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Comparative Analysis of Nutritional and Antimicrobial Activity of *Curcuma angustifolia* (Roxb.) and *Maranta arundinacea* (L.)

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ABSTRACT: *Curcuma angustifolia* (Roxb.) commonly called as Eastern arrowroot (*Zingiberaceae*) and *Maranta arundinacea* (L.) called as Western arrowroot (*Marantaceae*) are two starch yielding plants having medicinal and nutritive value. Despite many reports on their therapeutic and pharmacological potential both the plants are generally grown in wild with limited commercial cultivation. This study was done for comparative assessment of both the plants for phytochemical and antimicrobial evaluation sampled from the rural areas of Keonjhar and Sundergarh districts of Odisha. Results showed the presence of several bioactive constituents such as alkaloids, phenols, lipids, flavonoids, and steroids in both the plants except curcuminin *C. angustifolia*. Carbohydrate and protein content was comparatively higher in *M. arundinacea* than *C. angustifolia* at 20.59% and 0.98%. The methanol and acetone extracts also showed good antibacterial activity against both gram-positive and gram-negative bacteria. This study for the first time reports the characterization of the two arrowroot plants from the two districts of Odisha and aims to promote its wider use for its nutraceutical and therapeutic value to derive potential health benefits.

Keywords: *Curcuma angustifolia* (Roxb.); *Maranta arundinacea* (L.); Arrow root; Phytochemicals; Antimicrobial activity.

INTRODUCTION

Ethnomedicine based on traditional systems are playing important role in management of the health care needs for centuries in the developing countries. The Indian Systems of Medicine is recognized globally for its traditional systems of medicine (Ravishankar and Shukla 2007). The use of plants is mostly associated with the indigenous people for its long-term usage, affordability, safety and efficacy. Many studies have been directed against the pharmacological evaluation and characterization of the effective phytochemicals in plants. Present research trends are intended for exploration and application of the ethnomedicinal plants in drug discovery, development and production. Thus, ethnomedicinal plants with substantial role in healthcare management needs to be identified, characterized and scientifically validated. The phytochemicals like alkaloids, flavonoids, phenols, saponins and tannins etc. have been identified as the biologically active components in medicinal plants (Mujeeb *et al*., 2014).

Maranta arundinacea Linn. (Family: Marantaceae) and *Curcuma angustifolia* Roxb. (Family: Zingiberaceae) are rhizomatous annual herbs known for its medicinal uses since traditional times. The former is widely available in Khordha, Sundargarh districts of Odisha and the latter is cultivated in Keonjhar, Mayurbhanj districts of Odisha. These are herbaceous, perennial tropical plants found in Eastern, Central and Southern India. Rhizomes of the plants yield a white-starchy powder known as arrowroot have similar organoleptic and chemical characteristics and is also used as *Tugaksheeree in ayurvedic formulations* as an important ingredient (Rajashekhara *et al*., 2013).

Both plants have medicinal benefits that are used to treat a range of ailments, such as menstrual problems, bladder issues, cough, diarrhoea, fever, dysentery, gastroenteritis, anaemia, jaundice, asthma, TB, excessive thirst, liver problems, blood disorders, kidney stones, leukoderma and leprosy (Sharma *et al*., 2019). *C. angustifolia* is effective at treating oedema because of its diuretic properties. *C. angustifolia* tuber powder is also used to treat gastric ulcers, colitis, intestinal inflammation and act as carminative, astringent, and cardiotonic (Ray *et al*., 2011). Besides many studies have been made to establish its antimicrobial, antioxidant, antiproliferative, antidiabetic, and anticancer properties. Effect of both the starches on Amlapitta was investigated which showed that both drugs were equally effective (Rajashekhara and Sharma 2010).

Curcuma plants have a camphoraceous fragrance and numerous phytochemicals such as phenolics, flavonoids, and many antioxidant enzymes, and thus different species of this genus are well known because of their multiple uses in medicine, cosmetic, dye, flavouring agent, and nutraceuticals (Krishnarajm *et al*., 2010, Debbarma *et al*., 2022). Different aqueous, methanol, ethanol, and hexane extract of leaf and rhizome of *M. arundinacea* and *C. angustifolia* have showed the presence of phenols, flavonoids, tannins, alkaloids, steroids, terpenoids, and glycosides in ethanolic extract (Amrutha and Suganthi 2017; Samal *et al*., 2018; Nishaa *et al*., 2013; Devi *et al*., 2021; Rajkumari and Sanatombi 2017). Besides, *C. angustifolia* is a great source of vitamins, minerals, lipids, proteins and, carbohydrates (Chandel *et al*., 2018).

A study made on crude saponin extracted from *C. angustifolia* rhizome through cold-ethanol extraction method was found to have significant antioxidant and anticancer activity against MCF-7 cell line (Brindhadevi *et al*., 2022) while methanol extract exhibited antioxidant and hepatoprotective effects presumed to be mediated by the constituents such as α-tocopherol, phytol, squalene and eugenol as investigated under *in vitro* and *in vivo* conditions (Jena *et al*., 2019). The leaves of *C. angustifolia* subjected to GC-MS and GC-TOFMS analysis in different studies for essential oil extraction detected compounds like eucalyptol, curzerenone, α-lemenone, longiverbenone, and α-curcumene were found to exhibit antioxidant and antibacterial activity against bacterial and fungal pathogens (Albaqami *et al*., 2022; Jena *et al*., 2020).

The pharmacognostic potential of arrow root of *M. arundinacea* was investigated in terms of gastro-protection by determining the ulcer index for 6 groups of rats was found to have anti-ulcerative potential (Damarwati *et al*., 2020). Methanolic extract of *M. arundinacea* leaves also showed significant antidiarrheal activity on rats and brine shrimps (Rahman *et al*., 2015) while ethanolic extract was effective against oxidative stress (Ramadhani *et al*., 2017). Evaluation of *M. arundinacea* residue showed that rhizome residue was found to be rich in tannin content compared to other plant parts like leaves and stems which had high content of total N, total K, and C/N ratio, indicating its suitability for recycling as an organic constituent in fertilizer (Lamkeng, *et al*., 2022).

Recent studies were also implicated on synthesis of zinc oxide nanoparticles using *M. arundinacea* root extract showed enhanced antibacterial activity on oral pathogens (Deepika *et al*., 2020) while the leaf and rhizome extracts showed good vibriocidal activity (Samal *et al*., 2018). Growth inhibitory effects on various pathogens with methanol and chloroform rhizome extracts showed effective antibacterial properties, while in comparison the chloroform extract of *C. angustifolia* exhibited the highest inhibitory activity (Mounyr *et al*., 2016; Muhammad *et al*., 2020; Yadav and Kaliyaperumal 2021).

C. angustifolia and *M. arundinacea* though found in some geographical locations in India but not substantial investigation has been made on the physicochemical, phytochemical and antimicrobial properties from Odisha. The plant characteristics like the physicochemical parameters and phytochemical composition in different solvent scan also largely vary on the basis of biotic and abiotic factors surrounding the plants. This study thus for the first time was done for comparative assessment of both the starch producing plants *C. angustifolia* and *M. arundinacea* sourced from the two districts of Odisha.

MATERIALS AND METHODS

Collection and preparation of plant material. The fresh tubers of *C. angustifolia* and *M. arundinacea* were collected during the month of September in 2017, collected from Ghatagaon in Keonjhar District, Odisha and Nuagaon in Sundargarh District, Odisha respectively.

Preparation of plant material and extract. The collected tuber samples of *C. angustifolia* and *M. arundinacea* were processed for extraction. The dried material was mechanically grounded into powder and stored in airtight containers and the fresh samples were stored in freezer at 4°C for further use. The powdered materials were processed for maceration and soxhlation for the preparation of methanol, acetone and aqueous extracts and tested for both phytochemical and antimicrobial activities.

Determination of physicochemical characteristics. The fresh rhizome samples were subjected to determination of physicochemical parameters such as yield of crude extract (Salam*et al*., 2019), loss on drying/moisture content (Gharezi *et al*., 2012; Kativar *et al*., 2011) water-soluble extractive and alcohol soluble extractive (Kativar *et al*., 2011; Momin *et al*., 2012), pH1% w/v solution, pH 10% w/v solution and total ash value (AOAC).

Detection of phytochemicals. The preliminary phytochemical screening of methanol, acetone and aqueous extracts of *C. angustifolia* and *M. arundinacea* tuber samples were carried to detect the presence of different phytochemical constituents such as alkaloids, tannins, flavonoids, proteins, quinones, oxalates, sterols, saponins, glycosides, phenols, lipids and amino acids (Harborne 1998).

Nutritive analysis. Nutritive analysis of *C. angustifolia* and *M. arundinacea* tubers was done to estimate the carbohydrate (Dubois *et al*., 1956) and protein content (Lowry *et al*., 1951).

Antimicrobial activity. Gram-positive bacteria *Streptococcus mutans* (MTCC 497), *Streptococcus pyogenes* (MTCC 1926) and Gram-negative *Salmonella typhi* (MTCC 1252), *Shigella flexneri* (MTCC 1457) and *Vibrio cholerae*(MTCC 3906) were tested for antibacterial susceptibility by agar well diffusion assay (Allen *et al*., 1991). Stock solution of rhizome extract samples were prepared in 100% DMSO with concentrations of 50 mg/ml, 100 mg/ml, 150 mg/ml, 200 mg/ml and observed for antimicrobial activity. This experiment was done in triplicates and the diameter of zone of inhibition (in mm) was taken and the mean ± SD values was recorded.

RESULTS AND DISCUSSION

Physicochemical characteristic of *C. angustifolia* and *M. arundinacea* tubers. Physicochemical analysis showed that the water-soluble extractive value of *M. arundinacea* is higher than *C. angustifolia* tubers. The percentage loss on drying of sample, total ash content and pH 1% and pH 10% was also found to be higher in *M. arundinacea* (Table 1). The physicochemical parameters of the rhizome and starch from *C. angustifolia* and *M. arundinacea* obtained from Madhya Pradesh and Karnataka was investigated by Rajashekhara and found that comparatively both the plants showed variation but in our study *M. arundinacea* showed higher values for all the parameters (Rajashekhara *et al.*, 2010). This study showed the percentage of total ash that is the amount of minerals present was higher in *M. arundinacea* indicating that the mineral content in plant ash is variable and depends upon the geographic location. The extractive value was also high in *M. arundinacea* probably because of more soluble matter in the plant ash.

A study made on physicochemical characterization of the rhizome powder of *C. angustifolia* grown in Maharashtra, India was found to have 2.50% total ash, 0.50% acid insoluble ash, 2.0% acid soluble ash, 0.50% water insoluble ash, 2.0% water soluble ash, and 19.04% loss on drying. Also, the rhizomes were found to be high in protein, carbohydrates, and minerals (Jadhao *et al*., 2017). The physicochemical properties of dried rhizome powder of *M. arundinacea* grown in Kerela, India were investigated. The moisture content of the sample was determined to be 6.6%. The ash level was found to be 2.5%, reflects the amount of inorganic content present in the sample while the water-soluble extractive was 25.1% and alcohol-soluble extractive was 1.8% (Shintu *et al*., 2015). The results from our study were similar with the physicochemical parameters established in previous studies with small variations probably because of the differences in geographic location.

Yield of crude extract of *C. angustifolia* and *M. arundinacea* rhizome. Crude extract analysis showed aqueous extract of *M. arundinacea* having highest yield of 65.39 % followed by methanol extract at 11.96 % when compared to *C. angustifolia* (Table 2).

Comparative phytochemical screening of *C. angustifolia* and *M. arundinacea* rhizome. Phytochemical screening of aqueous, methanol, and acetone tuber extracts revealed the presence of different phytocompounds. All the three extracts of both the plants showed the presence of phenols and alkaloids. While flavonoids, tannins and saponins were differentially detected in various extracts (Table 3).

Plants produce aromatic chemicals or secondary metabolites that plays an important role in the defense mechanism against predation by many microorganisms, insects and herbivores (Arora, 2013). Plant alkaloids and their synthetic derivates have a great potential due to their analgesic, antispasmodic, and antibacterial properties and thus are widely utilised in medicine around the world (Stary, 1996; Edeoga *et al*., 2014). Flavonoids and tannins are important phytochemicals with significant antioxidant and free radical scavenger activity (Soni and Sosa 2013). The antioxidative characteristic of tannins is critical in preventing cellular oxidative damage, including lipid peroxidation, may be related to their anticarciogenic and antimutagenic potential. Tannins have also been reported to suppress the growth of many fungi, yeasts, bacteria, and viruses (Macakova *et al*., 2014). Flavonoids have been reported to possess a wide spectrum of health benefits in humans such as anti-inflammatory, anti-cancer, anti-aging, cardio-protective, neuroprotective, immunomodulatory, anti-diabetic, antibacterial, antiparasitic, and antiviral capabilities (Saini *et al*., 2017; Juca *et al*., 2020; Fraga *et al*., 2019). Saponins are known to induce a cytotoxic effect since ancient times and thus have a significant use in medicine. Some of the actions of saponin include the precipitation of red blood cells, coagulation, and anti-inflammatory effects (He *et al*., 2011). Qualitative test showed absence of terpenoids in aqueous extract of *C. angustifolia* but found in all other extracts of both the plants. Terpenes are constituted of hydrocarbons whereas terpenoids are modified class of terpenes with various functional groups and oxidised methyl groups moved or deleted at various places and have a wide range of biological activities including anticancer, antimicrobial, anti-inflammatory, antioxidant, and antiallergic (Masyita *et al*., 2022). Presence of quinones and curcumin was detected in all extracts of *C. angustifolia.* Quinones and curcumin were only present in the *C. angustifolia* extract as a whole. Quinones made up of different chemical constituents, have been reported to possess both in vivo and in vitro anticancer and broad-spectrum antibacterial effects (Goel *et al*., 2020). Curcumin is being studied extensively for its anti-inflammatory, anti-cancer, anti-metabolic syndrome, neuroprotective, and antibacterial effects (Hewlings *et al*., 2017). Both steroids with glycosides were found in all the extracts of *M. arundinacea* and only in aqueous extract of *C. angustifolia.* Glycosides is responsible for the antidiarrheal activity by inhibiting the release of autocoids and prostaglandins. Steroids is responsible for the antidiarrheal, anticancer, anthelmintic by inhibiting the histamine release in vitro conditions (Tiwari *et al*., 2011).

Nutritive analysis. The carbohydrate and protein content of *M. arundinacea* was found to be comparatively higher than *C. angustifolia* (Table 4).

Antimicrobial activities. Results for antibacterial activities of the tuber extracts against the five gastrointestinal and skin pathogens showed that the tuber extracts of *C. angustifolia* and *M. arundinacea* had a significant growth inhibitory activity against all the pathogenic microbes (Fig. 1-5). The acetone and methanol extract of *C. angustifolia and M. arundinacea* showed antibacterial efficacy for the test bacteria *S. mutans, S. pyogenes*, *S. typhi, S. flexneri* and *V. cholerae*. With increasing concentrations of extract (50-200 mg/ml) the growth inhibitory activity was found to be increased. Comparatively *M. arundinacea* was found to be more effective at each of the concentrations.

A previous study made on antibacterial activity by 96 well-plate method for methanolic extract of *C. angustifolia* rhizome against *P. aeruginosa, S. typhi, E. coli, S. arueus*, and *S. flexneri* showed varying degree of growth inhibitory activity in the range of 2 µl-8 µl of the methanolic extract attributed to a range of secondary metabolites found in the plant, including glycosides, flavonoids, tannins, and phytosterols (Jadhao *et al*., 2017). The antibacterial activity was also determined for aqueous and methanol extracts of *C. angustifolia* at sample concentration of 100 mg/ml against eight pathogenic bacteria causing diarrheal diseases by agar well diffusion method. The most susceptible strains were *S. typhi, E. coli*, and *V. cholerae*. *S. dysenteriae* demonstrated the least activity compared to other test strains (Panda *et al*., 2012). Besides the efficacy of the *M. arundinacea* and *C. angustifolia* was also studied against Methicillin-Resistant *Staphylococcus aureus* (MRSA) and fungal pathogens like *Aspergillus niger, Mucor indicus,* and *Rhizopus stolonifer* respectively (Balouiri *et al*., 2016; Syahputra *et al*., 2020; Viji and Wilson 2017).

This investigation thus indicates that the rhizome extracts have the potential for treatment of diarrheal diseases caused by gastrointestinal pathogens. The plant extracts carrying diverse phytoconstituents exhibit antimicrobial potential via diverse mode of actions and thus needs to be further explored (Hemeg *et al*., 2020).

Table 1: Physicochemical characteristics of *C. angustifolia* and *M. arundinacea* tubers.

Physicochemical Parameters	*C. angustifolia*	*M. arundinacea*
Water soluble extractive	18.46%	23.71%
Alcohol soluble extractive	0.60%	1.01%
Loss on drying	2.29%	6.84%
Total ash	1.51%	2.69%
pH1% w/v solution	7.32	7.51
pH10% w/v solution	8.57	8.63

Table 2: Yield of *C. angustifolia* and *M. arundinacea* rhizome.

Extraction method	Treatment	*C. angustifolia* Yield (%)	*M. arundinacea* Yield (%)
Soxhlation	Aqueous	28%	65.39%
	Methanol	8.70%	11.96%
	Acetone	1.61	6.23

Table 3: Phytochemical screening of *C. angustifolia* (C.A.) rhizome and *M. arundinacea* (M.A.) rhizome.

Phytochemicals	Acetone extract		Methanol extract		Aqueous extract	
	C. A	M.A	C.A	M.A	C. A	M.A
Alkaloids	-	+	-	-	+	+
Flavonoids	+	+	+	-	+	+
Phenols	+	+	+	+	+	+
Saponin	-	-	-	-	+	+
Tannins	+	-	+	-	+	+
Terpenoids	+	-	+	+	-	+
Quinones	+	-	+	-	+	-
Oxalates	+	-	+	-	-	-
Steroid	-	-	-	+	+	+
Glycosides	+	+	+	+	+	+
Carbohydrates	+	+	+	+	+	+
Proteins	+	+	+	+	+	+
Lipids	+	+	+	+	+	+
Amino acids	+	+	+	+	+	+
Curcumin	+	-	+	-	+	-

Table 4: Nutritional content of *C. angustifolia* and *M. arundinacea* rhizome.

Nutritional Parameters	*C. angustifolia*	*M. arundinacea*
Carbohydrate	15.29 mg/gm	20.59 mg/gm
Protein	0. 81 mg/gm	0.98 mg/gm

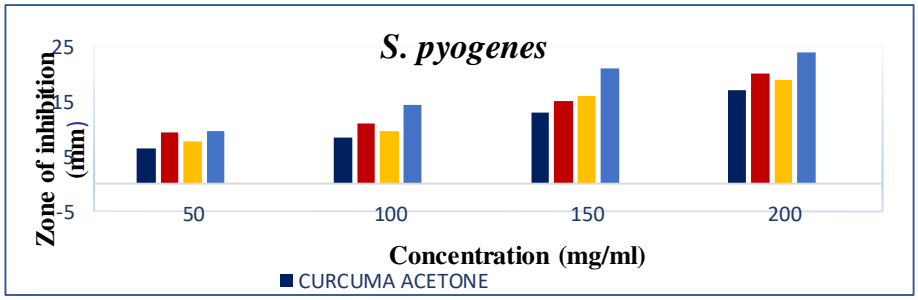

Fig. 1. Antimicrobial activity of acetone and methanol extract of *C. angustifolia* and *M. arundinacea* on *S. pyogenes.*

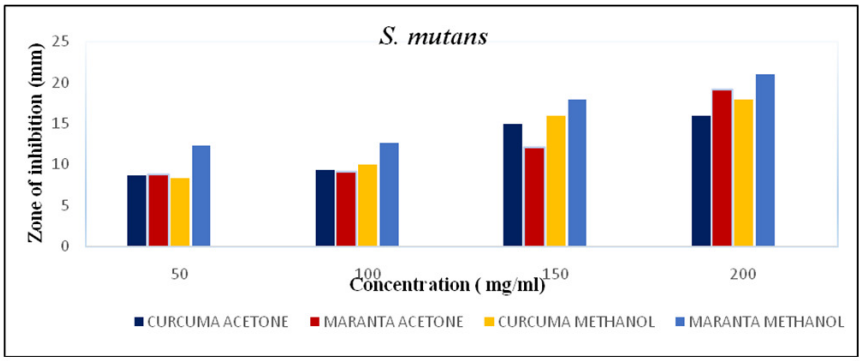

Fig. 2. Antimicrobial activity of acetone and methanol extract of *C. angustifolia* and *M. arundinacea* on *S. mutans.*

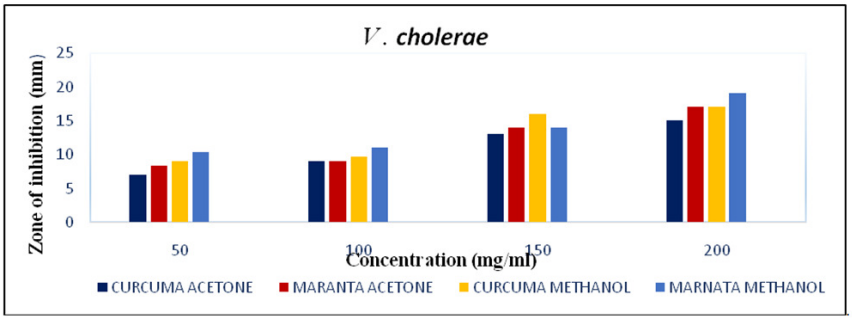

Fig. 3. Antimicrobial activity of acetone and methanol extract of *C. angustifolia* and *M. arundinacea* on *V. cholera.*

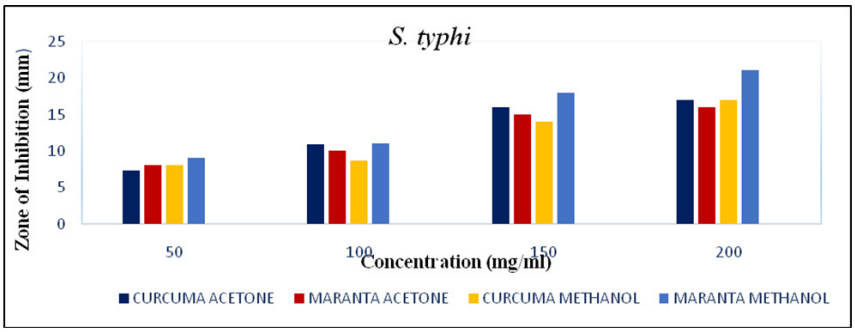

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Fig. 4. Antimicrobial activity of acetone and methanol extract of *C. angustifolia* and *M. arundinacea* on *S. typhi.*

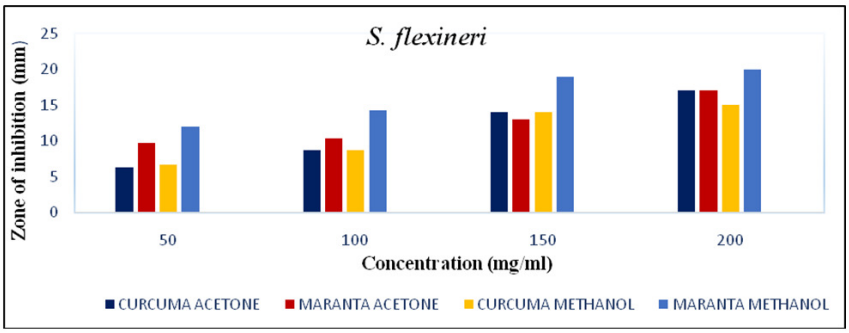

Fig. 5. Antimicrobial activity of acetone and methanol extract of *C. angustifolia* and *M. arundinacea* on *S. flexneri.*

CONCLUSIONS

The present study has investigated the phytochemical constituents, nutritional content, and antimicrobial activity of *C. angustifolia* and *M. arundinacea* rhizomes grown in the unexplored Sundergarh and Keonjhar districts of Odisha. Both the plants showed the presence of various phytochemicals like flavonoids, phenols, tannins, terpenoids, quinones, saponin, glycosides, lipids, steroids, amino acids, whereas curcumin and oxalates were present only in *C. angustifolia* which indicates that the plants are an effective source of therapeutic drugs. Aqueous extraction was found to be the most favourable method for extracting most of the classes of phytochemical compounds amongst all the solvents tested. Further characterization of the bioactive compounds can lead to

identification of more antimicrobial compounds and help in combating the challenges of antimicrobial resistance. Additionally, the rhizomes can serve as a good source of carbohydrates and proteins and fulfil the nutritional requirements of people for all age groups.

FUTURE SCOPE

Food and medicine are the major challenges imposed for developing countries around the world. Scientific investigations are needed to be able to come up with appropriate answers to resolve these problems. Researchers are extensively working on ethnomedicinal plants to derive the important bioactives having utility and efficacy in food and medication. *C. angustifolia* and *M. arundinacea* are one such lesser explored but having large pharmacological and nutritional values. These plants need more attention and pharmacological investigation to implement its efficacy in various ailments.

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Conflict of Interest. None.

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