiinflammatory and Analgesic Activity

Analgesic and anti-inflammatory activity of 95% ethanolic extract of Woodfordia fruticosa (WFE) flowers in acute, subacute and chronic models of inflammation was assessed in rats and mice. Oral administration of WFE (250 and 500 mg/kg) exhibited significant anti-inflammatory activity in acute (carrageenin and autocoids induced hind paw edema), subcute (formaldehyde-induced hind paw edema) and chronic (cotton pellet granuloma) models of inflammation (Verma *et al.*, 2012).

Antitumour Activity

Woodfordin C, isolated from the dried flowers of *Woodfordia fruticosa*, prolonged the lifespan of mice inoculated with sarcoma 180 cells by 160%. One of the five mice survived to the 60th day at a dose of 10 mg/kg. The in vitro and in vivo antitumour activity of woodfordin C compared favorably with the topoisomerase- II inhibitors adriamycin and etoposide. Woodfordin C strongly inhibited intracellular DNA synthesis but not RNA and protein synthesis and showed remarkable activity against PC-l cells although only moderate activity against MKN45 and KB cells. Furthermore, woodfordin C had in vivo inhibitory activity against the growth of inoculated colon 38 cells, suggesting that the mechanism by which woodfordin C exhibits antitumour activity may be through inhibition of topoisomerase- II (Yoshida *et al.*, 1990).

Anti-Viral Activity

Methanolic and aqueous extracts of the flowers and leaves inhibited avian myeloblastosis virus reverse transcriptase (RT). No cytotoxicity was observed in the extracts even at concentrations where there was over 90% inhibition of RT activity. Gallic acid exerted anti-herpes simplex virus type 1 and anti-human immunodeficiency virus activity (Kratz *et al.*, 2008).

Immunomodulatory Activity

The contribution of *Woodfordia fruticosa* flowers to the immune-modulatory activity of the Ayurvedic drug Nimba arista was investigated and the preparation was found to inhibit both human complement activity and chemi-luminescence generated by zymosan stimulated human polymorpho-nuclear leucocytes. It was established that the increased biological activity was not due to microbial interference, but to immune-active constituents released from the *Woodfordia* flowers (Kroes *et al.*, 1993).

Pharmacognostical and Pharmacological Studies

In pharmacognostic study, *W. fruticosa* flowers showed the presence of unicellular tricomes, rosettes and cluster of calcium oxalate crystals; and anomocytic, actinocytic and anisocytic stomata. In physicochemical analysis, crude powder and methanol extract of wooodfordia fruticosa flowers were free from heavy metals. The highest extractive value was obtained from water and methanol. The solubility of the extract was maximum in polar solvents like DMF (Dimethylformamide), methanol and DMSO (Dimethyl sulfoxide); the extract was acidic in nature. In qualitative phytochemical analysis tannins and alkaloids were present in higher amount, while cardiac glycosides and steroids were totally absent. In quantitative analysis of phyto constitutents, total phenol content was higher than flavonoid content (Grover *et al.*, 2013). Hence, the determination of pharmacognostical and phyto-physicochemical profile of *W. fruticosa*. Flowers may be useful to supplement information in respect to its identification, authentication and standardization of herbal drugs.

Phytochemistry

Flowers are very rich in tannins, particularly hydrolysable tannins. Cyanidin-3.5-diglucoside, octacosanol, β-sitosterol and chrysophenol-8-O-β-D-glucopyranoside have also been isolated from flowers. Leaves contain ellagic acid, polystachoside, myricetin-3-galactoside and pelargonidin-3,5-diglucoside. Plant also contains woodfordins A, B, C, D, E and F, oenothein A and B, trimeric hydrolysable tannins, and tetrameric hydrolysable tannin (Ghani, 2003; Rastogi & Mehrotra, 1993).

Anti-Microbial Studies

Over the past 20 years, there has been an increased interest in the investigation of natural materials as a source of new antibacterial agents. Different extracts and essential oils from traditional medicinal plants have been tested to identify the source of therapeutic effects. As a result some natural products have been approved as new antibacterial drugs, but there is still an urgent need to identify novel substances that are active towards pathogens with high resistance. Natural products of higher plants may give a new source of antimicrobial agents with possibly novel mechanism of action. Contrary to synthetic drugs antimicrobials of plant origin are not associated with many side effects and have an enormous therapeutic potential to heal many infectious diseases.

The essential oil of *W. fruticosa* obtained by hydro-distillation was chemically characterized. The main components present in the essential oil of leaves are sesquiterpenoids (β-caryophyllene, γ- curcumene,

germacrene-D, β-selinene, elemol); and monoterpenoids (α-pinene, 2,6 dimethyl 1,3,5,7 octatetraene). The antibacterial activity of the essential oil was evaluated. It was found to be most active against *Pseudomonas aerogenosa* and *Bacillus subtilis* (Kaur *et al.*, 2010).

In Vitro Conservation Studies

Being highly medicinally important plant, *Woodfordia* is extensively exploited from its natural habitats. Very limited efforts have been made to conserve it either *in vivo* or *in vitro*. A comprehensive research (Balkwill, 1993) was undertaken on the generic limits, generic relationships, infra-generic classification (Balkwill & Balkwill, 1997) and species limits of the genus using morphological data (Makholela, 2000) and isozymes (Otto, 1994; Van *et al*., 2000). In most of the cases, in vitro regeneration results are not very significant. Various explants and media compositions are tested by various researchers.

According to Krishna *et al.*, (1994) a rapid propagation method comprising initiation of *in vitro* shoot tip culture from field-grown flowering plants and re-culture of the nodal segments of regenerated shoots in Schenk and Hildebrandt (1972) medium was developed for *Woodfordia fruticosa*. A medium supplement of 6-benzylaminopurine (0.2 $mg.l^{-1}$) induced high frequency (88%) development of axillary shoot buds (3.2) in 4–5 weeks (Krishnan and Seeni, 1994).

The rooted plantlets were transferred to a mixture of sand: soil and manure (1:1:1). The plants were watered and maintained under green house conditions for 8 weeks. The establishment rate was 89 per cent. Furthermore, SH medium is found to be the best basal medium for *in vitro* culture of *Thathiri* (*Woodfordia*). Shoot tips were the best explants for direct organogenesis and nodal segments were used as explants for indirect organogenesis. Multiple shoot induction was obtained when shoot tips were cultured in medium supplemented with BAP (0.5 mg/l) and (NAA 0.5 mg/l). Callus formation in the nodal explants of *Thathiri* was best in media with NAA 0.5 mg/l while callus regeneration was superior in media containing BAP 0.5 mg/l and NAA 0.5 mg/l. The best response in rooting was observed in media with IBA 0.2 mg/l (Gayathri *et al.*, 2008).

Mallesham *et al.*, (2012) reported efficient *in vitro* leaf regeneration in *Woodfordia fruticosa* from leaf segments derived from *in vitro*-grown plants. These were cultured on MS medium supplemented with Thidiazuron (2.27, 4.54, 6.81, and 9.08 μM) and 6-Benzyladenine (4.4, 8.90, 13.30, and 17.70 μM) alone or in combination with Indole-3-acetic acid (1.14 and 2.28 μM). Maximum number of shoots (15.6) with highest shoot length (2.90) were regenerated directly from the leaf explants with a combination of TDZ (4.54 μM) and IAA (2.28 μM), whereas the intervening callus phase was observed in the media supplemented with TDZ or BA alone. Islam *et al.*, (2009) also cultured shoot tips of *W. fruticosa* on MS medium supplemented with BAP alone and in combination with Kn or GA_3. Shoot proliferation and multiplication was observed from cultured shoot tips.

CONCLUSION

Medicinal plant is the most exclusive source of life saving drugs for majority of the world's population. They continue to be an important therapeutic aid for alleviating the aliments of human kinds. The search for defense mechanism, longevity and remedies to relieve pain and discomfort drove early man to explore these immediate natural surroundings. It led to the use of plants, animal products and minerals etc., and the development of a variety of therapeutic agents.

Today, there is a renewal interest in traditional medicine and an increasing demand for more drugs from plant source because green medicine is safe and more dependable then costly synthetic drug, many of which have adverse side effects.

The *W. fruticosa* was investigated from the ancient time for its phyto-chemical components and therapeutic values. *Woodfordia* is a long live shrub that has been used for centuries as a wound healer and for other medicinal purposes such as leprosy, burning sensation, skin diseases, diarrhea, dysentery, fever, headache, hemorrhoids, herpes, internal hemorrhage, leucorrhea, liver disorders, menorrhagia. The plant contains enormous phyto-chemical constituents of various properties such as antimicrobial action, anti cancer, antiviral etc. Hence most work could be done on the above plant to reveal the unknown mysteries which would help the need of the present pharmaceutical world.

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