Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(5): 1007-1019
Received: 25-07-2018
Accepted: 27-08-2018

Chintha Pradeepika
Scientist, Division of Crop Utilization, ICAR-Central Tuber Crops Research Institute, Sreekaryam, Trivandrum, Kerala, India

Selvakumar R
Scientist, Vegetable Science, ICAR-Central Institute of Temperate Horticulture, KD Farm, Old Air Field, Rangreth, Srinagar, Jammu and Kashmir, India

Krishnakumar T
Scientist, Division of Crop Utilization, ICAR-Central Tuber Crops Research Institute, Sreekaryam, Trivandrum, Kerala, India

Sajad UN Nabi
Scientist, ICAR-Central Institute of Temperate Horticulture, KD Farm, Old Air Field, Rangreth, Srinagar, Jammu and Kashmir, India

Sajeev MS
Principal Scientist, ICAR-Central Tuber Crops Research Institute, Trivandrum, Sreekaryam, Kerala, India

Correspondence
Chintha Pradeepika
Scientist, Division of Crop Utilization, ICAR-Central Tuber Crops Research Institute, Sreekaryam, Trivandrum, Kerala, India

Pharmacology and Phytochemistry of underexploited tuber crops: A review

Chintha Pradeepika, Selvakumar R, Krishnakumar T, Sajad UN Nabi and Sajeev MS

Abstract
Tuber crops play an important role in food security, nutritional security and climate change adaptation. These crops are essential components of stable daily diet in many under developed and developing countries around the globe and comprises of major and underexploited minor tuber species. Among these crops, the major edible species include cassava, sweet potato, yams, Chinese potato, canna, arrowroot, starchy Curcuma and aroids and minor non-edible medicinal crops include *Coleus forskohlii*, wild *Dioscorea*, wild *amorphophallus species* etc. These medicinally important tuber crops possess pharmacologically active principles and possess important medicinal properties. Over the past few decades, there has been observed significant revival of interest among the people on various natural products as powerful antioxidants, bioactive compounds and natural drugs, therefore current research on natural products remains the main means of discovering potential principle bioactive health compounds in the existing unexplored tuber species. The main objective of this review is to cover the details of local and traditional uses of the tuber species which includes pharmacology, photochemistry and toxicology of medicinally important minor underexploited tuber crops.

Keywords: Tuber crop, antioxidant, bioactive compounds, drug

1. Introduction
Root and tuber crops constitute the second largest group of cultivated species, after cereals in tropical countries and occupy prime position in the food security, due to their high carbohydrate content and calorific value (Lebot, 2009) [55]. In India there is an existing rich genetic diversity of tropical root and tuber crops particularly aroids, yams and several minor tuber crops (Chuakul *et al.* 2000; Keardrit *et al.* 2010) [26, 47]. They take special status during natural famines and calamities due to their natural adventitious root systems. The major tuber crops comprise of cassava, sweet potato, yam species, aroids and minor tuber crops include *Amorphophallus konjac*, wild *Dioscorea species*, Coleus, Costus, Typhonium, Tacca, Arrowroot, Canna, Chinese potato, Cocoyam, Ceropegia, Alocasia, winged bean, yam bean, swamp taro, giant taro and starchy *Curcuma* species (Parra *et al.*, 2001 and Neviani *et al.*, 2005) [84, 73]. Leaves of many tropical tuber crops are rich sources of many important bioactive principles that could contribute significantly for eradication of many dreadful diseases in the world. Minor tuber crops also contain several medicinally important bioactive principles in different parts such as tubers, stems and leaves besides the tubers serving as storehouses of different carbohydrates. Sujatha and Renuga (2013) [107] reported unexploited medicinal and edible tubers from fourty two settlements of Tribals from Pechiparai Social forest in Kanyakumari District, Tamil Nadu, India and documented the traditional knowledge of medicinal tuber crops of those particular tribal communities (Tholkappiyavathi et al., 2013) [109]. Recently, global interest has been focused towards the medicinal plants as potential sources of many useful drugs. The traditional uses and toxicological studies of minor and underexploited tropical tuber crops are shown in Table 1. Main aim of this review is to address the different types of minor and underexploited tuber crops, their local and traditional uses, species pharmacology, photochemistry and toxicology of medicinally important crops etc.

Table 1: Traditional uses and toxicology studies of minor and underexploited tropical tuber crops

Common name	Scientific name	Traditional uses	References	Toxicology studies	References
Arrow root	*Maranta arundinacea*	• Traditionally the tuberous rhizomes are used in the treatment of diarrhoea • The edible tuberous rhizomes are rich in starch and are also a commercial source of fine grade starch used often in weaned foods and biscuits	Nishaa *et al.* 2012 [74]	Highest dose of 400µg/mL of methanolic extract of *Maranta arundinacea* was not toxic to mice, tested by brine shrimp lethality test	Rahman *et al.* 2015 [92]
Coleus	*Coleus sp.*	• *C. barbatus* leaves are used to get relief from stomachalgia in Africa and Brazil • Whole plant of *C. vettiverioides* has been used to stop the vomiting and nausea in India. • Volatile oil extracted from *C. sylvestris* is being used by people in Australia for treatment of skin diseases • Seeds of *C. amboinicus* are used for treatment of acute oedematous and acute otitis in India. • Forskolin is also used in the preparation of medicines preventing hair greying and restoring grey hair to its normal colour • *C. aromaticus* leaf juice is carminative when mixed with sugar, given to children in colic	Soni and Singhai, 2012 [105]	• Forskolin also showed that it was extremely safe with an oral LD50 of 3100 mg/kg • Sclareol isolated from *C. forskohlii* reported to be non–cytotoxic to resting human peripheral blood mononuclear leukocytes and have LD50 > 5mg/kg in rats	Parra *et al.*, 2001 and Neviani *et al.*, 2005 [84, 73]
Costus	*Costus species*	• In India rhizomes of Costus are used for cold, pneumonia and rheumatism in Ayurvedic treatment, diabetic patients are advised to chew 2-3 leaves per day • In Traditional medicine, *C. igneus* is used to promote longevity, Reduces fever, asthma, bronchitis, treat rash • Roots are used against snake bite • Leaf infusion or decoction is utilized as a sudorific or in a bath for patients with high fever	Brackenridge *et al.*, 2002 [13]	Acute and subchronic toxicity studies of aqueous leaf and stem bark extract of *Costus afer* in mice	Udem and Ezeasor, 2010 [110]
Ceropegia	*Ceropegia pusilla*	• *Ceropegia pusilla* tubers are used in Indian Ayurvedic drug preparations that are active against ulcers, inflammation • The tubers of *Ceropegia* species are used by tribal women to promote fertility and vitality	Adibatti *et al.*, 1991 [5]	-	-
Starchy Curcuma species	*Curcuma zedoaria, C. aromatica, C. malabarica, C. amada, C. brog, C. rakthakanta*	• Traditionally *Curcuma zedoaria* has been used for treatment of many diseases such as stomach diseases, blood stagnation, hepato protection, diarrhoea, coryza, dermatosis disorders and rheumatism and promoting menstruation. • Dried rhizome and leaves of *Curcuma caecia Roxb* are used for treatment of piles, leprosy, asthma, cancer, wounds, fever, impotency, fertility, tooth ache, vomiting and allergies in North-East and Central India.	Tholkappiyavathi *et al.*, 2013 [109] Israr *et al.* 2012 [41]	*Curcuma xanthorrhiza* ethanolic extract showed absence of toxic effects which could compromise the medicinal use of this plant in folk medicine	Devaraj *et al.*, 2010 [27]
Giant taro	*Alocasia macrorrhiza*	• Its traditional medicinal uses have been recorded in the folklore, as	Acharya *et al.* 2014 [3]	Among ten isolated compounds, hyrtiosin B showed the toxicity	Ellil, 2014 [30]

		treatment of many parasitic infections, inflammations, cough, and toothache, used as diuretic.		on Hep-2 with IC50 of 4.65 µg/ml	
Konjac	*Amorphophallus konjac*	• Detoxification, tumour-suppression, blood stasis and phlegm liquefaction • Konjac gel has been used for treatment of asthma, cough, hernia, breast pain, burns and skin disorders • Konjac flour used as natural insect repellent and as animal fodder by the indigenous people in Southern China • Traditionally, corms are washed, peeled, sliced, dried and ground to produce konjac flour which is consumed in the form of cake (or gel) after boiling the flour with plant ash • konjac gel has been used for the treatment of asthma, cough, hernia, breast pain, burns as well as haematological and skin disorders	Niwa *et al.*, 2000; Brown, 2000; Long, 1998; Chan *et al.*, 2010 [78, 15, 58, 18]	Asthma and occupational exposure to airborne powder produced during the manufacture of konjac flour	Murti *et al.* (2010) [69]
Tacca	*Tacca leontopetaloidea, T. aspera, T. paxiana, T. plantaginea, T. subflabellata, T. chantrieri*	• Rhizomes of *T. integrifolia* are used for improving sexual function and controlling blood pressure in Thai herbal medicine. In china, Tacca species has been used for treatment of hepatitis, gastric ulcer, enteritis etc. • In South-east Asia, rural people has been used *T. chantrieri* rhizome decoction alone or combination with other herbs, to relieve pains of the body and stomach, and as an antidote for food poisoning	Chuakul *et al.*, 2000; Keardrit *et al.*, 2010 [26, 47]	Taccalonolide A (1) displayed a cytotoxic activity against P-388 leukemia in cell culture. Taccalonolides G- K (7- 11) showed only a weak cytotoxicity against P 388 leukemiacells *in vitro.*	Chen *et al.*, 1988; Chen *et al.*, 1997 [22, 23]
Typhonium	*Typhonium flagelliforme, T. trilobatum,*	• *T. flagelliforme* tuber has been used as important ingredient in the herbal cancer treatments	Choo *et al.* 2001a [24]	• Hexane phase of the petiole extracts of the *T.flagelliforme* found highly toxic to *A. salina* (LC50 = 762.08µg ml-1) • *T.flagelliforme* tuber has a cytotoxic activity against cancer cell growth • The tuber protein extract from *T.flagelliforme* showed anti-proliferative effect against MCF-7 and nontoxic for fibroblast cells until 100ppm	Sianipar *et al.*, 2013; Mohan *et al.* 2008; Alfarabi *et al.*, 2015 [101, 64, 8]
Swamp taro	*Cryptosperma merkusii*	• Swamp taro corms are can be roasted boiled, baked whole, mashed or grated and combined with coconut milk to make into pudding	-	-	-
Winged bean	*Psophocarpus tetragonolobus*	• In New Guinea, the pods and the edible tubers are considered roborant • Traditionally leaves and seed are eaten by rural folk to cure skin sores such as boils and ulcers	Stopp, 1962; Perry, 1980 [106, 89]	Winged bean protein hydrolysate not showed any cytotoxic effects on NIH/3T3 mouse fibroblast cell, so it is safe in terms of genotoxicity and cytotoxicity, it can be used in pharmaceutical and food industries as functional ingredient.	Kawanding *et al.*, 2015 [46]
Wild yam species	*Dioscorea species*	• In Nigeria, *D. bulbifera* used as powered bulbils soaked in water, which is effective against reducing the blood pressure • The leaf of aerial yam is used as a	Adeniran and Sonibare, 2013; Gao *et al.*, 2002; Gao *et al.*, 2001 [4, 35, 36]	Boiled water yam tubers (*Dioscorea alata*) were reported with low anti-nutritional compounds like alkaloids, saponins, flavonoids and tannins	Ezeocha and Ojimelukwe, 2012 [33]

		poultice for pimples and tumours and in bathwater to soothe skin irritations and stings • *D. bulbifera* widely used in traditional Indian and Chinese medicine for treatment of gastric cancer, sore throat, carcinoma of rectum and goiter. Many south Asians used root syrup of *Dioscorea* species to get relief from labour pain and treatment of asthma, colic pain, rheumatism, hiccough, gastric problem related to alcoholism.		as compared to raw tubers.	
Yam bean	*Pachyrhizus erosus*	• In some parts of Asia, seeds of yam bean are used to treat worms and powdered seed is applied to treat the prickly heat during summer months especially in Java, skin eruptions and as fish poison • *Pachyrrhizuss erosus* L. is used as folk medicine in treatment of insomnia	Perry and Metzger, 1980; Abid *et al.*, 2006 [88, 1]	Significant correlations were found between toxicity and resin content, rotenone content, and three colorimetric analytical values	Hansberry, 1947 [39]

2. Minor and underexploited tuber crops and their Medicinal properties

2.1. Konjac (*Amorphophallus konjac*)

It's originated in South East Asia and is an important commercial crop grown in China, Japan, Indonesia and subtropical regions of Asia. It is a large, perennial exotic Asian plant, producing elongated centre corm and single large leaf. Though it has long been used as source of flour in China and Japan, it is becoming increasingly popular as a health food in many countries (Mishra, 2013) [62].

2.1.1 Ethno-Pharmacology and Phytoconstituents

Konjac has been used as traditional medicine for treatment of cough, breast pain, asthma and skin disorders. Konjac can trigger absorption and digestion of protein and other nutritious substances, keeps the intestine clean, and assists in bowel movement. It also contains 9.7% of crude protein, minerals such as calcium, phosphorus, iron, zinc, manganese, chromium and copper (Chen *et al.* 2003) [20]**.** Presence of glucomannan, trigonelline, saponins, riboflavin, β-carotene, thiamine, choline, niacin, serotonin, betulinic acid, tricontane, lupeol, stigmasterol, sitosterol and its palmitate etc. has been reported in konjac corms (Niwa *et al.* 2000) [78].

2.1.2 Phytochemistry and Phytopharmacology

Li *et al.* (2005) [57] reported the presence of small amount of alkaloids (trigonelline), glucomannan and saponins at dormant stem base. Fresh konjac corm contains riboflavin, β-carotene, thiamine, choline, niacin and as well as serotoninand its derivatives namely cis-N-(p-coumaroyl) serotonin and trans-N-(p- coumaroyl) serotonin (Niwa *et al.* 2000) [78]. Corms have unique feature of containing high levels of glucomannan (over 45%), which is the best known natural edible and water-soluble fibre (Nishinari and Yoshimura, 1999) [77]. Regular consumption of glucomannan is reported to reduce total cholesterol, prevent constipation, reduce serum insulin, and regulate the levels of blood sugar and lipid metabolism, promote body weight loss and immune functions of human body and also function as a mycotoxin adsorbent. Corms also possess potential pharmacological properties such as antidiabetic activity (Chen *et al.* 2003) [20], anti-obesity activity (Keithley *et al.* 2005) [48], laxative activity (Chen *et al.* 2006) [21], anti-inflammatory activity (Onishi *et al.* 2004) [81] and prebiotic activity (Li *et al.* 2005; Niwa *et al.* 2000) [57, 78].

2.2 West Indian Arrowroot

Arrowroot (*Maranta arundinacea*), synonym west Indian arrowroot is a tropical, perennial tuberous plant belonging to the family *Marantaceae*, well known for its edible starch that finds wide application as infant food. It produces ginger like leaves, perennial rhizome and edible rhizomes contain the easily digested edible starch.

2.2.1 Ethno-Pharmacology

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 (Kumalasari *et al.* 2012) [52].

2.2.2 Phytoconstituents

Arrowroot comprised of different phytochemicals like flavonoids, alkaloids, tannins, glycosides, steroids, phenols, cardiac glycosides and saponins.

2.2.3 Phytochemistry

The GC-MS analysis of the ethanolic extract revealed the presence of 49 compounds such as cyclohexanone, 2-hydroxy- cyclopenta-2,4-dienone, 2,3-dimethoxy-succinicacid dimethyl ester, 5-diethylsilanyloxy-4-ethyl-2 phenyl-3a,4,7,7a-tetrahydro-isoindole-1,3-dione, triethyl-(3-methyl sulfanyl-1-vinyl-pent-1-enyloxy)-silane, (2-Methyl-thiiranyl)-methanol, 2-tert-butoxy-tetrahydro-furan, cis-2-(7-octynyl)cyclohexanol, tetradecane, cyclohepta-2,4,6-trienecarboxylic acid ethyl ester, benzyl-butyl-amine, 2,6-dimethoxy phenol, 2-methoxy-3-methyl-benzene-1,4-diol and 2,4-dimethoxy phenol (Nishaa *et al.* 2013) [74].

2.2.4 Phytopharmacology

Arrowroot has been described as a potent source of natural antioxidants and is also reported to possess immunostimulatory effects i*n vivo* as well as *in vitro* in rats and has anti-inflammatory and antiseptic properties (Kumalasari *et al.* 2012) [52]. The arrowroot tuber extract

exhibited antioxidant activity against, ABTS, DPPH, nitric oxide and hydrogen peroxide radicals (Nishaa *et al.* 2012) [75]. Rahman *et al.* (2015) [93] reported the remarkable antidiarrheal activity of methanolic leaf extract of arrowroot with slight cytotoxic effect.

2.3 *Ceropegia* species

Ceropegia pusilla is an endangered medicinal tuber crop belonging to the family Asclepiadaceae, with 200 species distributed in tropical and subtropical regions of old world, of which 48 species are distributed in India. It gained importance taxonomically and enthnobotanically.

2.3.1 Ethno-Pharmacology

The sweet-sour leaves are edible and consider being tonic and digestive, complete plant extract is used as an antidote for snake bite. *Ceropegia bulbosa* is used for the treatment of cold, sneezing and eye diseases in India (particularly in Bihar region).

2.3.2 Phytoconstituents

The presence of secondary metabolites like triterpenes, alkaloids, tannins, glycosides, saponin, flavonoids, steroid and phenols are reported in the tubers. The tubers are edible, contains starch, sugar, fats, crude fibre and medicinally important alkaloid 'ceropegin' (Jain and Defillips, 1991) [43].

2.3.3 Phytochemistry

Ceropegin is an alkaloid present in the edible tubers of Ceropegia that is used for preparation of many ayurvedic drugs and is effective against eye diseases, dysentery, diarrhoea, syphilis, cold and sneezing. Kalimuthu and Prabakaran (2013) [44] screened methanol extract of *Ceropegia pusilla* tuber *in vitro*, revealed the presence of potential phytochemicals such as 1, 2-diphenyl-1-butanol (8.04%) (E)-1, 2-bis (2-bromo-4, 5-dimethoxyphenyl)-N, N-dimethylethenylamine (6.48%), endo-9-anti-11-dichloro-syn-11 fluoro tricyclo [5.3.1.0] undecane (6.29%), 3-tert-Butoxycarbonylaminophenyl isonitrile (6.25%) and oleanolic acid (5.63%).

2.3.4 Phytopharmacology

Prashanth and Shiddamallayya (2014) [87] reported that *Ceropegia tuberosa* can be used for curing seminal debility and general debility. Prabakaran *et al.* (2014) [83] studied angiogenesis and antioxidant activity of *C. pusilla* tuber in vitro and *in vivo*. Anti-angiogenesis effect was studied by Chicken Egg Chorioallantoic Membrane (CAM) assay and antioxidant properties were analysed using 1, -diphenyl-2-picryl- hydrazyl free radical scavenging assay and cancer cell reducing power activity. *In vitro* anti-cancer activity of ethanolic extract of *in vitro* and *in vivo* tuber of *C. pusilla* has been studied by Kalimuthu *et al.* (2014) [45] and confirmed the *in vitro* antiproliferative property against HeLa line.

2.4 Coleus species

Chinese potato (*Solenostemon rotundifolius*) is an ancient Ayurvedic tuberous plant, belonging to the family *Laminaceae*, considered as native of India. This is commonly known as hausa potato, sudan-potato, country potato. It is popularly known as poor man's potato, because it fetches low price in market as compared to the other tuber crops. The flavonoids of Chinese potato have been reported to lower blood cholesterol (Abraham and Radhakrishnan, 2005) [2] as well as possess high antioxidant activity (Sandhya and Vijayalakshmi, 2005) [96]. Leaves also have reported medicinal uses such as treatment of nasal congestion, sore throat, coughs and also have antifungal, anti-inflammatory properties.

2.4.1 Ethno-Pharmacology

The Coleus leaves are bitter, acrid, appetizing, thermogenic, digestive, aromatic, carminative, anthelmintic, constipating, deodorant, expectorant, lithontriptic, diuretic and liver tonic and it has been used to treat congestive heart failure, painful urination, eczema etc. (Soni and Singhai, 2012) [105].

2.4.2 Phytoconstituents

Coleus species has been reported with presence of many bioactive compounds like alkaloids (forskolin and its derivatives), tannins and phenols with potential biological activities like increasing the insulin secretion, stimulating adenyl cyclise, inhibition of platelet aggregation, relaxation of the arteries etc. Various phytoconstitutents in Coleus species are forskolin (diterpenoid), ß-citronellol (3, 7- dimethyl oct-en-ol), α- cedrene, γ- cadinene, citronellal (3, 7-dimethyl-6-octenal), labdane derivative (8-α, 13-ß- dihydroxy labd 14-en-3-one) isolated from roots (Murugesan *et al.* 2012) [68].

2.4.3 Phytochemistry

Murugesan *et al.* (2012) [68] isolated 6 major components α-cedrene, β- cadinene, citronellal, two labdane derivatives and ß-citronellol from the root extracts of *C. forskohlii. Coleus aromaticus* is rich source in presence of essential oils like ethyl salicylate, chavicol, carvacrol, thymol, eugenol and also contains caffeic acid, chlorogenic acid, coumaric acid and polyphenolic compounds (Dutta *et al.*1959) [29].

2.4.4 Phytopharmacology

Coleus tubers are rich sources of both enzymatic and non-enzymatic antioxidants, has been reported to exhibit antitumor and anti-mutagenic, antiepileptic, antioxidant, leishmania, urolithiasis, neuropharmacoligical, radioprotective effect, antimicrobial, antibacterial and antifungal properties. Forskohlin (diterpenoid) is an active compound in the tuberous roots of *Coleus forskohlii*, used as potential drug in respiratory disorders, hypertension, congestive heart failure, colic, eczema and painful urination because it helps in the production of compounds that relax the bronchial muscle. It has also traditional use as a vital medicine against asthma, angina, psoriasis and prevention of cancer metastasis. Medicinally important tuberous coleus species are *C. forskohli, C. amboinicus, C. blumei and C. malabaricus* and among these *C. forskohlii* is an important species yielding highest amount of forskohlin, used for treating different diseases. Ethanolic extract of *Coleus aromaticus* is reported to have anticlastogenic potency (Prasad *et al.* 2002) [86], nephroprotective activities, diuretic properties (Patel *et al.* 2010) [85]. Three components of rosmarinic acid, chlorogenic acid, caffic acid rosmarinic acid have been extracted from *C. aromaticus* with water showed strong DPPH radical scavenging activity (Shyama and Vijayalaxmi, 2002) [104].

2.5 Costus species

Costus is a traditional medicinal plant, having the habit of erect or spreading stem, producing perennial rhizome and belongs to the family, *Costaceae*. There are different species in *Costus* genus, but *Costus speciosus* is mostly exploited for its medicinal use in Ayurveda. Different parts of *Costus* used as traditional medicine, especially rhizomes are better used

for treatment of diabetes, abdominal pains, gall bladder pain, chest pains, liver problems and jaundice, fever, skin diseases, worm infection, leprosy, burning sensation and bronchitis (Sivarajan and Balachandran, 1994) [102].

2.5.1 Ethno-Pharmacology
Rhizomes are bitter in taste and exhibit anthelmintic, astringent, expectorant properties and also used in the treatment diabetes, herbal remedy for fever and treating boils. Leaves are used for treatment of scabies, stomach ailments and its paste applied to the fore head to bring down the fever.

2.5.2 Phytoconstituents
Saponins are reported in seeds, rhizomes and roots of Costus plant. Diosgenin, sitosterol, dioscin, gracillin, cycloartanol, cycloartenol, cycloalaudenol, costunolide, eremanthin were extracted from roots (Duraipandiyan *et al.* 2012) [28]. Various compounds like 5α-stigmasten-3b-ol, sitosterol-β-D-glucoside, dioscin, prosapogenins A and B of dioscin, gracillin and quinines was isolated from rhizomes and roots of costus (Mahato *et al.* 1980) [60]. Five new compounds such as tetradecyl 11-methyltridecanoate, tetradecyl 13-methylpentadecanoate, 14-oxotricosanoic acid, 14-oxoheptacosanoic acid and 15-oxooctacosanoic acid isolated from rhizomes (Madan Gupta *et al.* 1981) [59].

2.5.3 Phytochemistry
Two sesquiterpenoid compounds were isolated (costunolide and eremanthin) from the *Costus speciosus* hexane extract and showed antibacterial and antifungal activities against *Trichophyton mentagrophytes, T. simii, T. rubrum, T. rubrum, Epidermophyton floccosum, Scopulariopsis sp, Aspergillus niger, Curvulari lunata, Magnaporthe grisea* (Duraipandiyan *et al.* 2012) [28]. Sheikh *et al.* (2013) [103] extracted the β- L-arabinopyranose methyl glycoside phytochemical with antidiabetic activity from *C. pictus*.

2.5.4 Phytopharmacology
Antifungal activity of costunolide and eremanthin, the phytochemical compounds, derived from the rhizome of C. *speciosus* acts against dermatophytes has been reported for the first time Duraipandiyan *et al.* (2012) [28]. Costunolide is a sesquiterpenes compound, possessing various immunological and biological actions, hypolipidemic effect, antimicrobial effect and antioxidant activities (Saraf, 2010) [99]. *Costus speciosus* contains several compounds such as tigogenin, dioscin, gracillin β-sitosterol glucoside and also reported anti-cholinesterase activity, estrogenic activity, diuretic activity, anti-hyperglycaemic activity, anti-stress activity. *Costus igneus* (spiral flag and Pushkarmula in Sanskrit) is commonly referred as "insulin plant" grown in tropical regions of India. People in these areas are traditionally taking 2-3 leaves twice a day for controlling of diabetes (Sardessai *et al.* 2014) [98]. Akpan *et al.* (2012) [7] reported antimicrobial activity of *Costus afer* and also revealed the presence of tannins, flavonoids, saponins, cardiac glycosides terpenes and phlobatanins. *Costus pictus* commonly called as spiral ginger has been suggested as a magical cure for diabetes. *Costus igneous* ethanolic extract treated animals showed decrease in serum cholesterol & serum triglyceride, LDL along with increase in HDL as compared to diabetic control group (Palanivel *et al.,* 2013) [82] and hepatoprotective activity against paracetamol induced liver damage (Chacko and Shastry, 2012) [17]. Ijioma *et al.* (2014) [40] reported the anti-nociceptive property of *Costus afer* stem juice and ethanol leaf extract in albino rats.

2.6 Giant Taro
Giant Taro (*Alocasia macrorrhiza)* is an indigenous belonging to the family Araceae. Giant taro is an important starchy crop with medicinal and nutritive values.

2.6.1 Ethno-Pharmacology
Traditionally different parts of giant taro are being used in treatment of inflammations and leaves extract is used for treatment of many diseases.

2.6.2 Phytoconstituents
The presence of glycosides, tannins, alkaloids, organic acids, steroids, triterpenes, saponins, flavonoids, gallic acid, ascorbic acid, glycosides, cyanogenetic glucosides and alocasin etc. are reported in giant taro tubers Ellil (2014)[30].

2.6.3 Phytochemistry
Ellil (2014)[30] isolated and reported the ten compounds from *A. macorrhiza* rhizomes those are, β-Sitosterol, epi-Betulinic acid, epi-ursolic acid, Oleanolic acid, 5α, 8α-epi-Dioxyergosta-6,22-dien-3β-ol, 5-Hydroxy-1H-indole-3-carboxylic acid methyl ester, α-monopalmitin, 5-Hydroxy-1H-indole-3-(2-oxo-acetic acid), Alocasin B, Hyrtiosin B, β-sitosterol 3-O-β-D-glucoside and 1-O-β-D-glucopyranosyl-(2S,3R,4E,8Z)-2-[(2(R)- hydroxyctadecanoyl)amido]-4,8-octadecadiene-1,3-diol respectively.

2.6.4 Phytopharmacology
Mubeen *et al.* (2012) [66] studied laxative and diuretic properties of *Alocasia macrorrhiza* on albino rats. Preclinical studies on rats proved the traditional diuretic activity of fresh leaves of Giant Taro (Acharya *et al.* 2014) [3]. The ethanolic leaf extract of *A. macorrhiza* comprised of potential properties such as antioxidant, anti-inflammatory, antinociceptive, antimicrobial, antidiarrheal, free radical scavenging and antiprotozoal (Mubeen *et al.* 2012) [66]. Rhizome extract from *A. macorrhiza* showed moderate $ABTS^{+}$ scavenging activity (66.47%) as compared to the standard antioxidant ascorbic acid (87.45%) (Ellil, 2014) [30].

2.7 Starchy *Curcuma species*
Curcuma genus contains about 80 species of rhizomatous herbs, mainly starchy Curcuma species includes *Curcuma aeruginosa*, *C. amada*, *C. aromatica*, *C. brog*, *C. zedoaria*, *C. caesia*, *C. harita*,*C. leucorrhiza*, *C. malabarica*, *C. rakthakanta*, *C. sylvatica* (Angel, 2012) [10]. *Curcuma zedoaria* is an herbaceous and starchy rhizomatous plant belonging to the family Zingiberaceae and grows up to one and half meter or even more.

2.7.1 Ethno-Pharmacology
Rhizomes of *Curcuma aromatica* and *C. xanthorrhiza* are medicinally important species, widely used in India as a flavouring agent, tonic, carminative and used against snakebite (Chopra *et al.* 1941) [25]. Rural people used starchy curcuma species rhizomes for its digestive stimulant, rubefacient, expectorant, demulcent, diuretic, carminative and its root for treatment of cold, cough, fever, dyspepsia and infections.

2.7.2 Phytoconstituents
Starchy curcuma species contains diverse group of bioactive compounds such ascurcuminoids including curcumin [1, 7-bis-(4-hydroxy-3-methoxyphenyl)-1, 6-heptadiene-3, 5-Dione], turmerin (a water-soluble peptide), essential oils (such as turmerones, atlantones and zingiberene), flavonoids, steroids, phenols, glycoside, alkaloids, tannins and saponins (Tholkappiyavathi *et al*. 2013) [109].

2.7.3 Phytochemistry
Curcumin [1, 7-bis-(4-hydroxy-3-methoxyphenyl)-1, 6-heptadiene-3, 5-Dione] is the important compound present in the rhizomes of *Curcuma zedoaria* (White turmeric), *Curcuma manga* (Mango ginger), *Curcuma aromatica* (Wild turmeric), *Curcuma xanthorrhiza* (Ubatmaaju) and non-curcumin species include *C. amada, C. caesia, C. aeruginosa, C. amada, C. brog, C. malabarica, C. rakthakanta and C. sylvatica* (Lakshmi *et al.* 2011) [53].

2.7.4 Phytopharmacology
Essential oils extracted from *Curcuma zedoaria* tubers possess antibacterial properties and used in the treatment of colds and infections, carminative, digestive stimulant. Curuminoids are the novel compounds derived from *C. zedoaria* and have potential to fight against ovarian cancer cell lines (OVCAR-3) (Syu *et al.* 1998) [108]. Lakshmi *et al.* (2011) [53] reported the effect of isocurcumenol derived from *C. zedoaria* as potential inhibitor of cell proliferation of human lung, leukemia, nasopharyngeal carcinoma and murine lymphoma cells and highlighted the potential of isocurcumenol as a good anti-tumour agent. The white turmeric having wide range of properties such as carminative, demulcent, rubefacient, expectorant, diuretic and stimulant is used in many treatments like halitosis dermatosis disorders, diarrhoea, coryza, rheumatism, stomach diseases, hepato protection etc. and showed anti-amoebic activity, antibacterial activity, antifungal, anti-arthritic activity, anti-oxidant activity, anti-inflammatory activity, anticancer activity, anti-hyperlipidemic activity, anti-hyperglycemic activity, anti-microbial and analgesic activity (Lakshmi *et al.* 2011) [53]. *Curcuma aungustifolia* is medicinally important starch producing species, showing activities like anticancerous and hepatoprotective. Angel (2012) [10] showed the higher antioxidant activity correlation with the presence of higher phenols in the rhizomes as compared to leaves of *C. rakthakanta*, *C. aeruginosa*, *C. brog*, *C. malabarica* and *C. sylvatica*. Pharmacological studies in mice showed that, curcumenol derived from *Curcuma zedoaria* was effective agent against the analgesic effect on neurogenic pain and it confirmed/justified the traditional use of this plant against many treatment of dolorous processes (Navarro *et al.* 2002) [72].

2.8 Swamp taro
Swamp taro (*Cyrtosperma merkusii*) is the important staple food on Pacific atoll islands (Murti *et al.* 2010) [69] and volcanic islands of Micronesia (Bradbury and Holloway, 1988). The plants are large and grow to a height of 15-20 feet and are grown in swamp areas and fresh water marshes.

2.8.1 Ethno-Pharmacology
Swamp taro tubers are consumed in the cooked form, preferred cryptosperma as coarse-textured, compared to taro, giving a gritty feeling in the mouth.

2.8.2 Phytoconstituents
It is important staple food in many islands of pacific, nevertheless few studies not been conducted on swamp taro nutritional composition. Englberger *et al.* (2008) [32] reported the presence of carotenoids (b- and a-carotene, β-cryptoxanthin, lutein, zeaxanthin, and lycopene) and minerals (including iron, zinc, and calcium) in swamp taro cultivars.

2.8.3 Phytochemistry
Englberger *et al.* (2003) [32] screened 13 Kosrae and Pohnpei *Cyrtosperma* cultivars for β-carotene and other carotenoids and cultivars were found to be rich in β-carotene and other carotenoids in range of 50 to 2040 mg of β-carotene/100g. They screened 34 cultivars of *Cyrtosperma* for carotenoids (b- and a-carotene, β-cryptoxanthin, lutein, zeaxanthin, and lycopene) and minerals (including iron, zinc, and calcium), and the range of β-carotene was found to be 50 to 4486mg/100g.

2.9 Tacca species
Tacca species have been used in traditional Chinese medicine and Thai herbal medicine for the treatment of various ailments. The plant is a tuberous marshy perennial, belonging to the family Dioscoreacae and originated in Malaysia and the Pacific Islands (Purseglove, 1972) [91]. *Tacca* species find extensive use in ethnomedicine and ethnopharmacology and there are approximately 15 species such as *T. aspera*, *T. leontopetaloides*, *T. integrifolia*, *T. involucrata* (wild type), *T. chantrieri*, *T. paxiana*, *T. plantaginea*, *T. subflabellata*, *T. cheancer* and *T. chantrieri*etc.

2.9.1 Ethno-Pharmacology
Generally tubers are poisonous, but this can be removed by repeated soaking or washing or rinsing with water. Tubers are good sources of starch and medicinally important, containing steroidal saponins, ceryl alcohol and a bitter principle, Taccalin (Caddick *et al.*, 2002) [16]. *Tacca integrifolia* tubers are used in leprosy, haemorrhagic diathesis and skin diseases. *Tacca leontopetaloides* fresh tubers are acrid, bitter, poisonous possess rubefacient property, used in treatment of dysentery, piles and diarrhoea (Jagtap and Satpute, 2015) [42]. In Nigeria, traditionally tubers of *Tacca involucrata* consumed as food, as well as roots and flowers are used by local people for treatment of snake bite, hepatitis, worm infections and as aphrodisiac.

2.9.2 Phytoconstituents
Tacca leontopetaloides tubers are good sources of diverse classes of secondary metabolites such as flavonoids (rutin, diosmin, saponin, chlorogenic acid and quercetin), phenols, alkaloids, tannins, coumarins, polysaccharides, glycosides, gums, terpenes, terpenoids, a bitter principle *i.e.* taccalin (Caddick *et al.* 2002) [16], steroids viz., taccalonolides, withanolides and their glucosides.

2.9.3 Phytochemistry
Tacca species gained the attention because of the presence of taccalonolides, withanolides etc. which are used as potential anticancer agents. Jagtap and Satpute (2015) [42] investigated the biochemical and ethnopharmacological significance of *Tacca leontopetaloides* and recorded the presence of flavonoids such as rutin, diosmin, saponin, chlorogenic acid and quercetin in tubers.

2.9.4 Phytopharmacology
Keardrit *et al.* (2010) [47] studied the analgesic, antipyretic and anti-inflammatory effects of *T. chantrieri* and confirmed the ethnomedical use. The disintegrate property of *Tacca involucrate* starch extracted from tubers was demonstrated by Ofoefule (1998) [79].

2.10 *Typhonium* species
Typhonium flagelliforme generally referred as rodent plant in Malaysia. This plant is traditionally used by Malaysian people for treatment of cancer, because some of compounds from plant have been identified as anticancer.

2.10.1 Ethno-Pharmacology
Chinese and Filipinos have used flowers of *Typhonium flagelliforme* as anticoagulant and leaves as well as tubers exhibited antibacterial properties. It has been used in many traditional medicines to treat various problems particularly by the tribal people such as treatment for snake bite, gastric ulcer, head ache, asthma, swelling, vomiting, cough, skin eruptions, diarrhoea and dysentery (Ali *et al.* 2012) [9].

2.10.2 Phytoconstituents
Typhonium species are having sound sources of phytochemicals such as alkaloids, steroids, flavonoids and terpenoids in different plant parts.

2.10.3 Phytochemistry
Isovitexin, a flavonoid glycoside has been isolated from *Typhonium flagelliforme,* showed antioxidant activity.

2.10.4 Phytopharmacology
Mohan *et al.* (2008) [64] studied the antibacterial and antioxidant activities of *Typhonium flagelliforme* and reported to possess valuable anti-leukemic effects, anti-ulcerogenic activity of aqueous leaf extract was also reported against ethanol-induced gastric mucosal injury in rats (Bardi *et al.* 2011) [12]. Pharmacological studies in rats showed that it has capacity to prevent hepatocarcinogenesis, anti-infammatory, analgesic and anti-diarrheal activity activities of leaf extract of *Typhonium trilobatum* has been reported to support the ethnopharmacological uses of this plant. Alfarabi *et al.* (2015) [8] studied the anti-proliferation activity of lectin (tuber protein) from *Typhonium flagelliforme,* and referred it as a potential material for breast cancer treatments. Farida *et al.* (2012) isolated a flavonoid glycoside, isovitexin has antioxidant activity (DPPH free radical scavenging) with IC50 34.39µg/mL and cytotoxic activity using BSLT (LC50 15.84µg/mL). Analgesic, anti-inflammatory and anti-diarrheal activities of ethanolic leaf extract of *Typhonium trilobatum* has been studied by Ali *et al.* (2012) [9], that supports the ethnopharmacological uses of plant. Roy *et al.* (2012) [95] reported the potential wound healing activity of the different extract of *Typhonium trilobatum* in albino rats, among different extracts methanolic and ethyl acetate extract were found effective against wounding healing activity compared to chloroform extract in terms of breaking strength incision model.

2.11 Yam bean
Yam bean (*Pachyrhizus erosus*) commonly called as as jicama or Mexican yam bean or Mexican turnip, belongs to the family Leguminosae, native to North America. Total 6 species are grown for its edible tuberous tubers, but *P. erosus, P. tuberous, P. aphipa* are important.

2.11.1 Ethno-Pharmacology
It Yam bean produces the edible tuberous roots. Seeds contains high protein and oil, used to treat worms and powdered seed is applied to treat the prickly heat during summer months especially in Java, skin eruptions and as fish poison (Perry and Metzger, 1980) [88] and know to contain wide number of phytochemicals such as flavonoids, rotinoids and phenylfuranocoumarin.

2.11.2 Phytoconstituents
Even though yam bean seeds are rich sources of protein; they are not used for consumption because of presence of toxic rotenone.

2.11.3 Phytopharmacology
Presence of rotenone in the pods enables their use as potent insecticidal material (toxic to insect pests), showed potential antitumor activity and antifungal activity. Abid *et al.* (2006) [1] screened ethanol and chloroform extracts of *Pachyrrhizus erosus* seeds for central nervous system (CNS) depressant activity and results showed that ethanol extract of the seeds (150 mg/kg, p.o) decreased locomotor activity, produced muscle relaxation and showed anti-anxiety and anti-aggressive activity. Widyarman *et al.* (2014) [110] studied effects of *Pachyrhizus erosus* juice in hampering blood glucose in rat models and conclude that there was no effect on hampering blood glucose levels.

2.12 Wild yam species
Wild yam species includes *Dioscorea belophylla, D. villosa, D. opposite, D. japonica, D. nipponica, D. caucasia, D. transversa, D. dregeana, D. dumetorum, D. rupicola, Dioscorea hispida, Dioscorea pentaphyla, Dioscorea deltoidea, D. prazeri, D. floribunda* and *D. composita.*

2.12.1 Ethno-Pharmacology
Tuber extract from wild yam species has been used for rheumatoid arthritis, stomach cramps, and pain from gallstones, menstrual cramps and discomfort, relieve labour pains, dysmenorrhoea, intestinal colic, treat scabies, boils, and relieve the pain of childbirth. Dioscorea species possess profound therapeutic uses and consumed as food especially by the tribal people, apart from that these are mainly used for medicinal purposes to cure many dolorous processes.

2.12.2 Phytoconstituents
Sheikh *et al.* (2013) [103] screened different Dioscorea species for phytochemiclas and confirmed the presence of wide classes of phytochemicals such as flavonoids, alkaloids, terpenoids, cardiac glycoside, steroids and saponins.

2.12.3Phytochemistry
The *Dioscorea hispida* tuber peel is rich source of many phenolics compounds like caffeic acid, chlorogenic acid, phydroxybenzaldehyde and methylester of protocatechuic acid (methoxyprotocatechuate), these compounds are useful as dietary antioxidants to serve as a protective factor against oxidative cellular damage.

2.12.4 Phytopharmacology
Wild yam species possess various useful properties such as antispasmodic, aphrodisiac, purgative, anti-helminthic, deflatulent, rejuvenating, antioxidant activities, anti-inflammatory activity, anti-phlogistic effect and antibacterial

activity. Catechin and other phenolic compounds present in *Dioscorea bulbifera* might be the responsible for the treatment of human cancer and flavonoids to the anti-tumor promoting activity. *D. villosa* has potential therapeutic uses such as relieving gas and pains of the bowels, labour pain during delivery (Moerman, 1998) [63]. Adeniran and Sonibare (2013) [4] reported on anti-helminthic activity of *D. bulbifera* in Nigeria and confirmed the ethnomedicinal uses of this plant by rural people, it also showed anti-hyperglycemic and anti-dyslipidemic activity (Ahmed *et al.*, 2009) [6].

2.13 Winged bean

Winged beans (*Psophocarpus tetragonolobus*) are versatile edible legumes of tropical origin, belonging to the family, Fabaceae.

2.13.1 Ethno-Pharmacology

It serves as root vegetable as well as it produces the edible leaves, shoot, pods, flowers and seeds. Winged beans are bountiful sources of minerals, fibre, vitamin C, vitamin A. Rural people are consuming the leaves and seed to cure skin sores such as boils and ulcers (Perry, 1980) [89].

2.13.2 Phytoconstituents

The most remarkable feature of winged bean tubers is that they are rich sources of protein, starch and B-complex vitamins (Thiamin, pyridoxine (vitamin B-6), niacin, and riboflavin). It is reported that 100g tuber provides 11.6 g of protein on comparison to 2.02 g/100 g and 1.36 g/100 g protein content in potato and cassava respectively. Immature pods of winged bean are commonly used as very low calorie vegetables that contains 49 calorie per 100g beans but mature beans comprise of high calorie content and high in protein content that equivalent to soy bean protein (Garcia and Palmar, 1980) [37].

2.13.3 Phytochemistry

Mohanty *et al.* (2013) [65] quantified the total polyphenols, flavonoids and tannins in *P. tetragonolobus* and revealed the highest percentage presence of kaempferol (1.07 - 790.5µg/g) and the lowest percentage of gallic acid (0.09 - 3.49µg/g) in the seeds.

2.13.4 Phytopharmacology

Latha *et al.* (2007) [54] reported the antimicrobial activities and toxicity of crude extract of the *Psophocarpus tetragonolobus* pods, suggested that pods are potential sources of novel antimicrobial compounds and high LC_{50} value signified that this plant is not toxic to human.

2.14 Blue Taro

Blue taro (*Xanthosoma violaceum*) is herbaceous perennial plant belonging to the family, Araceae. It is commonly cultivated for tubers as well as leaves in many tropics; it produces arrow shaped leaves from tubers. Nevertheless less information is available on phytoconstituents, phytochemistry and pharmacological studies.

2.14.1 Ethno-Pharmacology

Tubers are peeled and consumed after boiling as potatoes in different places of Kerala, India. Young leaves and petioles are eaten as spinach after chopping and cooked, eaten.

2.14.2 Phytoconstituents

Blue taro showed the high levels of phenolics compounds especially flavones, whose effectiveness as antioxidant agents (Rice-Evans *et al.* 1997) [94].

2.14.3 Phytochemistry

Picerno *et al.* (2003) [90] studied the polyphenol profile determination including total polyphenols, isolated the new flavone C-glycoside, apigenin 6-C-â-D-glucopyranosyl-8-C-â-D-apiofuranoside, as well as known flavone C-glycosides, including vitexin, isovitexin, isovitexin 4′-Orhamnopyranoside, apigenin 6-C-[â-D-glucopyranosyl-(1f6)-â-D-glucopyranoside] and apigenin 6,8-diC-â-D-glucopyranoside.

2.14.4 Phytopharmacology

The blue taro leaves were showed the antioxidant which has free radical scavenging properties due to the presence of the high phenolic content (Picerno *et al.* 2003) [90].

2.14.5 Conclusions

In conclusion, most of these minor and under-utilized tuber crops are very rich in nutrients, bioactive medicinal compounds and source for many food and industrial starches. These crops continue to play an important role in the tribal communities, especially as primary diet and medicine in their critical times. Their immense potential could be explored for therapeutic purpose and /or as precursors for the synthesis of powerful and useful novel drugs. These crops being affordable to the poor people and hence the nutritional balance could be easily achieved. But minor tubers have remained underutilized due to lack of knowledge and awareness among people about their important role in human health. They have great potential and warrant future studies for the characterization of active compounds and their scientific validation as well as effective development of new promising leads in indigenous medicine sector.

3. Acknowledgements

The authors are thankful to the Dr. G. Padmaja, Emeritus Scientist, ICAR-CTCRI, Trivandrum, Kerala, India for helpful comments and fruitful discussions.

4. References

1. Abid M, Hrishikeshavan HJ, Asad M. Pharmacological evaluation of *Pachyrrhizus erosus* seeds for central nervous system depressant activity. Indian J Physiology and Pharmacology. 2006; 50(2):143-151.
2. Abraham M, Radhakrishnan VV. Assessment and induction of variability in coleus (*Solenostemon rotundifolius*). Indian Journal Agricultural Sciences. 2005; 75:834-836.
3. Acharya SD, Kateel R, Shenoy R, Sheetal D, Pai PG. Evaluation of the Diuretic Activity of Alocasia macrorrhizos in Rats. Research Journal of Pharmaceutical, Biological and Chemical Sciences. 2014; 2:1358-1362.
4. Adeniran AA, Sonibare MA. *In vitro* potential anthelmintic activity of bulbils of *Dioscorea bulbifera* L. on earthworms and liver flukes. Journal of Pharmacognosy and Phytotherapy. 2013; 5(12):196-203.
5. Adibatti NA, Thirugnanasambantham P, Kuilothngan C. A pyridine alkaloid from *Ceropegia juncea.* Phytochemistry. 1991; 30:2449-2450.

6. Ahmed Z, Chishti MZ, Johri RK, Bhagat A, Gupta KK, Ram G. Anti-hyperglycemic and anti-dyslipidemic activity of aqueous extract of *Dioscorea bulbifera* tubers. Diabetologia Croatica, 2009, 38-3.
7. Akpan MM, Odeomena CS, Nwachukwu CN, Danladi B. Antimicrobial assessment of ethanolic extract of *Costus afer* leaves. Asian Journal of Plant Science Research. 2012; 2:335-34.
8. Alfarabi M, Rosmalawati S, Bintang M, Miftahudin Elrade R, Chaidir. Antiproliferation activity of tuber protein from *Typhonium flagelliforme* (Lord.) blumei on MCF-7 cell line. International Journal of Biosciences. 2015; 6:52-60.
9. Ali K, Ashraf A, Biswas NN. Analgesic, anti-inflammatory and anti-diarrheal activities of ethanolic leaf extract of *Typhonium trilobatum* L. Schott. Asian Pacific Journal of Tropical Biomedicine. 2012; 2(9):722-729.
10. Angel GR, Vimala B, Nambisan B. Phenolic content and antioxidant activity in five underutilized starchy *Curcuma species*. International Journal of Pharmacognosy and Phytochemical Research. 2012; 4(2):69-73.
11. Badmaev V, Majeed M, Conte A, Parker JE. Diterpene forskolin: a possible new compound for reduction of body weight by increasing lean body mass. Townsend Letter, 2001, 115.
12. Bardi DAA, Sarah Khan MA, Sabri SZ, Kadir FA, Mahmood AA, Zahra AA, Suzy M, Al-Hanhana M, Al-Magrami A. Anti-ulcerogenic activity of *Typhonium flagelliforme* aqueous leaf extract against ethanol-induced gastric mucosal injury in rats. Scientific Research and Essays. 2011; 6(15):3232-3239.
13. Brackenridge, Betty, Richard Rubin. Sweet Kids: How to Balance Diabetes Control and Good Nutrition with Family Peace, 2nd ed., Alexandria, VA: American Diabetes Association, 2002.
14. Bradbury JH, Holloway WD. Chemistry of Tropical Root Crops: Significance for Nutrition and Agriculture in the Pacific. Australian Centre for International Agricultural Research, Canberra, Australia, 1988.
15. Brown D. Aroids, Plants of the Arum Family. Timber Press, Portland, Oregon, 2000.
16. Caddick RL, Rudall WP, Hedderson AJ, Chase MW. Yams reclassified: Are circumscription of Dioscoriaceae and Dioscoreales. Taxon. 2002; 51:103-114.
17. Chacko N, Shastry CS. Hepatoprotective activity of *Costus igneus* against Paracetamol induced liver damage. International Journal of Advances in Pharmacy, Biology and Chemistry. 2012; 1(2):247-251.
18. Chan K, Chua M, Baldwin TC, Hocking TJ. Traditional uses and potential health benefits of *Amorphophallus konjac*. Journal of Ethnopharmacology. 2010; 128:268-278.
19. Chee YC, Kit LC, Teng WS, Yukio H, Koichi T. The cytotoxicity and chemical constituents of the hexane fraction of Typhonium *flagelliforme* (Araceae). Journal of Ethnopharmacology. 2001; 77:129-131.
20. Chen HL, Sheu WH, Tai TS, Liaw YP, Chen YC. Konjac supplement alleviated hypercholesterolemia and hyperglycemia in type-2 diabetic subjects- a randomized double blind trial. Journal of the American College of Nutrition. 2003; 22(1):36-42.
21. Chen HL, Cheng HC, Liu YJ, Liu SY, Wu WT. Konjac acts as a natural laxative by increasing stool bulk and improving colonic ecology in healthy adults. Nutrition. 2006; 22:1112-1119.
22. Chen ZL, Wang BD, Chen MQ. Study on the bitter principles from Tacca plants: structures of taccalonolides A and B. Acta Chimca Sinca. 1988; 46:1201-1206.
23. Chen ZL, Shen JH, Gao YS, Wicht M. Five taccalonolides from Tacca plantaginea. Planta Medica. 1997; 63:40-43.
24. Choo CY, Chan KL, Takeya K, Itokawa H. Cytotoxic activity of *Typhonium flagelliforme* (Araceae). Phytotherapy Research. 2001a; 15(3):260-262.
25. Chopra RN, Gupta JC, Hopra GS. Pharmacological action of the essential oil of *Curcuma longa*. Indian Journal of Medical Research. 1941; 29:769-772.
26. Chuakul W. Encyclopedia: Medicinal plants, Vol. 2. Bangkok: Department of Pharmaceutical Botany, Faculty of Pharmacy, Mahidol University, 2000, 207.
27. Devaraj S, Esfahani AS, Ismail S, Ramanathan S, Yam MF. Evaluation of the Antinociceptive Activity and Acute Oral Toxicity of Standardized Ethanolic Extract of the Rhizome of *Curcuma xanthorrhiza* Roxb. Molecules. 2010; 15:2925-2934.
28. Duraipandiyan V, Al-Harbi NA, Ignacimuthu S, Muthukumar C. Antimicrobial activity of sesquiterpene lactones isolated from traditional medicinal plant, *Costus speciosus* (Koen ex. Retz.) Sm. BMC Complementary and Alternative Medicine. 2012; 12:13. http://www.biomedcentral.com/1472-6882/12/13.
29. Dutta S. Essential oil of *Coleus aromaticus* of Indian origin, Indian Oil and Soap Journal. 1959; 25:120.
30. Ellil MEAA. Phytochemical and Biological Study of Some Plants Belonging to Family Araceae. Ph. D thesis submitted to the Department of Pharmacognosy, Mansoura University, 2014.
31. Englberger L, Aalbersberg W, Ravi P, Bonnin E, Marks GC, Fitzgerald MH *et al.* Further analyses on Micronesian banana, taro, breadfruit and other foods for provitamin-A carotenoids and minerals. Journal of Food Composition and Analysis. 2003; 16:219-236.
32. Englberger L, Schierle J, Kraemer K, Aalbersberg W, Dolodolotawake U, Humphries J *et al.* Carotenoid and mineral content of Micronesian giant swamp taro (*Cyrtosperma*) cultivars. Journal of Food Composition and Analysis. 2008; 21:93-106.
33. Ezeocha VC, Ojimelukwe PC. The impact of cooking on the proximate composition and anti-nutritional factors of water yam (*Dioscorea alata*). Journal of Stored Products and Postharvest Research. 2012; 3(13):172-176.
34. Farida YP, Wahyudi S, Wahono S, Hanafi M. Flavonoid glycoside from the ethyl acetate extract of keladitikus *Typhonium flagelliforme* (Lodd) Blume leaves. Asian Journal of Natural and Applied Sciences. 2012; 4(1):16-21.
35. Gao H, Kuroyanagi M, Wu L, Kawahara N, Yasuno T, Nakamura Y. Anti-tumorpromoting constituents from *Dioscorea bulbifera* L. In JB6 mouse epidermal cells. Biological and Pharmaceutical Bulletin. 2002; 25:1241-1243.
36. Gao H, Wu L, Kuroyanagi M. Seven compounds from *D. bulbifera* L. Natural Medicines. 2001; 55(5):277.
37. Garcia VV, Palmar O. Proximate analysis of five varieties of Winged beans. Journal of Food Technology. 1980; 15:469-476.
38. Ghosh S, Ahire M, Patil S, Jabgunde A, Dusane MB, Joshi BN *et al*. Antidiabetic activity of *Gnidia glauca* and

Dioscorea bulbifera: potent amylase and glucosidase inhibitors. Evidence-Based Complementary and Alternative Medicine, 2012; doi:10.1155/2012/92905.
39. Hansberry R. Variations in the chemical composition and insecticidal properties of the yam bean (*Pachyrrhizus*). Journal of Agricultural Research. 1947; 74(2):55-64.
40. Ijioma SN, Nwosu CO, Emelike CU, Okafor AI, Nwankwo AA. Antinociceptive property of *Costus afer* Ker stem juice and ethanol leaf extract in albino rats. Comprehensive Journal of Medical Sciences. 2014; 2(2):14 -19.
41. Israr F, Hassan F, Naqvi BS, Azhar I, Jabeen S, Hasan SMF. Studies on antibacterial activity of some traditional medicinal plants used in folk medicine. Pakistan Journal of Pharmaceutical Sciences. 2012; 25(3):669-74.
42. Jagtap S, Satpute R. Chemical fingerprinting of flavonoids in tuber extracts of Tacca leontopetaloides. Journal of Academia and Industrial Research. 2015; 3(10):485-489.
43. Jain SK, Defillips RA. Asclepiadaceae. In: Medicinal plants of India. Algonac, India. 1991; 1:89-94.
44. Kalimuthu K, Prabhakaran R. Phytochemical screening and GC-MS analysis of methanol extract of *Ceropegia pusilla in vitro* tuber. International journal of inventions in pharmaceutical sciences. 2013:1(4):376-383.
45. Kalimuthu K, Prabakaran R, Saraswathy M. *In vitro* Anticancer Activity of Ethanolic Extract of *In vitro* and *In vivo* Tuber of *Ceropegia Pusilla* Wight and Arn. International Journal of Pure and Applied Bioscience. 2014; 2(4):82-87.
46. Kawanding OJ, Abdullah N, Noor ZM, Hashim N, Saari N, Yahya MFZR, *et al*. Genotoxicity and Cytotoxicity Evaluation of Winged Bean (*Psophocarpus tetragonolobus*) Protein Hydrolysate. International Conference on Food, Ecological and Life Sciences (FELS-2015) June 15-16, 2015 Bangkok (Thailand).
47. Keardrit K, Rujjanawate C, Amornlerdpison D. Analgesic, antipyretic and anti-inflammatory effects of *Tacca chantrieri*. Journal of Medicinal Plants Research. 2010; 4(19):1991-1995.
48. Keithley J, Swanson B. Glucomannan and obesity: a critical review. Alternatives Therapies in Health and Medicine. 2005; 11:30-34.
49. Khalili RMA, Shafekh SE, Norhayati AH, Fatahudin IM, Rahimah R, Norkamaliah H *et a*l. Total phenolic content and *in vitro* antioxidant activity of winged bean (*Psophocarpus tetragonolobus*). Pakistan Journal of Nutrition. 2013; 12(5):416-422.
50. Khare CP. Indian Medicinal Plants: an Illustrated Dictionary Published by Springer-Verlag Berlin/Heidelberg, 2007, 181-182.
51. Kirtikar KR, Basu BD. Indian Medicinal Plants Vol.**3**.
52. Kumalasari ID, Harmayani E, Lestari LA, Raharjo S, Asmara W, Nishi K, Sugahara T. Evaluation of immunostimulatory effect of the arrowroot (*Maranta arundinacea*. L) *In vitro* and *In vivo*. Cytotechnology. 2012; 64:131-137.
53. Lakshmi S, Padmaja G, Remani P. Anti-tumour Effects of Isocurcumenol Isolated from *Curcuma zedoaria* Rhizomes on Human and Murine Cancer Cells. International Journal of Medical Chemistry, 2011. doi:10.1155/2011/253962.
54. Latha LY, Sasidharan S, Zuraini Z, Suryani S, Shirley, L, Sangetha S, *et al.* Antimicrobial activities and toxicity of crude extract of the *Psophocarpus tetragonolobus* pods. African Journal of Traditional. 2007; CAM 4(1):59-63.
55. Lebot V. Tropical root and tuber crops. Soil, plant growth and crop production, 2009, 2.
56. Lee J, Jung Y, Hwa Shin J, Kyoung Kim H, Cheol Moon B, Hyun Ryu D *et al*. Secondary metabolite profiling of *Curcuma Species* grown at different locations using GC/TOF and UPLC/Q-TOF MS. Molecules. 2014; 19:9535-9551.
57. Li B, Xia J, Wang Y, Xie BJ. Grain-size effect on the structure and anti-obesity activity of konjac flour. Journal of Agricultural and Food Chemistry. 2005; 53:7404-7407.
58. Long CL, Li H, Ouyang ZQ, Yang XY, Li Q, Trangmar B. Strategies for agrobiodiversity conservation and promotion: a case from Yunnan, China. Biodiversity and Conservation. 2003; 12:1145-1156.
59. Madan Gupta M, Ram Lal N, Yogendra Shukla N. 5α-stigmast -9(11)-en-3β-ol, a sterol from *Costus speciosus* roots. Phytochemistry. 1981; 20:2257-2259.
60. Mahato SB, Sahu NP, Ganguly AN. Carbon-13 NMR Spectra of Dioscin and Gracillin isolated from *Costus speciosus*, Indian Journal of Chemistry. 1980; 19B:817-819.
61. Mishra T, Goyal AK, Middha SK, Sen A. Antioxidant properties of *Canna edulis* Ker-Gawl. Indian Journal of Natural products and resources. 2011; 2(3):315-321.
62. Misra RS. Konjac needs domestication, Indian Horticulture, May-June. 2013; 58(3):22-24.
63. Moerman DE. Native American ethnobotany. Portland, OR: Timber Press, 1998.
64. Mohan S, Abdul AB, Wahab SIA, Al-Zubairi AS. Antibacterial and antioxidant activities of *Typhonium flagelliforme* (Lodd) Blume tuber. American Journal of Biochemistry and Biotechnology. 2008; 4:402-7. doi: 10.3844/ ajbbsp.2008.402.407.
65. Mohanty CS, Verma S, Singh V, Khan S, Gaur P, Gupta P *et al*. Characterization of winged bean (*Psophocarpus tetragonolobus* (L.) DC.) based on molecular, chemical and physiological parameters. American Journal of Molecular Biology. 2013; 3:187-197.
66. Mubeen US, Vimlesh M, Santanu B. Laxative and diuretic property of ethanolic extract of leaves of Alocasia macrorrhiza LINN. On albino rats. International Research Journal on Pharmacy. 2012; 3(2):174-176.
67. Muniyandi SK, Nandanan AT, Veeti SC, Narayanan A, Ganesan B. Studies on *Costus speciosus* Koen Alcoholic Extract for Larvicidal Activity. International Journal of Pharmacognosy and Phytochemical Research. 2013; 5(4):328-329.
68. Murugesan S, Rajeshkannan C, Sumathi R, Manivachakam P, Suresh Babu D. Bioactivity of root hexane extract of Coleus forskohlii Briq. Labiatae; GC/MS/MS Characterization and identification. European Journal of Experimental Biology. 2012; 2(5):1469-1473.
69. Murti K, Panchal MA, Lambole V, Gajera V. Pharmacological properties of *Amorphophallus konjac*- a review. Pharmacology. Newsletter, 2010, 1017-1023.
70. Nadkarni KM. Indian Materia Medica. Popular Prakasha, Bombay, India, ISBN. 1976; 81-7154-144-5:303-304.
71. Nambisan B, Angel GR, Vimala B. Antioxidant and anti-inflammatory effect of proteins isolated from eight species of *Curcuma*. Phytopharmacology. 2013; 4(1):96-105.

72. Navarro DF, Souza MM, Neto RA, Golin V, Niero R, Yunes RA *et al*. Phytochemical analysis and analgesic properties of *Curcuma zedoaria* grown in Brazil. Phytomedicine. 2002; 9:427-432.
73. Neviani P, Santhanam R, Trotta R, Notari M, Blaser BW, Liu S. The tumor suppressor PP2A is functionally inactivated in blast crisis CML through the inhibitory activity of the BCR/ABL regulated SET protein. Cancer Cell. 2005; 8:355-68.
74. Nishaa S, Vishnupriya M, Sasikumar JM, Gopalakrishnan VK. Phytochemical screening and GC-MS analysis of ethanolic extract of rhizomes of *Maranta arundinacea*. Research Journal of Pharmaceutical, Biological and Chemical Sciences. 2013; 4(2):52-59.
75. Nishaa S, Vishnupriya M, Sasikumar JM, Hephzibah P, Christabel, Gopalakrishnan VK. Antioxidant activity of ethanolic extract of *Maranta arundinacea* tuberous rhizomes. Asian Journal of Pharmaceutical and Clinical Research. 2012; 5(4):86-88.
76. Nishanthini A, Mohan VR. Antioxidant activities of *Xanthosoma sagittifolium* Schott using various *in vitro* assay models. Asian Pacific Journal of Tropical Biomedicine, 2012, S1701-S1706.
77. Nishinari K, Yoshimura M. Dynamic viscoelastic study on the gelation of Konjac glucomannan with different molecular weights. Food Hydrocolloids. 1999; 13:227-233.
78. Niwa T, Etoh H, Shimizu A, Shimizu Y. Cis-N-(p-Coumaroyl) serotonin from Konnyaku, *Amorphophallus konjac* K. Koch. Bioscience. Biotechnology and Biochemistry. 2000; 64:2269-2271.
79. Ofoefule SI. Studies on tabletting properties of Tacca involucrate starch. Bollettino chimico farmaceutico. 1998; 6:218-222.
80. Okimasu S, Kishida N. Hiroshima Joshi Daigaku, Kaseigakubu Kiyo 13, 1 (in Japanese), 1982.
81. Onishi N, Kawamoto S, Nishimura M, Nakano T, Shigeta S, Hashimoto K. The ability of konjac-glucomannan to suppress spontaneously occurring dermatitis in NC/Nga mice depends upon the particle size. Biofactors. 2004; 21:163-166.
82. Palanivel V, Mohamed Jihad EV, Senthil Kumar KL. Evaluation of hypoglycemic activity of *Costus igneus* extract (whole plant) on alloxan induced diabetic rats. International journal of advanced pharmaceutical genuine research. 2013; 1(2):9-19.
83. Prabakaran R, Kalimuthu K, Vani C, Brindha C. Angiogenesis and Antioxidant Activity of *in vitro* and *in vivo* Tuber of *Ceropegia pusilla* Wight and Arn. British Journal of Pharmaceutical Research. 2014; 4(5):608-616.
84. Parra AL, Yhebra RS, Sardinas IG, Buela LI. Comparative study of the assay of *Artemia salina* L. and the estimate of the medium lethal dose (LD50 value) in mice, to determine oral acute toxicity of plant extracts. Phytomedicine. 2001; 8(5):395-400.
85. Patel R, Mahobia N, Gendle R, Kaushik B, Singh S. Diuretic activity of leaves of *Plectranthus amboincus* in male albino rats. Pharmacognosy Research. 2010; 2:86-88.
86. Prasad SS, Naik P, Vijayalaxmi KK. Efficiency of *Coleus aromaticus* extract in modifying cyclophosphamide and mitomycin-C induced clastogenicityin mouse bone marrow cells. Journal of Experimental Biology. 2002; 40(9):1020-25.
87. Prashanth K, Shiddamallayya N. Documentation of wild plant tubers as food resources in Hassan district, Karnataka. International Journal Applied biology pharmaceutical technology. 2014; 5(2):90-95.
88. Perry LM. Medicinal Plants of East and Southeast Asia. The MIT Press, Cambridge, USA, 1980, 231.
89. Perry LM, Metzger J. Medicinal Plants of East and South East Asia: Attributed Properties and Uses. MIT Press. Cambridge, Massachusetts, USA, 1980, 221.
90. Picerno P, Mencherini T, Lauro MR, Barbato F, Aquino R. Phenolic constituents and antioxidant properties of *Xanthosoma violaceum* leaves. Journal of Agricultural and Food Chemistry. 2003; 51:6423-6428.
91. Purseglove JW. Taccaceae. Tropical Crops. Monocotyledons 2, 1st Ed., Longman Group Ltd., London, United Kingdom, 1972.
92. Rahman M, Hossain A, Siddique SA, Biplab KP, Uddin H. Anti-hyperglycemic, antioxidant, and cytotoxic activities of *Alocasia macrorrhizos* (L.) rhizome extract. Turkish Journal of Biology. 2012; 36:574-579.
93. Rahman K, Md Rahman AU, Md Rahman MT, Chowdhury A, Md Uddin MF and Sumi CD. Evaluation of antidiarrheal activity of methanolic extract of *Maranta arundinacea* Linn. leaves. Advances in Pharmacological Sciences, 2015. http://dx.doi.org/10.1155/2015/257057.
94. Rice-Evans CA, Miller NJ, Paganga G. Antioxidant properties of phenolic compounds. Trends Plant Science. 1997; 2:152-159.
95. Roy SK, Mishra PK, Nandy S, Datta R, Chakraborty B. Potential wound healing activity of the different extract of Typhonium trilobatum in albino rats. Asian Pacific Journal of Tropical Biomedicine, 2012, S1477-S1486.
96. Sandhya C, Vijayalakshmi NR. Antioxidant activity of flavonoids from *Solenostemon rotundifolius* in rats fed normal and high fat diets. Food Research International. 2005: 38:615-629.
97. Sanjay J, Rajendra S. Phytochemical Screening and Antioxidant Activity of Tuber Extracts of *Tacca pinnatifida* J.R. & J.G. Forest. International Journal of Recent Trends in Science and Technology. 2014; 9(3):389-396.
98. Sardessai Y, Angle GP, Joshi A, Carvalho S, Bhobe M. Antimicrobial Activity of Methanolic Extract of the Rhizomes of *Costus igneus.* Journal of Pharmaceutical, Chemical and Biological Science. 2014; 2(3):176-185.
99. Saraf A. Phytochemical and Antimicrobial Studies of Medicinal Plant *Costus speciosus* (Koen.). E-Journal of Chemistry. 2010; 7(S1):S405-S413. http://www.e-journals.net.
100. Selima K, Chatterjee NC, Cakilcioglu U. Antioxidant activity of the medicinal plant *Coleus forskohlii* Briq. African Journal of Biotechnology. 2011; 10(13):2530-2535.
101. Sianipar NF, Maarisit W, Valencia A. Toxic activities of hexane extract and column chromatography fractions of rodent plant (*Typhonium flagelliforme*). Indonesian Journal of Agricultural Sciences. 2013; 14(1):1-6.
102. Sivarajan, Balachandran, Ayurvedic drugs and their plant sources. Oxford and IBH Publishing, 1994.
103. Sheikh N, Kumar Y, Misra AK, Pfoze L. Phytochemical screening to validate the ethnobotanical importance of root tubers of *Dioscorea* species of Meghalaya, North East India. Journal of Medicinal Plants Studies. 2013; 1(6):62-69.

104. Shyama PS, Naik P, Vijayalaxmi KK. Efficiency of Coleus aromaticus extract in modifying cyclophosphamide and mitomycin-C induced clastogenicity in mouse bone marrow cells. Journal of Experimental Biology. 2002; 40:1020-1025.
105. Soni H, Singhai AK. Recent updates on the genus coleus: a review. Asian Journal of Pharmaceutical and Clinical Research. 2012; 5(1):12-17.
106. Stopp K. The medicinal used by the Mt. Hagen people (mbowamb) in New Guinea. Economic Botany. 1962; 17:16-22.
107. Sujatha S, Renuga FB. Medicinal and edible tubers from fourty two settlements of tribals from Pechiparai social forest in Kanyakumari District, India. Scholars Academic Journal of Biosciences. 2013; 1(5):213-216.
108. Syu WJ, Shen CC, Don MJ, Ou JC, Lee GH, Sun CM. Cytotoxicity of curcuminoids and some novel compounds from *Curcuma zedoaria*, Journal of Natural Products. 1998; 61(12):1531-1534.
109. Tholkappiyavathi K, Selvan MK, Neyanila SK, Yoganandam GP, Gopal V. A concise review on *Curcuma zedoaria*. International Journal of Phytotherapy. 2013; 3(1):1-4.
110. Udem SC, Ezeasor CK. The acute and subchronic toxicity studies of aqueous leaf and stem bark extract of Costus afer ker (Zingiberaceae) in mice. Comp Clin Pathol. 2010; 19:75-80.
111. Widyarman AD, Nurdiamah E, Soetedjo NNM. Effects of bengkoang (*Pachyrhizus erosus* juice in hampering blood glucose in rat models. Althea Medical Journal. 2014; 1(1):25-29.