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An ethnobotanical approach to control *Typha angustifolia*: A case study from Sri Lanka

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Abstract

Typha is a cosmopolitan genus that is infamous globally for having nuisance plant species. In Sri Lanka, *Typha angustifolia* is distributed in both coastal and inland wetlands, including lagoons, paddy fields, and small reservoirs. Pervasive effects of *Typha* include hindrance to fishing activities, navigation, agriculture, human health, and ecosystem functions, especially provision of habitats for wading birds in coastal lagoons. The present study attempted to formulate an ethnobotanical strategy to control the distribution of *Typha* in Embilikala lagoon in Bundala National Park in Hambantota District in Southern Sri Lanka. *T. angustifolia* edible plant parts were tested for antioxidant activity to promote it as a phytonutrient that boosts the overall health of the body. Hexane, methanol, and aqueous extracts of leaf, leaf base, rhizome, and pollen of *Typha* were analyzed with DPPH and ABTS bioassays for the presence of antioxidants. Leaves were tested for their quality as raw material for making paper using the mould and deckle pouring method and couching technique. Methanol was found to be superior to hexane and deionized water as a solvent for both the assays. Leaf base (99.5±5.3 μg/mL) and rhizome (65.3±0.6 μg/mL) of *T. angustifolia* showed higher radical scavenging activity, and in some instances, higher than that of standard butylated hydroxytoluene (BHT) (119.3±4.5 μg/mL), indicating their potential as sources of bioactive compounds that can reduce free radicals. Contents of heavy metals (Arsenic: 0.338±0.040, Cadmium: 0.628±0.146, Chromium: 63.641±1.30, Lead: 15.657±1.70 ppb) in the rhizomes were below the standard permissible level (100.0 ppb). Pulp made with *Typha* leaves alone and a mixture of *Typha* (95%) and wastepaper (5%) were used successfully to produce writable paper. Findings suggest that *T. angustifolia,* which is widely considered as an invasive plant and marginally utilized currently, has a promising potential to be exploited as food and raw material to introduce new livelihoods to rural communities. This ethnobotanical approach may potentially be used to control the distribution of *T. angustifolia* in wetlands where it is found in invasive proportions.

Keywords

Control, Invasive plants, Sri Lanka, *Typha angustifolia*

Introduction

Typha angustifolia, locally known as "Hambupan", is a cosmopolitan perennial aquatic herb found in wetland ecosystems. It is recorded to be present in at least 56 countries, out of which 15 countries, including Sri Lanka, reckon it as an invasive species (GBIF. Secretariat, 2021). *Typha* is listed as the sixth most invasive plant in Sri Lanka due to its large-scale distribution and threat to the existing ecosystems (MMD&E, 2015). Even though it is a common aquatic plant in dry zone wetlands in Sri Lanka, its' extensive distribution in the coastal lagoons, i.e., Embilikala and Malala lagoons in Bundala National Park, the first Ramsar wetland in the country, has drawn considerable scientific interest.

Prolific production of pollen grains (up to 420 million) and 20,000–700,000 small fruits per inflorescence that are wind-dispersed to more than 1 km distance (Stewart *et al*. 1997) supported by their long viability and rapid germination within 2–20 days qualify *Typha* as a highly invasive plant (van der Valk and Davis 1978). Anthropogenic hydrological changes and eutrophication augment *Typha*'s invasive capacity. Drainage from agricultural fields irrigated by Lunugamvehera reservoir which has been constructed by damming Kirindi Oya is discharged into Embilikala lagoon (4.3 km^2) since 1986 and drainage from Badagiriya reservoir is received by Malala lagoon in Bundala National Park. This has led to reduced water salinity and nutrient enrichment (Matsuno *et al*, 1998; CEA, 1993) in these saline coastal lagoons that have transformed the area into a favorable habitat for *Typha* to colonize.

Nuisance characteristics of *Typha* are not only restricted to invasion and reducing biodiversity, but also blocking canals and covering low-lying agricultural fields. Fishing in Embilikala lagoon is hampered due to the expansion of *Typha* beds that reduces open water surfaces to lay fishing nets. Besides, some villagers are affected by wind-blown *Typha* flowers during the blooming season, causing breathing problems, especially with children. It also has colonized the littoral zones of the lagoons, eliminating the resting and breeding grounds of migratory waterfowl (Suraweera & Dahanayaka, 2017). Dense monocultures of *T. angustifolia* also lowers the scenic beauty of the wetlands, that is reckoned to diminish their value as a tourist attraction.

Although *Typha* is not used in any form in Sri Lanka, young leaves, pollen and rhizomes are reported to be edible and can be used to produce fibre, biofuel, soil stabilizers, weaving and insulating material and paper pulp (Kumar *et al*. 2013). Comparison of nutrient contents in *Typha* with two other types of typical food, *Lasia spinosa* (Kohila) and potatoes, reveal that edible parts of *Typha*, particularly tender leaves and rhizomes, are substantially rich in dietary fiber. It also contains higher amounts of proteins than Kohila, another aquatic plant that contains high amounts of dietary fibre and is consumed as a vegetable. Besides, it contains high amounts of Vitamin C and B6, Na, Ca, and Mg. The absence of fat qualifies *Typha* as healthy food to control weight and obesity as well as non-communicable diseases such as hypertension and diabetes (Costa Fruet *et al*., 2012).

Deliberate water level changes, periodic burning, mechanical/ manual removal of plants and killing them with herbicides are the options available for controlling the distribution of *Typha*. Apart from irregular manual removal, marginal efforts are taken to control rapid distribution of *Typha* in Sri Lanka. We hypothesized that developing methods to utilize *Typha* plant parts as food and raw material to initiate cottage industries may provide a community-based strategy to control the invasive distribution of *T. angustifolia* in wetlands within and outside Bundala National Park. The present study therefore is aimed to investigate the potential of controlling *T. angustifolia* by enhancing their use as food and raw material for cottage industries that can open up new livelihoods for local communities.

Materials and methods

Study area

Bundala wetland complex, i.e., Bundala, Embilikala and Malala lagoons and associated land in Hambantota District, (6°12′50″N 81°13′30″E) on the Southern coast of Sri Lanka

constitute the Bundala National Park. Annual rainfall in this area is less than 1300 mm; therefore, these wetlands are located in the dry climatic zone.

Characterizing *T. angustifolia* as a food

Previous studies (Costa Fruet *et al*., 2012) had shown the nutritional value of *T. angustifolia* and this study focuses on the antioxidant activity of *Typha* and the heavy metal contamination levels that is essential to establish its' potential as a healthy food.

Antioxidant assessment

Hexane, methanol, and aqueous extracts of powdered samples of *Typha* leaves, leaf bases, rhizomes, and pollen (collected from Embilikala lagoon) were prepared, filtered, evaporated and stored at -20 °C for analysis of bioactive properties. Samples were assayed for their antioxidant activity using DPPH (Chatatikun and Chiabchalard, 2013) and ABTS (Piljac *et al*., 2009) assays with BHT and ascorbic acid as controls. Each sample was replicated three times. The absorbance was measured using a Micro-plate Reader (Biotek, USA). The percentage inhibition was calculated using the equation given below.

$$\text{Percentage Inhibition} = \left(\frac{\text{Absorbance of control} - \text{Absorbance of test sample}}{\text{Absorbance of control}}\right) \times 100\%$$

The inhibition rate was calculated and plotted against the test concentrations to obtain the half maximal inhibitory concentration (IC_{50}). The IC_{50} of the extracts were calculated using GraphPad Prism version 8.00 for Windows, GraphPad Software, La Jolla California USA.

Analysis of heavy metal content in edible parts of *T. angustifolia*

Rhizomes of *T. angustifolia* were collected from the Embilikala lagoon, cleaned, chopped into small pieces, and oven-dried at 40 °C for 72 hours. Two grams of powdered material were digested with concentrated nitric acid in a micro-digester and the digestion was topped up with de-ionized water up to 100 ml. An aliquot was then used from the stock digested solution for the analysis of arsenic (As), cadmium (Cd), lead (Pb) and chromium (Cr) using atomic absorption spectrophotometry. The digested samples were atomized in an atomic absorption unit (Shimadzu AA- 6300) and the absorption was measured at their characteristic wavelengths (As: 193.7 nm, Pb: 283.306 nm, Cd: 228.802 nm, Cr: 357.869 nm). Standard series of As, Pb, Cd and Cr solutions were also prepared. Concentrations of the heavy metals of *Typha* samples were calculated from the calibration curves ($R^2 > 0.99$) prepared from the absorbance values of standard series of respective cation solutions.

Paper making with *T. angustifolia* leaves

T. angustifolia plants were collected from Embilikala lagoon and leaf bases and rhizomes were removed after cleaning. The fresh leaves were cut into small pieces (3 x 5 cm) and dried under direct sunlight. One kg of dried leaves was boiled with 200 g of sodium carbonate (Na_2CO_3) and 10L of water at 100 °C for 5 hours. Then, the boiled samples were cleaned under flowing water to remove the chemicals and macerated using an

electric blender. Mould and deckle pouring method and couching techniques were used in the papermaking process (Hiebert, 2006).

Results and Discussion

DPPH radical scavenging activity

The IC_{50} values of extracts of leaf base and rhizome samples were lower than that of the standard BHT (119.3±4.5 µg/mL), nevertheless, the IC_{50} values of leaf and pollen samples were higher than that of BHT (Figure 1 and Table 1). Rhizomes of *T. angustifolia* showed the highest antioxidant activity. Since the crude samples of hexane and aqueous extracts did not dissolve in the DPPH solvent, they were not used for the assay.

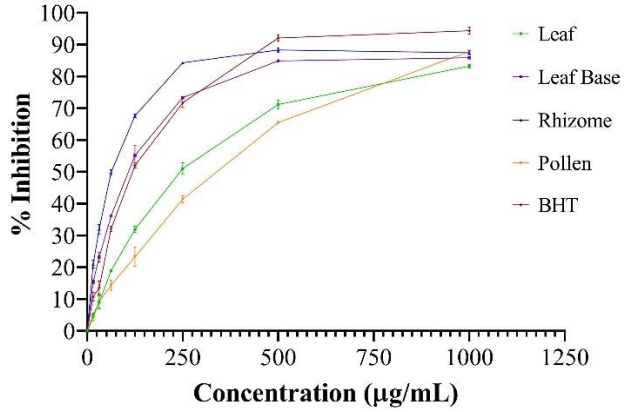

Figure 1. *Antioxidant activities of methanol extracts of leaf, leaf base, rhizome and pollen of T. angustifolia and standard synthetic antioxidant, BHT in the DPPH assay. Each value is expressed as mean ± SD (n=3)*

Table 1. *IC_{50} values of methanol extracts of T. angustifolia plant parts in DPPH assay*

Sample	IC_{50} (±SD µg/mL)
Leaf	246.3±12.5
Leaf base	99.5±5.3
Rhizome	65.3±0.6
Pollen	324.9±8.9
BHT	119.3±4.5

ABTS radical scavenging activity

Total antioxidant activities of hexane, methanol, and aqueous extracts of *Typha* plant parts (Figure 2 and Table 2) were determined using ABTS assay and compared with the positive controls, BHT and ascorbic acid (Figure 2).

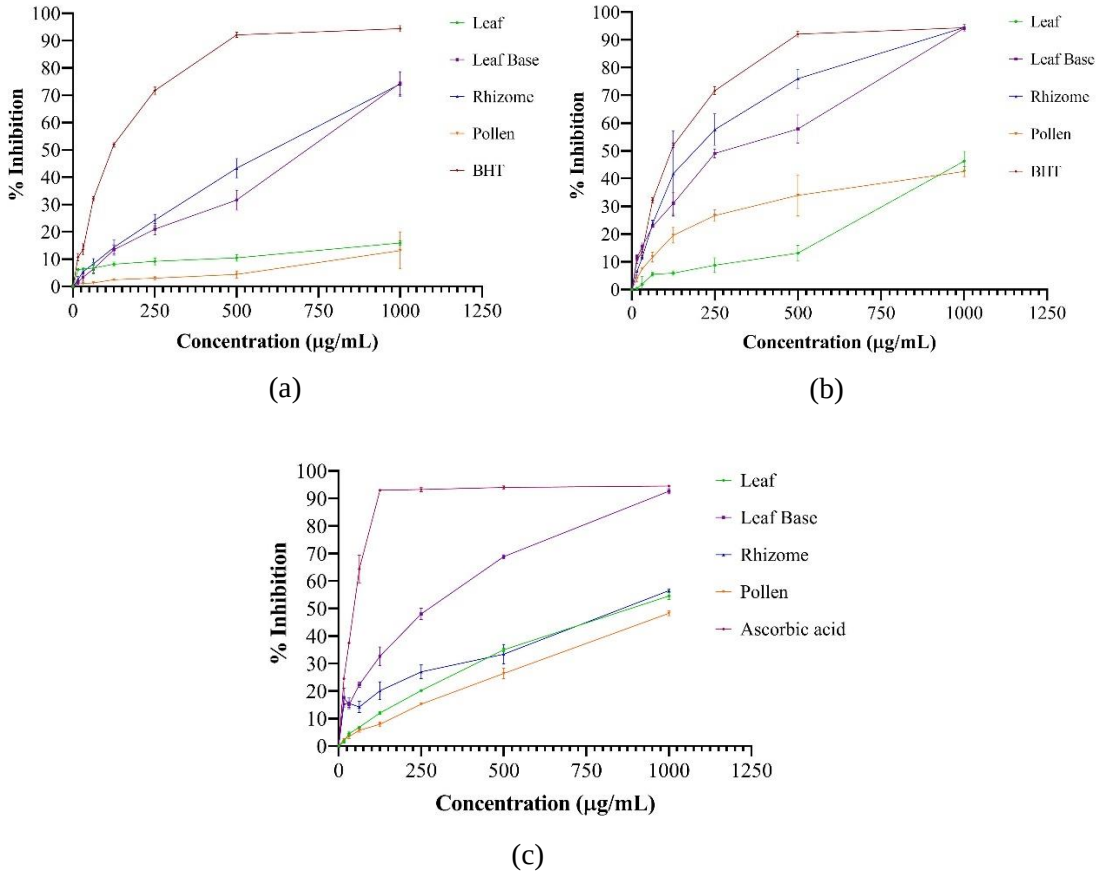

Figure 2. *Antioxidant activities of hexane (a), methanol (b) and aqueous (c) extracts of leaf, leaf base, rhizome, and pollen of T. angustifolia and standard synthetic antioxidant, BHT (a, b) and ascorbic acid (c) in the ABTS assay. Each value is expressed as mean ± SD (n=3)*

The half maximal inhibitory concentration value is the concentration of the sample that can scavenge 50% of free radicals. The IC_{50} value is inversely proportional to the free radical scavenging activity/ antioxidant property of the sample (Table 2).

Table 2*. IC_{50} values of hexane, methanol, and aqueous extracts of T. angustifolia plant parts in ABTS assay*

Sample	IC_{50} (±SD µg/mL)		
	Hexane	**Methanol**	**Aqueous**
Leaf	n.d.	n.d.	847.59±17.37
Leaf base	721.9±22.9	341.36±58.49	263.20±17.74
Rhizome	609.2±53.9	188.90±60.90	807.77±66.56
Pollen	n.d.	n.d.	n.d.
Control	119.3±4.5 (BHT)	119.3±4.5 (BHT)	44.90±1.49 (Ascorbic)

* n.d. - not detected

Results revealed that methanol is the superior solvent for the extraction purpose. All the extracts of plant parts showed higher IC_{50} values than that of positive controls. In comparison of the IC_{50} of the methanol extracts to BHT, the rhizome showed the highest antioxidant activity than other plant parts. Even though hexane extracts of *Typha* edible

parts (leaf base and rhizome) showed higher IC_{50} values than the BHT control, they showed comparable activity with other solvents. *Typha* rhizome showed the highest antioxidant activity than hexane extracts of other parts. All the aqueous extracts of *T. angustifolia* plant parts showed higher IC_{50} values than standard ascorbic acid (44.9±1.4 µg/mL). While *Typha* pollen did not show positive activity, rhizomes are relatively rich in antioxidants. Edible parts of *Typha* plant therefore were revealed to possess significant antioxidant activities that have a tremendous potential to be introduced as a low-cost nutrient source of food. As *Typha* is amply available in these areas, it can potentially be made into preserved foods such as pickles, rhizome floor, dried chips, snacks, and biscuits.

Heavy metals in the edible plant parts of *T. angustifolia*

Presence of As, Cd, Pb and Cr were detected in parts of *Typha* tested, their concentrations however were below the standard permissible levels (Table 3).

Table 3. *Heavy metal analysis of T. angustifolia and permissible levels for consumption*

Metal	Concentration (±SD ppb) resulted in this test	WHO/FAO CODEX standard (ppb)
Arsenic	0.338±0.040	100.0
Cadmium	0.628±0.146	3.0
Chromium	63.641±1.30	50.0
Lead	15.657±1.70	100.0

***T. angustifolia* as raw material for paper making**

Writable papers were made using pulp made only with *Typha* (100%) and (95%) *Typha* + (5%) wastepaper. These can be successfully produced in different thicknesses; as standard A4 papers (0.1 mm) and shipping boxes (4.8 mm). Further studies are recommended to expand the variety of papers with improved quality. *Typha* leaf material therefore could be used as raw material to initiate new livelihoods based on handmade paper and paper products for the rural communities in Hambantota District, where *T. angustifolia* is distributed in invasive proportions. Continuous use of *Typha* leaves may reduce its' rapid spread in the wetlands of Bundala National Park, the surrounding marshy lands and rice fields.

Conclusion

The findings of this study sufficiently substantiate the potential of edible parts of *Typha angustifolia* (especially the rhizome) to be used as an economical, nutritious source, provided they are harvested from unpolluted areas, particularly with heavy metals. Handmade paper production with *T. Angustifolia* leaves also show promising potential to be developed into a cottage industry in *Typha* infested areas. This ethnobotanical approach supported by institutional facilitation provides a pragmatic green method to control the invasive distribution of *T. angustifolia* in the wetlands of Bundala National Park and elsewhere.

Acknowledgement

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