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A comprehensive review on phytochemistry and pharmaceutical applications of *Maranta arundinacea* L.

[a]B. Aswini, [a]P. Sivagurunathan, [a]S. Sowndarya, [a]V. Sumathi, [b]L. Vennila, [c]S. Vivekanandhan and [a*]C. Uma

[a]Department of Microbiology, Faculty of Science,
Annamalai University, Chidambaram-608002 (India)
[b]Department of Biochemistry and Biotechnology, Faculty of Science,
Annamalai University, Chidambaram-608002 (India)
[c]Department of Microbiology, K.S.R. College of
Arts and Science For Women, Tiruchengode, Tamil Nadu-637215 (India)

Abstract

The review paper focuses on current and updated knowledge till 2021, of the precious plant *Maranta arundinacea* L. which is grown widely across the globe.

It is a neglected plant that was used mainly as fodder and has not been used to its full potential, it has recently gained popularity because of its various phytochemical applications. The plant extract from its rhizome can be used as an alternative for starch, baby weaning food and patients with intestinal disorders due to its increased digestibility and pharmaceutical industry because of its potent phytochemical compounds. The review focusses on the characterization, phytochemical analysis, pharmacological importance of *Maranta arundinacea*. The presence of phenols, tannins, sterols, flavonoids *etc.* make the plant a medically important. The review focusses on medical application of plant rhizome, leaves and starch isolated. It highlights the characterization which will help in the authentication of plant. The review brings about the different researches done on the plant mainly their pharmaceutical applications which will bring light to its characterization and ethnopharmacological importance of the plant species maranta which was done in many localized areas with different parameters.

The review gives concrete evidence of the importance of plant and bring the plant in the limelight. The characterization helps in

*Address correspondence to this author at the Department of Microbiology, Faculty of Science, Annamalai University, P.O. Pin: 608002, Chidambaram, India;
Tel/Fax: +91-9942370082, +914144 238080; E-mails: umasaravanan1@gmail.com

authorization of plant and adulteration with other plant, the phytochemical analysis gives the compounds present in the plant and the reason for its drug effectiveness. This study will help in making common ground for further analysis and open up the scope for future formulations in the pharmaceutical industry.

Key words : *Maranta arundinacea*, Arrowroot, Phytochemical analysis, Physicochemical analysis, Pharmacognostic standardization, pharmacological analysis

The earth is abundant with a wide diversity of flora. They are exploited as food, fuel, and medicines. The usage of plants for healing was well accepted from the traditional period, and because of that, there is great demand for medicines and drugs from plants and their derivatives[15]. There is continuous exploration and experimentation done on plant parts. Since mankind, plants were used to treat common infectious diseases and many of these plants are still used as a part of the treatment of various maladies[45]. Of the whole population of the world, 60-80% among them still depend on conventional medicines for the healing of familiar diseases[44].

Natural antioxidants are normally procured from plant sources and their efficiency relay on the variety, extraction, or processing method of floral species and the habitat in which they grow. Their activity varies depending on the source material, the presence of synergists, antagonists, and the matrix used. The study of these medicinal plants is important to encourage the utilization of herbal medicine and to find out their potential as a source of new medicine[53]. Today, herbal medicine is one of the essential areas of folk medicine, and research into herbal medicines has become increasingly popular due to their therapeutic importance. The tendency is increasing to compare plant-specific phytochemical components with their pharmaceutical effects[17]. Because of their efficacy in pharmacological activities, low toxicity, and their economic importance the curative properties of plants are being examined in the light of structured developments throughout the world[55]. Plants contain various biological compounds, including antioxidants such as phenol, flavonoids, steroids, alkaloids, carotenoids, and glucosinolates[52].

Modified roots occupy an important place in the food security of developing countries because of their high calorific value and their carbohydrate contents. Very few of those are cultivated, but most of the plants are grown wild or neglected[61]. The communities in developing countries exploit specific locally available traditional food resources which make the foundation of staple food. Traditional and indigenous foods are less deleterious to the environment and address cultural needs and preserve the cultural heritage of local communities. Underutilized minor crop species are still a major source of nutrition for many indigenous communities. The food and nutrition security of poor and marginal rural people is possible through the conservation and promotion

of indigenous crop species that contain high nutrition[50].

India is known for its varied geographical diversity which has a great influence on the formation of its diverse habitats and vegetation types. The traditional healing system was always an important part of maintaining the physical and psychological well being of the majority of tribal people in India. India carries rich genetic diversity in tropical root and tuber crops, mainly aroids, yams, and many minor tuber crops[32]. Various nutriment tuber species are suggested in the preparation of stimulants, tonics, demulcent, and expectorants. These effects need to be documented to validate, quantify and spread the knowledge. From antient times traditional healing plays a major role in the maintanance of physical and psycological well being of the major share of the tribal through out the world. But now because of their pharmacological properties and based on the concept that bio remedy is unharmed; the usage of herbal medicine is thriving[13,21,56].

Various parameters for quality control of herbs are provided by World Health Organization (WHO)[35]. The identification of plant chemicals and plant standardization will be the basis for identifying and ensuring the safety of plant medicines. The pharmacognostic assessment, primary phytochemical screening, and physicochemical examination of the plant will aid in the of plant resources[56].

Arrowroot :

Maranta arundinacea (Arrowroot) is a plant that was exploited in ancient times for fuel and food before but it is forgotten in time as new plants were introduced. It is a herbaceous, perennial tropical plant belonging to the family *Marantaceae*. The medicinal herb is used since the traditional period for its starch[56]. It is gluten-free hence easily digestible starch and is used for various stomach and urinary-related medical conditions. And due to its rich starch, it is being used in food industries also. The arrowroot plant is identified to possess phytochemicals which make them medically important in exhibiting antidiarrheal, probiotic, antiulcer, antioxidant, antimicrobial, vibriocidal, and immunostimulatory effects[15].

In recent decades, the volume of information generated for amylaceous crops has been significant, especially relating to the properties of their starch. However, little has been advanced in the knowledge of general aspects of these crops, such as the factors that determine final product quality. Although many studies are available on crop cultivation and arrowroot starch properties, several aspects of the medicinal properties of this crop still need to be studied to enhance its value and to understand the full potential of this plant[12].

The present study aims to review its composition, characterization, pharmacognostic standardization preliminary phytochemical screening of rhizome of *Maranta arundinacea* L., and its ethnopharmacological activities which will bring light to the importance of the forgotten plant *Maranta arundinacea* L. This review helps to bring an overview of the scientific analysis of the plant and helps to highlight its properties and explore its diverse medicinal values.

Common names :

Scientific name- *Maranta arundinacea* Linn.
English- Arrow root
Sanskrit- Tavaksri
Hindi- Tikhor
Bengali- Ararut
Malayalam- Kochikuva, Kuva
Tamil- Kuvai
Kannada- Kavihettu

Distribution :

Arrowroot requires a good water supply, evenly distributed during growth. It does better in deep, friable, well-drained, and slightly acid loam soils. Few of the variety grows well on light soils[25]. *Maranta* is indigenous to tropical America, where it is known to Indians in pre-Columbian days. Later, its cultivation spread to India, Srilanka, Indonesia and the Philippines. The crop is native to northern South America and possibly the West Indies. In India, it is grown in North-Eastern states, West Bengal, Assam and in South India, mostly in Kerala as a rainfed crop[31].

Traditional uses :

Very little information is available on the medicinal properties and application of arrowroot or *Maranta*[31]. Arrowroot starch is one of the purest forms of natural carbohydrate and has maximum viscosity. Arrowroot is generally used in powder form; it is a starch and its underground stem and root are used for medicinal purposes.

Rhizomes are preliminary used in the treatment of diarrhoea and UTI (Urinary tract infection)[35]. It helps in maintaining blood pressure and it is highly effective for improving cardiovascular health and for people suffering from hypertension to improve their sleep cycle due to its high magnesium content[9]. The starch is processed into jelly form and can be used as weaning food for infants. Mashed rhizomes are applied as a topical applicant for wounds from poisoned arrows, scorpion, and black spider bites and to arrest gangrene. Freshly squeezed juice mixed with water is used as an antidote internally for vegetable poisons[29].

Taxonomy :

The family *Marantaceae* includes 31 genera and 530 species, with numerous species that present potential or actual commercial value. The family is found in all tropical regions of the world on the American, African, and Asian continents (80.0, 9.0, and 11%, respectively). In Brazil, 12 genera and 150 species are found, and nine genera are found in the Amazon region[8].

According to the *Inventaire National du Patrimoine Naturel* (2018) and Tropicos (2019), the current botanical classification of the species is:

Kingdom: Plantae (Haeckel, 1866)
Subkingdom: Viridaeplantae (Cavalier-Smith, 1981)
Infrakingdom: Streptophyta (John, Williamson & Guiry, 2011)
Class: Equisetopsida (C. Agardh, 1825)
Division: Tracheophyta (Sinnott ex Cavalier-Smith, 1998)
Superdivision: Spermatophyta (Willk, 1854)
Subclass: Magnoliidae (Novák ex Takht, 1967)

Superorder: Lilianae (Takht., 1967)
Order: Zimgiberales (Griseb, 1854)
Family: *Maranta*ceae (R.Br., 1814)
Genus: *Maranta* (Plum. ex L.)
Species: *Maranta arundinacea* (L., 1753)

Pharmacognostic standardisation :

Pharmacognosy is the study of medicines derived mainly from plant sources which deal with standardization, authentication, and expanding the knowledge of formulated drugs which are produced by nature. Most of the research in pharmacognosy has been done in identifying controversial species of plants, and authentication of commonly used traditional medicinal plants through morphological, phytochemical, and physicochemical analysis. The pharmacognostic study ensures the plant's identity and establishes standardized parameters that help prevent fraud and prevent theft. These studies will contribute to the identification of the plant species and ensure the reproducibility of the plant products, which leads to the safety and effectiveness of naturally produced products[7].

Organoleptic characters :

Organoleptic evaluation can be done using sense organs, which provide the simplest as well as quickest means to establish the identity and purity to ensure the quality of a particular drug[7]. The parameters of *Maranta arundinacea* were recorded by Rajashekhara and peers[44] which are given in Table-1.

Macroscopic study of the arrowroot plant:

Maranta is a perennial herbaceous plant with 1 to 2 meters of height, with an elevated, smooth, distinct branch, flowering from a meaty root with fusiform modifications. Stems are thin, leaf blades are lanceolate, attenuate, acuminate, 10 to 20 centimetres long, having thin petiole, green, and rounded at the base. The inflorescence is terminal, lax, divaricate, and scanty-flowered. Flowers are white, and about 2 centimetres long[65].

Microscopic Study of arrowroot plant leaf and rhizome :

The microscopic study is the anatomical study which is done by taking an appropriate section of the plant parts under study. Detailed T.S. of rhizome of *Maranta arundinacea* showed epidermal cells followed by an array of parenchymatous cells. These parenchymatous cells were filled with oval-shaped starch granules towards the centre. Vascular bundles) were scattered in paren-chymatous ground tissue. Epidermal peeling of the leaf of *Maranta arundinacea* showed variously

Table-1. Organoleptic characterization of *Maranta arundinacea*

Sl. no.	Parameters	Rhizome	Starch	Reference
1.	Texture	Fibery powder	Fine smooth	(Rajashekhara,
2.	Colour	Creamy white	White	*et al.*,[44])
3.	Taste	Mealy sweetish	Starchy sweetish	
4.	Odour	Characteristic	Odourless	

shaped epidermal cells with a diacritic type of stomata. The epidermal cells also hold certain trichomes[56].

Powder microscopic characters :

Powder analysis has revealed fragments of vessels with spiral thickness, xylem fibres, starch and calcium oxide crystals. The characters play an important role in Ayurveda in identifying, characterization, and authenticity of plant materials in the process of drug standardization[60].

Characterization of Arrowroot

Physicochemical parameters of Maranta plant :

The characterization of arrowroot is normally influenced by the agronomic conditions, breed, and geographical areas which in turn affect the chemical composition and colour of arrowroot. But their pasting properties, spectral analysis, morphological analysis and crystallinity are found to be identical[57]. Tribal starchy tubers and rhizomes have the advantage to be used as the sources of starch and flours and have the potential to replace commercial starches in various fields like industrial, food, and medicinal applications[3]. Starch extracted from Marantha is considered a non-conventional raw material. It has received less attention due to the scanty knowledge of its characteristics. So physico-chemical characterization of starches plays an important role[4].

The starch contains a B-type crystal, which was revealed by X-ray spectra, gelatinization temperature of 65.5°C as described by thermal analysis (DSC)[4]. On powdered rhizome identified the presence of physicochemical parameters like moisture content, total ash, and extractive values of alcohol and water which were studied by Shintu and her peers[56]. The research done by Ayala Valencia and her peers[4] in arrowroot showed high amylose content than tubers with similar properties like cassava, tapioca, potato, etc, which is an important character for the formation of films. SEM showed granules with irregular size and shape with spheroids and elongated forms. Varied parameters are discussed by researchers across the globe mostly in the field of agriculture, which is referred to in table-2.

Chemical composition :

The arrowroot rhizome contains an average of 20% starch, depending on plant age of which between 20% and 30% is amylase. A large amount of amylose is an important characteristic because it decreases the energy required to start the gelatinization. Starches with higher content of amylose have fewer crystalline regions and, consequently, lower gelatinization temperatures[10].

As for the components of rhizome, one of the pioneering studies, Erdman and Erdman[12] evaluated the arrowroot biomass. Their analysis indicated that the air silage and processing residues of thick and thin arrowroot contained 10.8–21.1% crude protein; 11.1–30. 2% crude fibre, 3.8–17.0% ash; and in vitro digestibility of dry matter of 38.5–60.3%. The amylose and amylopectin values for Arrowroot starch were 15.21 and 84.79%.

Table-2. Recent studies under Physicochemical characteristics of Maranta arundinacea

Sl no	Parameters		References
1)	Moisture	Proximate composition of rhizome flours & starch	3,4,45,67
2)	Crude protein		
3)	Crude lipid		
4)	Total dietary fibre		
5)	NFE (Nitrogen free extractives)		
6)	Determination of loss on drying at 110°C		
7)	Ash value (% of total ash)		
8)	Acid insoluble ash		
9)	Water-soluble ash		
10)	Methanol soluble extractive value		
11)	Water-soluble extractive value		
12)	Hexane soluble extractive value		
13)	Ethanol soluble extractive value		
14)	pH value		
15)	Volatile oil content		
16)	Proteins		
17)	Total starch		
18)	amylose		
19)	amylopectin		
20)	Yield		
21)	Calorific value		
22)	Sodium	Mineral composition	
23)	Potassium		
24)	Calcium		
25)	Magnesium		
26)	Phosphorus		
27)	Zinc		
28)	Manganese		
29)	Iron		
30)	Copper		
31)	Niacin	Vitamins	
32)	Ascorbic acid		

Mineral Composition :

Pérez and Lares[37] in 2005 evaluated some chemical and mineral characteristics of Arrowroot, finding a high percentage of phosphorus, sodium, potassium, magnesium, iron, calcium, and zinc in its composition and stability during cooking, which can be an interesting character to be considered from the nutritional and industrial point of view. Despite the obvious importance, very little research has been done concerning the mineral composition in starches. The same was found out by Tresina and associates[63] in 2020) for its rhizome. It contains a high amount of potassium followed by calcium, magnesium, phosphorus, sodium, iron, manganese and zinc.

Nutritional composition :

Arrowroot flour has a nutritional composition of 5.0% soluble dietary fibre, 8.7% insoluble dietary fibre, 0.14% protein, 25.9% amylose, 0.84% fat, 11.9% water and 0.58% ash[25].

Preliminary Phytochemical screening :

Each herb is like a factory capable of generating an unlimited number of very complex and unusual chemical substances, and its structure is a structure that could otherwise disappear forever from imagination (*Maranta. —Arrow-Root. | Henriette's Herbal Homepage*, n.d.). To explore the significance of any medicinal flora the primary step is to screen for its phytochemicals, as it will provide a broader objective regarding the nature of volatile compounds present in it[34].

Table-3. Phytochemical Screening of *Maranta arundinacea*

Phytochemical component	Biochemical Assay	Methanolic extract	Aqueous extract	Petroleum ether extract	Chloroform extract	Ethylacetate extract	Ethanolic extract	References
Alkaloids	Hager's Test	++	++	-	-	-	+	37,40, 57
Carbohydrate	Benedict's Test & Fehling's Test	+	+	+	+	+	+	
Glycosides	Keller Killiani Test	++	++	+	+	+	+	
Flavonoids	Alkaline reagent Test	+	-	-	-	+	+	
Terpenes	Salkowski's Test	+	+	-	-	-	-	
Saponins	Froth Test	++	-	+	+	+	+	
Phenol	Lead acetate Test & Ferric chloride Test	+	+	-	-	+	+	
Tannins	Lead acetate Test	++	-	-	-	+	++	
Proteins & amino acids	Xanthoproteic Test	+	+	-	-	-	+	
Fixed oils &fat		-	-	-	-	-	-	
Gum		+	-	-	-	-	-	
steroids		+	-	-	-	+	+	

(++ strong presence, + Presence, - absence)

Qualitative preliminary phytochemical screening suggested the presence of various chemical components such as alkaloids, glycosides, phenolic compounds, terpenoids, saponins, flavones, tannins, proteins and gums as shown[21,56] in table-3.

GC-MS analysis :

Gas chromatography (GC-MS) is carried out for the direct analysis of phytocompounds existing in traditional medicines and medicinal plants as it is a great method for analysing non-polar components, fatty acids, lipids, sterols, alkaloids, etc. The method gives a direct spectral output of all the components of flavonoid out from the sample[15]. The volatile components are present in the ethanolic extract of the dried and powdered rhizomes of *Maranta arundinacea*. L. which was analysed by Nishaa and her colleagues[34] revealed the presence of 49 compounds and the experiment done by Firoskhan and peers[14] in the ethanolic extract of *Maranta* observed the presence of 9 active bio compounds. The bioactive compound (RT) and its molecular formula are shown in Table 3. The difference in the extraction may be due to the different parameters used for the analysis like oven temperature, pressure, injection temperature, time etc.

The GC-MS analysis is a good step to analyse the phytocompounds in plant extracts. The presence of diverse bioactive compounds in *Maranta arundinacea* aid in some biologically important activity which may be promoted as a phytopharmaceutical plant[14]. Some of the compounds identified in the study have potential bioactivities whereas many compounds' bioactivity has yet to be corroborated. The neophytadiene compound shows analgesic, antipyretic, anti-inflammatory, antimicrobial, and antioxidant activity; hexahydrofarnesl acetone exhibit antimicrobial and anti-inflammatory activity; 3,7,11,15-tetramethyl-2-hexadecen-1-ol reveals strong antimicrobial and anti-inflammatory activity; ethyl palmitate exhibit antioxidant, anti-inflammatory, anticancer; phytol express antimicrobial, antioxidant, and anticancer activities; palmitic acid, ethyl ester shows anti-oxidant, hypocholesterolaemia, nematicide, antiandrogenic, haemolytic, pesticide, lubricant, 5-alpha reductase inhibitor, antipsychotic; farnesyl bromide exhibit antiplasmodic activity; stigmasterol reveal antioxidant, antimicrobial, anticancer, anti-arthritic, anti-asthma, anti-inflammatory, anti-osteoarthritic, anti-hypercholesterolemia, cytotoxicity, antitumor, hypoglycaemic, antimutagenic, and CNS effects and gamma-sitosterol display antimicrobial, anticancer, hepatoprotective, anti-arthritic, antiasthma activity.

The difference in the chemical composition of the extracted starches may be influenced due to the planting density, starch isolation method, variation in the rhizome origin and the local climate during their cultivation. The studies were done in rhizome only not on leaves extract.

Ethnopharmacological activities of *Maranta arundinacea* :

Antidiarrheal Activity :

Diarrhoea is one of the most common causes of death for thousands of people every year. As a result, the identification of new

Table-4. GC MS analysis of ethanolic extract of *Maranta arundinacea* L. rhizomes

S. No.	Retention factor (RT)	Compound	References
1.		Cyclohexanone	
2.	4.45	2-Hydroxy- cyclopenta-2,4-dienone	
3.		2,3-Dimethoxy-succinicacid dimethyl ester	
4.		5-Diethylsilanyloxy-4-ethyl-2phenyl-3a,4,7,7a-tetrahydro-isoindole-1,3-dio	
5.	6.41	Triethyl-(3-methyl sulfanyl-1-vinyl-pent-1- enyloxy)-silane	
6.		(2-Methyl-thiiranyl)-methanol	14,34
7.	7.18	2-tert-Butoxy-tetrahydro-furan	
8.		Cis-2-(7-octynyl)cyclohexanol	
9.		4-tert-Butyl-[1,3,2]dioxathiolane 2-oxide	
10.		(2-Acetoxy-1-methyl-vinyl)-methylidyne-ammonium	
11.	8.10	Tetradecane	
12.		Cyclohepta-2,4,6-trienecarboxylic acid ethyl ester	
13.	10.54	Benzyl-butyl-amine	
14.		1-(4-Methoxy-cyclohexyl)-hex-5-en-1-one	
15.		9-(4-Methoxy-phenyl)-9-oxo-nonanoic acid methyl ester	
16.	11.74	1-Ethoxymethyl-4-methyl-benzene	
17.		2,6-Dimethoxy phenol	
18.	12.42	2-Methoxy-3-methyl-benzene-1,4-diol	
19.		2,4-Dimethoxy phenol	
20.		2-tert-Butyl-1,2-dimethyl-cyclopropane,carboxylic acid methyl ester	
21.	13.27	1,1,2,2-tetramethyl-3-oxo-octahydro-4-oxacyclobuta(?) naphthalene-2a-carbonitrile	
22.		C-[2,2-Dimethyl-3-(2-methyl-propenyl)-1- phenylsulfanyl-cyclopropyl]-methylamine	
23.	16.10	2-Phenoxysulfonyl-acetimidic acid methyl ester	
24.	16.32	2-Phenoxysulfonyl-acetimidic acid methyl ester, hydrochloride	
25.		3,6,10-Trimethyl-8,11-dihydro-7H[cyclodeca[b]furan-4-o	
26.		1-Benzyl-4-tert-butyl-4,5-dihydro-1H[1,2,3,4,5]-thiatetrazoboro	
27.		4-Ethoxymethylene-7,7-dimethyl-bicyclo[3.2.0] hept-2-en-6-one	
28.	16.705	Neophytadiene	
29.	16.823	Hexahydrofarnesl acetone	

30.	17.36	2-(2-Nitroallyl)-cyclohexanone	
31.		1,4,7,10,10-Pentamethyl-2,4,6,8,9-pentaaza-tricyclo[5.2.1.02,6] dec-8-ene-3,5-d	
32.		2,3,3,4,7-Pentamethyl-1,5,7-triaza-tricyclo[3.3.0.02,4]octane-6,8-dione	
33.	17.383	3,7,11,15-tetra methyl-2-hexadecen-1-ol	
34.	17.91	6-Chloro-3,4,4a,5,6,8a-hexahydro-2H-chromene	
35.		5-(1-chloro-1-methyl-ethyl)-3,5-dimethyl-cyclopent-2-enone	
36.		7a-(2-Methoxy-ethyl)-1-methyl-1,2,3,6,7,7a-hexahydro-inden-5-on	
37.		3-3-(Methoxy-phenyl)-2-methyl-oxetan-3-ol	
38.	19.41	2-Benzyloxy-7-(tetrahydro-pyran-2-yloxy)- heptan-1-ol	
39.		(1-Acetyl-5-formyl-6-methyl-cyclohexa-2,4- dienyl)-acetic acid ethyl ester	
40.		3-Phenyl-1-(toluene-4-sulfonyl)-pyrrolidine-2,5-dicarboxylic acid 2- benzyl ester 5-tert-butyl ester	
41.	19.546	Ethyl palmitate	
42.	20.18	Cyclopropyl-oxo-acetic acid methyl ester	
43.	20.84	2-Allyl-5a-hydroxy-octahydro-5-oxa-2-azacyclopenta[c]inden-1-one	
44.	21.26	Cyclohexylmethyl-diethyl-methoxy-silane	
45.		2,2-Dimethoxy-4a,5,6,7,8,8a-hexahydro-2H-benzo[e][1,2]oxasilane	
46.		2,2-Dimethoxy-2H-benzo[e][1,2]oxasilane	
47.		4-(3,4-Dimethoxy-phenyl)-butan-1-ol	
48.	22.388	Phytol	
49.	24.105	Palmitic acid, ethyl ester	
50.		1,1-Diethoxy-2-methyl-propan	
51.	24.16	2,4'-Dimethyl-[2,4']bi[1,3]dioxanyl	
52.		2-Methyl-3,3-bis-(2-trimethylsilane-ethoxy)- propionic acid methyl ester	
53.		2-Methoxyimino-4-methyl-pentanoic acid benzyl ester	
54.	29.94	2-(Benzyl-{2-[(dimethyl carbamoyl-phenyl-methylene)-hydrazino] -ethyl}-hydrazono)- N,N-dimethyl-2-phenyl-acetamide	
55.		3-Methylene-1-oxa-spiro[3,6]decane	
56.	37.958	Farnesyl bromide	
57.	43.289	Stigmasterol	
58.	44.873	Gamma-Sitosterol	

sources of anti-diarrheal drugs is one of the most important priorities in modern research. Diarrhoea is described as abnormally frequent defecation of low-consistent faeces caused by disturbances in the intestine during electrolyte transport. A survey was conducted to find the alternative for WHO-ORS in developing countries by Rolston and colleagues[47]. In the survey, the effects of the most commonly used, boiled and cooled supernatants of the following liquid food rice (Otyzu suriva)-water, ragi (*Eleusine coracana*)-water, arrowroot (Maranta arundinacea)-water], and tender coconut water, and of the bicarbonate- and citrate-WHO-ORS on intestinal water transport were evaluated using a rat model of secretory diarrhoea. Arrowroot solutions were observed to reduce cholera toxin or reduce net water absorption. WHO have encouraged studies for the treatment and prevention of diarrhoeal diseases using traditional medical practices[63].

The investigation done by Rahman and peers[39] in 2015 was to analyse the antidiarrheal and cell toxicity of methanol extracts from *Maranta arundinacea* L. leaves in rats and brine shrimp, respectively. It was observed that Maranta was potent against brine shrimp with an LD50 value of 420 µg/mL and it was proved that the highest dose of 400 µg/mL of Maranta was not toxic to mice. These results indicate that bioactive compounds are present in methanolic extract of *Maranta arundinacea* leaves including significant antidiarrheal activity and could be accounted for pharmacological effects. The antidiarrheal activity of the methanolic extract of the leaves *of M. arundinacea* could therefore be due to the presence of flavonoids and phenols.

Vibriocidal activity :

The activity of a compound which can act against cholera causing organisms can be considered vibriocidal activity. According to the World Health Organization (WHO), over one million people in the United States are reported to have had acute diarrhoea as a result of Vibrio cholera infection every year. Studies by Samal and collegues., in 2019 were conducted on various *Maranta* extracts of leaves and rhizomes[51]. The experiment was conducted on various extracts, such as aqueous, ethanol, hexane, and methanol of leaf and rhizome to identify its vibriocidal activity, and significant activeness results were obtained against ethanol extracts which indicates that the ethanol extracts may possess more bioactive compounds and chemical constituents which are responsible for strong vibriocidal activity[36,51].

Antiulcerogenic activity :

An ulcer is the rupture of mucosal integrity which may lead to active inflammation and cause localized defects[42]. The anti ulcer activities were assessed in the test drug group with that of the stress control group by determining and comparing the changes in ponderal changes, ulcer index, rectal temperature and histopathological parameters. Gastric ulcer, being the most prevalent gastrointestinal disorder, is a main therapeutic target. Stress ulcers are due to both physiological and psychological factors which are crucial for gastrointestinal defence and increased accumulation of acid and pepsin, leading to auto digestion of the gastric mucosa[19]. *M. arundinacea* shows better activity against

anti-stress ulcers. The protective action of starch against stress induced ulceration may be due to the presence of its histamine antagonistic, anti secretory, and anticholinergic effects. Furthermore, as it reverses stress hypothermia besides attenuating stress ulcers, it seems to have better anti stress effects. It is highly effective against stress-induced ulceration which may be due to the reduction in the production of free radicals or improvement and building up of anti-oxidant in the body[40].

Antioxidant activity :

Antioxidants are those compounds which inhibit ROS/RNS (Reactive Oxygen Species/ Reactive Nitrogen species) and free radicals. The mechanism helps in the neutralization and destruction of the compound in the oxidation process. The tubers are known for their abundant energy storage capacity and the antioxidant capacity of *M. arundinacea* was a positive correlation with the presence of high amounts of phenols, tannins and flavonoids[50].

In the studies carried out by Nishaa and her peers[33] methanolic extract of *Maranta arundinacea* rhizome showed antioxidant and free radical scavenging activity through in vitro models such as DPPH, hydroxyl radical, superoxide radical, ABTS radical cation, and reducing power in a dose-dependent manner when compared to the standard antioxidant From the experiment it was confirmed that *Maranta arundinacea* rhizome can be used as a good natural antioxidant.

The experiment by Ramadhani and collegues.,[42] where the effect of ethanolic extract of arrowroot tubers (*Maranta arundinacea*) against oxidative stress using the parameter of SGOT (Serum Glutamate Oxaloacetic Transaminase), MDA (Malodialdehyde) and SGPT (Serum Glutamate Pyruvate Transaminase) level in ethanol-induced rats was showed that the phenols, flavonoids and saponins are present in the extract which act as antioxidants. Hence the ethanolic extract of Maranta tubers helps in the decrease of SGOT, MDA, and SGPT concentration.

Anti-inflammatory activity :

Inflammation is described as a kind of immune reaction against harmful pathogens or disrupted cells which is controlled by immune cells, blood vessels and molecular mediators[30]. Arrowroot showed good anti-inflammatory study against the standards. The extract mediated with selenium nanoparticles was evaluated using an albumin denaturation assay carried out on brine shrimp nauplii. An increase was found in the anti-inflammatory property of arrowroot-mediated selenium nanoparticles with increasing concentration in comparison to the standard diclofenac[16]. The study to determine the anti-inflammatory activity was also conducted in different concentrations in Maranta by the protein-denaturation method which shows a significant decrease in the activity[23].

Adaptogenic Activity/ Acute toxicity Effect:

Acute toxicity refers to the sudden harmful outcome generated as a result of a single dose of drug administration, which should be several dosages higher than the therapeutically

equivalent dose (TED)[40]. In the acute toxicity study, conducted by Rajashekhara and his collegues[40] in the year 2014, the effect of *M. arundinacea* starch was studied after a single administration up to TED X 4 (4400 mg/kg), as the maximum dose. The experimented animals were periodically analysed for 72h and for up to 7 days mortality was recorded. The experiment concluded that the drug did not exhibit any toxic symptoms or mortality even up to the maximum dose level of 4400 mg/kg. The LD50 value was likely to be very much higher than the max dose used in their study which indicates the drug to not produce any toxicity. This proved that the test drugs, in the given form, were not likely to have any toxicity potential at the dose level which is used in the therapeutical industry.

Cytotoxicity activity :

A lethality test was conducted in brine shrimp which is regarded as a convenient probe for preliminary bioassessment of toxicity, cell line toxicity, detection of fungal toxins, pesticides, heavy metals and antitumor activity[2,31].

The cytotoxicity assay was conducted on Maranta rhizomes and leaves by Rahman *et al*.,[41] using the method Brine shrimp lethality bioassay test, a dose-dependent effect was observed in the extracts used. Arrowroot contains terpenoids which are believed to have anti-cancer properties such as immune modulation and anti-inflammation. The leaves were also assessed for their cytotoxicity using a sensitive in vitro brine shrimp lethality bioassay. From this result, it can be well predicted that the *M. arundinacea* extracts do not have considerable cytotoxic activity. The same was observed by Francis and peers[16] in 2020 in arrowroot mediated selenium nanoparticles where it showed a lower cytotoxicity rate.

Antimicrobial activity :

The ability to inhibit the growth of microorganisms is known as antimicrobial activity. Bioactive compounds are generally seen as secondary metabolites in all plant cells. Secondary metabolites exert antimicrobial activity through different mechanisms. The presence of antimicrobial activity is proved because of its phytoconstituents mainly phenols, flavonoids, tannins, alkaloids, steroids, and terpenoids[39]. There is a positive correlation between total phenolic content, flavonoid content and antimicrobial activity[19,54,64]. Not much information as regards the antimicrobial effect of arrowroot (*Maranta arundinacea* L.) against bacteria is present.

Arrowroot has been proven to have bioactive compounds such as alkaloids, glycosides, flavonoids, terpenes, saponins, and tannins. The presence of possible constituents was observed even in a low concentration of solvent extracts of leaf and rhizome. MIC and MBC of arrowroot methanolic extract against MRSA (Methilin-resistant *Staphylococcus aureus*) is 100% showing its inhibitory activity[21,62]. In 2015 Rahman *et al*.,[39]), showed that ethanol yielding extracts were more powerful than others which also might be due to the dissolving or diffusing nature of bioactive compounds present within plants extracts. Ethanolic extracts of the leaf, as well as the rhizome, have exhibited the minimum inhibition

activity against different strains of *V. cholerae* which confirms that *M. arundinacea* can inhibit the growth of diarrhoea causing bacteria[51].

Selenium nanoparticle is used as a new member of the drug as a nano-carrier in medicine[1]. Selenium nanoparticle synthesised using *Maranta arundinaecea* exhibits an inhibition in *Streptococcus mutans* and *Lactobacillus*. It can be further developed as toothpaste and some other dental products to control the dental carries[5].

Gastroprotective effect :

The arrowroot tubers (*Maranta arundinacea* L.) are known to be widely used in the treatment of gastric ulcers, which are peptic ulcers in the stomach. The plant is believed to possess carbohydrates and flavonoids that play a role in reducing inflammation. The animal studies done on rats by Lailli and coresearchers[26] in 2020, produced ulcer indices, smaller than the negative control (4.25), and % protection ratios higher than the positive control. The histopathological imaging showed that the stomach of rats receiving arrowroot tuber starch at 250 mg/kg BW presented no pathological changes. Based on these findings, the arrowroot tuber starch is proven to have the ability as a gastroprotective agent.

Immunostimulatory effect :

Arrowroot (*Maranta arundinacea.* L.) is an underutilized local crop potentially to be developed as a carbohydrate source and functional food. The arrowroot tuber extracts have been observed to have the effect of inducing or stimulating an immune response *in vivo* as well as *in vitro* conditions. The studies by Kumalasari and companions[27] revealed that the feeding of the arrowroot tuber powder for 14 days significantly enhanced IgG, IgM, and IgA levels in serum. Arrowroot tuber extract stimulated IgM production by HB4C5 cells and immunoglobulin (IgG, IgA and IgM) production by splenocytes *in vitro*. In addition, the arrowroot tuber extracts strongly enhanced interferon production by splenocytes. In vivo study indicated that the diet containing arrowroot extracts increased the serum IgG, IgA and IgM levels in mice[25].

Prebiotic activity :

A prebiotic was first defined as "a nondigestible food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon, and thus improves host health" [46].

Information on the effect of oligosaccharide components of local tubers which have the potential function as prebiotics is still limited. The arrowroot powder contained dietary fibre, raffinose, lactulose and stachyose. According to studies on probiotics, those oligosaccharides have prebiotic effect. The incorporation of arrowroot carbohydrate extracts reduces the titrable acidity, increases the pH and gives higher biomass of probiotics. It can be concluded that arrowroot extracts possess the prebiotic potential and could be applied in maintaining greater than 106 CFU/g for *Lactobacillus acidophilus* during storage of fermented products[22]. The incorporation of

Arrowroot carbohydrate extract is a possible method for the development of bio-yoghurt with enhanced survival of probiotic bacteria during prolonged cold storage[58]. Arrowroot powder consumption can improve the physical properties of digesta. Soluble fibre fermented by bacteria will increase the amount of mucus, the viscosity and the osmotic pressure of digesta. Therefore, the digesta became bulkier, and soft and increased its water-binding capacity[20].

Aphrodisiac activity :

An aphrodisiac is defined as an agent (food or drug) that arouses sexual desire. The study of aphrodisiacs is important because they may provide a means to treat the psychological components of sexual dysfunction as opposed to the current treatments, surgical implants and injection therapy, which only treat the mechanical component[48]. The available chemical drugs and their treatments have limited efficacy, and unpleasant side effects and may lead to certain medical conditions. To overcome the problem of sexual (or) erectile dysfunction various natural aphrodisiac potentials are preferred.

Aphrodisiac potentials inhibit the hydrolyzing action of PDE-5 with the result that active C.GMP can accumulate and it helps in the 'Undisturbed' and prolonged erection through increased blood flow. The rhizome of *Maranta arundinacea* is believed to possess an aphrodisiac character[6,43].

Anti-termite properties :

The plant uses the rhizome to store starch, proteins and other nutrients. Rhizome extracts of many plants are being used as effective insecticidal agents. The ethanolic and petroleum ether extracts of *M. arundinacea* exhibited anti-termite activity. Dose-dependent mortality was noted in both ethanolic and petroleum ether extracts of Maranta rhizome which were used in the studies done by Sri and peers[60] in 2016 . A comparative study was performed on four different varieties belonging to the *Zingiberaceae* family and among them, *M. arundinacea* showed a moderate mortality rate of termites, which may be due to the presence of all phytochemical compounds (carbohydrates, proteins, steroids, terpenoids, phenolic compound, oil, alkaloids, flavonoids, tannins, saponins and cardiac glycosides) but these components may be present in low concentration in the rhizome, hence moderate mortality rate was observed.

Table-5. Ethanopharmacological Activities of *Marantha arundinacea*

Sl No.	Plant part	Experimental extract used	Parmacological activity	Result	Reference
1.	Leaves	methanol	Antidiarrheal activity	Significant	41
2.	Rhizome		Antidiarrheal activity	Alternative to WHO-ORS	47
3.	Leaves rhizome	ethanol	Vibriocidal activity	Strong vibriocidal	36,51
4.	Rhizome		Antiulcerogenic activity	Anti-ulcer activity against stress	40

				induced ulcer,	
5.	Leaves Rhizome	Methanol	Antioxidant activity	Significant anti-radical activity	(Kusbandari & Susanti, 2017) (Ruba & Mohan, 2013)
6.	Rhizome	ethanol	Antioxidant activity	Decrease in liver damage by ROS/RNS, attenuate oxidative stress	33, 42 (Sasikumar & Gopala-krishnan, 2012)
7.	Rhizome	Acetone	Antioxidant activity	free radical scavenging activity (anti-radical activity) and antioxi-dant potential	50
8.	Starch from rhizome	Water, Selenium nanoparticles	Anti-inflammatory	Significant anti-inflammatory activity	16, 23
9.	Rhizome		Adaptogenic activity/ acute toxicity effect	No toxicity up to maximum dose of 4400 mg/kg	40
10.	Leaves	methanol	Cytotoxicity activity		39
11.	Rhizome	Selenium nanoparticle	Cytotoxicity activity	Lowered cytotoxicity	16
12.	Rhizome leaves	methanol	Antimicrobial activity	*Staphylococcus aureus*	62
13.	Rhizome leaves	ethanol	Antimicrobial activity	*Vibrio cholera*	36,51
14.	Rhizome	Selenium nanoparticle	Antimicrobial activity	*Streptococcus mutants, Lactobacillus*	5
15.	Rhizome		Gastroprotective effect	Significant	26
16.	Starch from Rhizome		Immunostimulatory effect	IgG, IgA and IgM	25
17.	Rhizome starch	Direct intake	Prebiotic activity	Prebiotic effect by maintaining higher viability of probiotics	20,22,58
18.	Rhizome starch		Aphrodisiac activity	significant	43
19.	Rhizome	Ethanol, Petroleum ether	Anti-termite properties	moderate mortality rate of termites	60

Since the establishment of mankind, plants play an indispensable index in the field of medicine. Their medicinal properties are due to the phytochemical components present in them. *Maranta arundinacea* commonly known as arrowroot is an obliterated plant due to the introduction of new breeds which is grown wild in many parts of the world. The presence of diverse phytochemicals makes the Maranta plant in the spotlight. The extracts of the Maranta plant can be used as an alternative to many chemically formulated drugs which lead to side effects after their prolonged use. So, the plant derivatives provide an effective alternative in the quest for drugs in the pharmaceutical industry as they provide nil to negligible side effects when taken in recommended quantity and help to provide a safer approach. The plant also plays an important part in the food industry as biofilms and as an alternative for a starch obtained from the rhizome because of its gluten-free nature and gelatinization properties. So, its characterization, phytochemical studies and pharmacognostic standardization become an important parameter for the plant identification and authentication of genuine plant material and to avoid adulteration by other starches.

Through the studies done by different researchers till 2021 it was confirmed that the plant contains chemical components like alkaloids, tannins, glycosides, phenolic compounds, terpenoids, saponins, flavones, proteins *etc* which make it important in the pharmaceutical industry. The phytochemical properties are the ones which make them medically valuable or give them various ethnopharmaceutical properties. Its gelatinization and freeze-thaw stability make it a great use in the food industry also.

The popularity of the Maranta plant is a growing trend and hence more studies have to be carried out. In the present review, the quantitative values were found to be different for the same parameters done by different researchers as it is localized reports from different areas where the plant is grown. It may be due to the quality of the plant, water availability and other environmental factors like soil, its compositions *etc* and also due to the localized information. Even though the quantitative values are different the composition and its characteristics remain the same. So, to have a better understanding of the value of the plant there is a need for a detailed study and authenticated documentation about the plant in a broader aspect to fill the gap in the adequacy of the information. The worldwide studies for the not so well-known tribal plants will help to raise different questions and will suggest what is the future scope for further research needed to be done.

Conflict of Interest :

The authors confirm that there is no conflict of interest related to the manuscript.

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