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Abstract:	Colocasia esculenta (C. esculenta) is a widely cultivated plant for consumption of both leaves and tubers. Taro, a common name for the corms and tubers of several genera of the family Araceae, is a source of edible corms of C. esculenta. It is majorly cultivated in Southeast Asia by several common names like Arbi, Arvi and Eddoe. A wide range of chemical compounds including flavonoids, β-sitosterol, and steroids have been isolated from this species. Various parts of C. esculenta are traditionally used to treat many diseases. Extracts from this plant have been found to possess various pharmacological activitiesThe leaves have been studied to possess anti-diabetic, anti-helminthic and anti-inflammatory action.C. esculenta is reported to possess hypoglycemic efficacy due to the presence of cyanoglucoside. The present review tries to cover all the information available on research work of this plant in yesteryears in a nutshell with the intention to serve as a literature platform for further researches on this plant.

AN OVERVIEW OF TRADITIONALLY USED HERB, *COLOCASIA ESCULENTA*, AS A PHYTOMEDICINE

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Short Running Title: *COLOCASIA ESCULENTA:* AN OVERVIEW

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ABSTRACT:

Colocasia esculenta (*C. esculenta*) is a widely cultivated plant for consumption of both leaves and tubers. Taro, a common name for the corms and tubers of several genera of the family *Araceae,* is a source of edible corms of *C. esculenta.* It is majorly cultivated in Southeast Asia by several common names like *Arbi, Arvi* and Eddoe. From this species, a wide range of chemical compounds have been isolated for example, flavanoids, β-sitosterol, steroids, etc. Various parts of *C. esculenta* are used traditionally to treat number of diseases. Extracts from this plant have been found to possess various pharmacological activities. The leaves of this plant have been studied to possess anti-helminthic, anti-diabetic and anti-inflammatory actions. There have also been reports proving hypoglycemic efficacy of *C. esculenta* due to the presence of cyanoglucoside. The present review tries to cover all the information available on research work of this plant in yesteryears in a nutshell with the intention to serve as a literature platform for further researches on this plant.

Key words: Phytomedicine**;** *Colocasia esculenta;* Araceae*;* Medicinal uses; Taro

1. INTRODUCTION

In order to meet the global healthcare needs, traditional medicine systems have played a very important role. Indian Systems of Medicine being one of the largest and oldest systems, constitutes all the medicines which have their origin in India. Plants have played a very vital role in sustaining and improving quality of human life and have served humans well as important components of medicines, seasoning, beverages, cosmetics, and dyes. Due to this fact, the focus on plant research has increased all over the world. There are any herbs that are used to treat liver, cardiovascular, digestive, metabolic and central nervous system (CNS) disorders. Medicinal plants or herbal drugs and their extracts containing isolated compounds have showcased a wide spectrum of biological activities. One of such a plant with wide applications is *C. esculenta*.

Taro, a common name for the corms and tubers of numerous genera of the family *Araceae*, is a source of edible corms of *C. esculenta*. It is most extensively cultivated in Southeast Asia by several common names like *Arbi, Arvi* and Eddoe. The juice of the plant leaf is rubefacient, stimulant, styptic and is useful in internal haemorrhages, adenitis, otalgia and buboes. The corm juice is demulcent, laxative and anodyne. The leaves of the plant have been found to exhibit anti-helminthic, anti-diabetic and anti-inflammatory activity[1]. *Colocasia species* is an ancient crop used all over the world; Africa, Asia, the West Indies, and South America. It is grown throughout the humid tropics. Its edible corms and leaves are traditionally used for liver related ailments[2]. *Colocasia esculenta* (L) Schott of the family *Araceae* is an herbaceous perennial plant. The crop is cultivated as annuals. The green leaves of the plant are large in size and are often described as 'Elephant ear'. They can reach up to 1-2 m high during growth period. The main edible part of the crop are the starchy, tuberous roots; however, the leaves of the plant are also used as a leafy vegetable. The leaves of *C. esculenta* have been reported to be rich in nutrients including minerals and vitamins such as phosphorours, calcium, vitamin C, iron, riboflavin, thiamine and niacin [3]. Among various edible plants from *Araceae* family commercially cultivated in India, *C. esculenta* has a significant dietary importance for having multiple uses in various culinary preparations of its edible parts i.e. corm, stem and leaves. *C. esculenta* fresh edible leaves are rich sources of protein, dietary fibre, ascorbic acid and some nutritionally important minerals. Leaf juice of the plant also finds

its application in scorpion sting, in snake bite, in food poisoning from plant origin, etc. The plant also finds its application in Ayurveda identified ailments *viz. vata* and *pitta*, constipation, alopecia, stomatitis, haemorrhoids and general weakness[4-5]. *Colocasia antiquorum* is found to possess hepatoprotective activity against liver injury in rats that were experimentally induced [2]. *C. esculenta* is reported to possess hypoglycemic efficacy due to the presence of cyanoglucoside[6]. The plant is also reported to possess hypolipidemic and antihyperlipidemic activity due to the presence of arabinogalactan[7] and mono and digalactocyl diacylglycerols. The plant gets its antifungal property due to presence of cystatin[8]. Antibacterial activity of *C. esculenta* has been reported by Ravikumar and co-workers in previously published literature [9].

The objective of this review article was to shed light on the vast applications of traditionally used herb, *Colocasia esculenta.* This contribution also provides a broad review of botanical features, chemical constituents, pharmacological profile and medicinal / pharmaceutical applications of *C. esculenta.*

2. PLANT BOTANY

Colocasia esculenta Linn. (Fig.1) is a tall herb having tuberous or a stout short caudex, leafing and flowering together. Leaves are simple and have a stout petiole, ovate-cordate or sagittate-cordate, lamina peltate. Spadix is shorter than the petiole and much it is shorter than the spathe rather than slender. Appendix much shorter than the inflorescence, style very short; stigma discoid[10]. It is erect, elongate-conical or fusiform, subulate or abbreviate. Erect petiole is up to 1.2 m in length, with a dull and non-polished surface above, coloured or paler beneath. They are rarely glaucous. The leaf peduncle is shorter than the petiole. Spathe is pale yellow and measures 15 to 35 cm in length; tube greenish, oblong. The lamina is narrowly lanceolate, convolute, acuminate and curved slightly backwards in flower. Female inflorescence is short but male inflorescence is long, cylindrical and usually interposed neuters between the two. Seeds oblong, sulcate. Albumen copious; embryo axile. The plant stem is above ground and swollen slightly at the base of the leaf-sheaths, arising from a hard-tapering rhizome; stolon's and a tuberous rhizome suckers are sometimes present.

(a) Leaves **(b) Tubers**

Fig. 1: Picture of parts of *Colocasia esculenta* plant

2.1 Leaf microscopy

Histological features of *C. esculenta* leaf are summarised below[11]:

a) Epidermis

Single layer of spherical to polygonal cells with cutinized upper surface are present in upper epidermis of the leaf. The shape of the cells are straight to slightly beaded anticlinal walls and wavy with presence of Chlorophyll in epidermal cells. Lower epidermis shows single layer of polygonal cells which have straight to slightly beaded anticlinal walls. The lower epidermis also shows presence of papillae and paracytic type of stomata.

b) Mesophyll

Mesophyll shows dorsiventral arrangement, differentiated into palisade and spongy parenchyma. Chlorophyll and phenolic compounds are present in palisade cells.

c) Spongy parenchyma

The leaf shows presence of vacuoles and is made up of parenchymatous cells which varies in sizes and shapes measuring about 7-9 cells in thickness. Interspersed vascular elements are present intermittently. A majority of cells are filled with compound-type starch grains which are simple, spherical with centric helium and less prominent striations.

d) Conducting tissue system

The vascular bundles present are simple and each one of them are surrounded by a single layer of parenchymatous bundle. The larger vascular bundles are surrounded by sclerenchymatous bundle sheath which extends up to the upper or lower or both epidermis[11].

3. PHYTOCHEMISTRY

Flavonoids and triterpenoids are the two pharmacologically active groups of compounds mainly present in the *Colocasia* leaf extracts. The flavanoids that are present in the *Colocasia* leaf extracts are vicenin-2, iso-vitexin, iso-vitexin 3'-O-glucoside, vitexin X''-O-glucoside, iso-orientin, orientin, orientin7-O-glucoside, leteolin 7-O-glucoside [12]. The leaves of the plant also contains fibres, calcium oxalate, minerals (Calcium phosphorus etc.), and starch, Vitamin A, B, C, etc.[13]. Phytochemical investigations on the *Colocasia* extracts have shown the presence of anthocyanins viz. cyanidin-3-rhamnoside, cyanidin-3-glucoside and pelargonidin-3-glucoside. These anthocyanins have antioxidant activities as evident from previous studies[14-16]. It is due to these anthocyanins that the *C. esculenta* plant leaves showcases hepatoprotective as well as anti-lipid peroxidative activity. The tubers of *C. esculenta* contains globulins that accounts for around 80% of the total tuber proteins present. The starch content present in the flour varies from 73-76% and the starch yields are in the range of 51-58%.[17] The starch contains 0.23-0.52% lipid and 0.017-0.025% phosphorus in the form of phosphate monoester derivatives[17]. The nitrogen content of the flours varies from 0.33-1.35%. Table 1 shows chemical constituents of different parts of *C. esculenta* plant.

Table 1: Chemical constituents of different parts of *Colocasia esculenta* plant

Plant part	Chemical constituents		References
Leaves	Calcium oxalate, minerals like calcium phosphorus, fibres, starch, vitamin A, B, C		13, 18
	Apigenin		
	Luteolin		
	Anthocyanin		
	Flavanoids	• Orientin	12
		• Iso-orientin	
		• Iso-vitexin	

		• Vicenin-2	
		• Orientin 7-O-glucoside	
		• Iso-vitexin 3'-O-glucoside	
		• Vitexin X" -O-glucoside	
		• Luteolin 7-O-glucoside	
Tubers	Starch	73-76%	[13, 17-20]
	Natural polysaccharide	• 56% Natural sugars	
		• 40% Anionic components	
	Oxalate	Soluble-19-87mg/100g	
		Insoluble-33-156mg/ 100g	
	Amino acids	13 to 23%	
	Nitrogen content	0.33 to 1.35%	
	Lipid	0.23 to 0.52%	
	Phosphate monoester	0.017 to 0.025%	
	Dihydroxysterols		
	β-sitosterol		
	Stigmasterol		
	Nonacosane		
	Cyaniding 3-glucoside		
	Aliphatic compounds	• Tetracos-20-en-1, 18-diol	
		• 25-methyl triacont-10-one	
		• Octacos-10-en-1, 12-diol	
		• Pentatriacont-1, 7-dien-12-ol	
		• 25-methyl-tritriacont-2-en-1, 9, 11-triol	
	Octadecenoic acid		
	Enzymes	Lipoxygenase	
		Lipid hydro peroxide-converting enzyme	
Petiole	Anthocyanins	3.29%	[21]

4. PHARMACOLOGICAL ACTIVITIES

4.1 Antimicrobial activity

The aqueous extract of *C. esculenta* has been reported to possess antimicrobial activity. Study was performed for isolates of bacteria namely *Escherichia coli, Aeromonas hydrophila, Flavobacterium sp., Edwardsiella tarda, Klebsiella sp., Salmonella sp., Vibrio alginolyticus, V. parahaemolyticus, V. cholerae* and *Pseudomonas Aeruginosa.* The plant extract showed maximum activity against *S. mutans* amongst all the selected strains of microbe. The extract of *C. esculenta* exhibited good antimicrobial activity against some of bacteria and fungus that were tested at low concentration[22].

4.2 Antihepatotoxic activity

C. esculenta leaf juice demonstrated hepatoprotective and anti-hepatotoxic activity. The hepatoprotective and anti-hepatotoxic studies were conducted against two well-known hepatotoxins paracetamol and CCl_4 using *in vitro* rat liver slice method. CCl_4 and Paracetamol generate free radicals that causes oxidative stress. It also damages various cell organelles thus injuring the hepatocytes. The hepatoprotective efficacy was measured using the leakage of marker enzymes of liver function such as AST, ALP and ALT in the incubation medium. In presence of CCL_4 and paracetamol, there was an increase in the levels of marker enzymes. Insignificant changes were noted in the enzymes levels at one and two hour's interval. At four hours interval, the marked elevations of toxicity marker enzymes were seen. However, the leaf juice of *C. esculenta* abnormally declined the leakage of AST, ALP and ALT in the medium demonstrating integrity of hepatocyte [23].

4.3 Antidiabetic activity

The antidiabetic activity of the ethanol extract of *C. esculenta* (EECE) leaves was carried out in rats using alloxan induced diabetes model. EECE (100, 200 and 400 mg/kg) and metformin (450mg/kg) were administered orally in alloxan (120 mg/kg, i.p.) induced diabetic rats. At 4 h (96 mg/dl) the onset of reduction of blood glucose was observed, peak at 6 h (120 mg/dl) but anti-hyperglycaemic effect diminished at 24 h. Maximum reduction in blood glucose was observed (174.34 mg/dl) in subacute study, at the dose of 400 mg/kg on 14th day. These results suggested that EECE (400 mg/kg) exhibits anti-hyperglycaemic activity in alloxan induced diabetic rats[24-25].

4.4 Anti-lipid peroxidative activity

C. esculenta whole leaf juice has been reported to possess the free radical scavenging property. The *in vitro* free radical scavenging effect was studied on liver cells by using rat liver slice model[26]. The liver slices were incubated in presence of cytotoxic concentrations of CCl_4 and acetaminophen. The marked elevations and prevention of depletion of total tissue glutathione were observed in the presence of *C. esculenta* whole leaf juice. [26]

4.5 Antimetastatic activity

Breast cancer mortality is primarily due to the occurrence of metastatic disease. The compound(s) that are derived from roots of the plant of *C. esculenta* has the capability to potentially and specifically inhibit tumor metastasis. It exhibited demonstrable activity in a preclinical model of metastatic breast cancer. Taro extract treatment also inhibited prostaglandin E2 (PGE2) synthesis and down regulated cyclooxygenase 1 and 2 mRNA expression. Taro extract modestly inhibits the proliferation of some, but not all, breast and prostate cancer cell lines and it completely blocks tumour cell migration. [27]

4.6 Antifungal activity

Yang et al evaluated the antifungal activity of taro along with molecular cloning and recombinant gene expression studies. CeCPI, a cysteine protease inhibitor (cystatin), was isolated from taro corm (*Colocasia esculenta*). The result confirmed that recombinant CeCPI protein exhibited strongly cysteine protease inhibitor activity. Thus, the investigation clearly discovered a toxic effect of the plant on the mycelium growth of phytopathogenic fungi[28].

4.7 Anti-inflammatory activity

The ethanolic extracts of the leaves of *C. esculenta* possess anti-inflammatory activity. The study was conducted in Wistar rats using the carrageenan-induced left hind paw oedema, carrageenan-induced pleurisy, and cotton pellet induced granuloma model. The results indicated that the ethanolic extract exhibits significant anti-inflammatory activity when compared with the standard and untreated control[29].

5. USES / APPLICATIONS

5.1 Medicinal uses

C. esculenta has many medicinal applications as discussed earlier. All the plant parts viz. leaves, stem and tubers shows different medicinal properties. Some of the properties includes antimicrobial, antihepatotoxic, anti-diabetic, anti- lipid peroxidative action, anti-metastatic, antifungal, anti-inflammatory and many more.

People of the *Munda* tribe, traditionally used corm of taro as a remedy for body ache. The juice extracted from corm of the plant is used in alopecia, as an expectorant, stimulant, appetizer and astringent. When cooked, the vegetable contains mucilage and found to be an effective nervine tonic. Table 2 summarizes chemical constituent and corresponding activity of *C. esculenta* plant parts.

Table 2: Chemical constituents and activity of different parts of *Colocasia esculenta* plant

Plant part	**Form**	**Responsible chemical constituent**	**Activity**	**References**
Leaves	Juice	*ß-carotenes, and cryptoxanthin* along with vitamin A	Maintaining healthy mucus membranes, skin and vision. Helps to protect from lung and oral cavity cancers. Good stimulant, expectorant, astringent, appetizer and otalgia. Juice is applied over scorpion sting or in snake bite as well as it is used in food poisoning of plant origin.	[30]
	Ethanolic extract		Anti-inflammatory	[29]
	Hydroalcoholic extract		anti-depressant, anxiolytic, sedative, and smooth muscle relaxant activity	[31]
Corm	Juice	9, 12, 13-trihydroxy-(E)-10-octadecenoic acid, lipoxygenase and lipid hydroperoxide-converting enzyme	External- alopecia, body ache. Internal-laxative, demulcent, anodyne, galactagogue, piles, antidote to the stings of wasps and other insects.	[19]
			Antifungal	
Leaf stalks	Juice	Flavanoids and terpenoids may be responsible.	Absorbent in cases of inflamed glands and buboes.	
	Peel decoction		Anti-diarrhoeal, increases body weight, prevents excessive secretion of sputum in asthmatic individuals	
Petiole	Pressed juice		Stypic, otorrhoea, arrests arterial haemorrhage, stimulant, rubefacient	
Whole plant	Press extract	Cyanoglucoside	Hypoglycemic	[32]
	Ethanolic extract	Monogalactosyl diacylglycerols,	Hypolipidemic	[7, 8]

		digalactosyl diacylglycerols		

2. Pharmaceutical Applications

The gum as well as starch obtained from the tuber of the *C. esculenta* plant can be used as an effective binder and mucoadhesive matrix forming agent[33].

Soumya M et al. successfully prepared sustained release and evaluated matrix tablets of taro gum using metaprolol succinate as the model drug. The quantity of taro gum (X1) and polyvinylpyrrolidone (PVP) K30 (X2) were selected as independent variables. The time required for 90% of *in vitro* drug release was selected as the dependent variable. Tablets were prepared by direct compression and were evaluated for various post compression parameters such as tablet hardness, friability, weight variation, drug content and *in vitro* dissolution[34].

Another research paper by Gurpreet Arora et al. reported application of Taro gum in development of Mucoadhesive matrix tablets. Matrix tablets of Domperidone as a model drug was compressed using direct compression technique. This study showed concentration dependent mucoadhesive and release retardant potential of taro gum in the formulation of gastro retentive mucoadhesive matrix tablets[35].

Chukwu and Udeala studied the effectiveness of *C. esculenta* gum in poorly compressible drugs-paracetamol and metronidazole tablet formulations. The effectiveness of a polysaccharide gum obtained from the *C. esculenta* was evaluated comparatively with acacia and methylcellulose as binders in the formulation of poorly compressible drugs. At 4% w/w nominal concentration of *Colocasia* gum in metronidazole tablets and 6% w/w in paracetamol tablets showed very long disintegration time and prolonged release profile. The binders used for comparison yielded tablets that show better *in vitro* release characteristics[36].

C. esculenta polysaccharide can be used as a disintegrant in the formulation of orally disintegrating tablets. Its disintegrating property was reported to be comparable with that of the commercially available super-disintegrants.

6. PATENTS FILED/PUBLISHED

Table 3 summarises different patents filed /published/granted involving *Colocasia* plant.

Table 3: List of Patents involving *Colocasia* plant

Title	Patent Number	Publication date	Inventors	Description
Colocasia plant named 'Mojito'	USPP21995 P2	Jun 28, 2011	Ty Richard Strode	The present invention relates to a new and distinct cultivar of *Colocasia* plant, botanically known as *Colocasia esculenta.*
Colocasia plant named 'Midnight'	USPP17887 P2	Jul 31, 2007	Richard Strode	
Colocasia plant named 'MAUI GOLD'	USPP24482 P2	May 20, 2014	John J. Cho	
Colocasia plant named 'Noble Gigante'	USPP25219 P2	Jan 6, 2015	Brian Paul Williams	
Production process of *Colocasia esculenta* starch	CN103772511 A	May 7, 2014	--	This invention discloses a production process of *C. Esculenta* starch. Process includes peeling, smashing, adjusting pH of the slurry to 8.5-10, performing standing for 50-100 min. This is followed by sqeezing, filtering, rinsing filtrate by water, collection of lotion, sieving, centrifugation and drying.
Preservation method of *Colocasia esculenta*	CN103609665 A	Mar 5, 2014	--	The invention discloses a preservation method of *Colocasia Esculenta*, belonging to the technical field of storage of agricultural products. Carrying out jet impaction and blanching by overheated steam, carrying out jet impaction and micro-drying by gas, and packaging and preserving by using a freshness protection package. *Colocasia esculenta* can be preserved for 8 months under the low temperature condition (the temperature is 0-4^{o} C and the relative humidity is 80-95 percent and can be preserved for above 2 months at a normal temperature; no chemical additives are introduced in a processing process, and thus the food safety is high.

Herbal formulations and cigarettes containing same useful in controlling body weight.	US20070042055 A1	Feb 22, 2007	Pushpangadan Palpu et. al.	The present invention relates to herbal formulation comprising a combination of fiber, powder, and/or granules of aerial parts of plants, *Colocasia esculenta* being one of the component.

7. CONCLUSION

C. esculenta is a largely cultivated plant used from ages as food and medicine. Flavonoids and triterpenoid's are the two major therapeutically active groups of compounds found in the plant. Pharmacologically, the plant is antimicrobial, antihepatotoxic, antidiabetic, anti-lipid peroxidative, antimetastatic, antifungal and anti-inflammatory. There are also many pharmaceutical applications for the plant.

There is a lot of scope for usage of *C. esculenta* in pharmaceutical industries as well as in research work. Herbal formulations consisting of plant extracts from different parts of plants can be developed for many ailments as discussed in this paper. More research work can be done on structural investigation and applications of the gum obtained from *C. esculenta*. The starch and the gum obtained from the tubers can be commercially made use of in pharmaceutical industries in form of binder, matrix forming agent, thickening agent etc. Thus, there is need to explore this plant so as to make use of its medicinal and pharmaceutical properties to its fullest.

8. CONFLICT OF INTEREST

The author(s) declare that there is no conflict of interests regarding publication of this article.

9. ACKNOWLEDGEMENT

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REFERENCES

1. Lin H, Huang AS, Chemical composition and some physical properties of a water-soluble gum in taro *(Colocasia esculenta.)*, Food Chemistry, 48 (4) (1993) 403–409.
2. Tuse TA, Harle UN, Bore VV, Hepatoprotective activity of *Colocasia antiquorum* against experimentally induced liver injury in rats, *Malyasian J pharma sci, 2(2)* (2009) *99-112.*
3. Lewu, MN, Adebola PO and Afolayan, AJ, Effect of cooking on the proximate composition of the leaves of some accessions of *Colocasia esculenta* (L.) Schott in KwaZulu- Natal province of South Africa, *African J of Biotechnology*, 8(*8*) (2009) 1619-1622.
4. Awasthi CP and Singh AB, Nutritional quality evaluation of edible leaves of some promising Colocasia and Alocasia collections, *Ind J Agric Res.*34*(2)* (2000) 117-121.
5. Devarkar VD, Marathe VR, Chavan DP, Dietary and medicinal significance of wild vegetables from Osmanabad region, Maharashtra (India), *Life Sciences Leaflets*, 11 (2011) 317-332.
6. Phillip BA, Grindleya, OF, Asemotaa, HN, Errol Y and Morrisona, A, Carbohydrate digestion and intestinal ATPases in streptozotocin-induced diabetic rats fed extract of yam (*Dioscorea cayenensis*) or dasheen (*Colocasia esculenta*), Nutrition Research, 22 (2002) 333–341.
7. Boban, P, Nambisan B and Sudhakaran, P, Hypolipidaemic effect of chemically different mucilages in rats: A comparative study, British Journal of Nutrition, 96 (2006) 1021–1029.
8. Tanaka, R, Sakano, Y, Nagatsu, A, Shibuya M, Ebizukab Y and Goda Y, Synthesis of digalactosyl diacylglycerols and their structure–inhibitory activity on human lanosterol synthase, Bioorganic and Medicinal Chemistry Letters, 15 (2005) 159–162.

9. Ravikumar S, Gracelin N, Anitha Anandha, G Selvan Palani, A Kalaiarasi, *In vitro* antibacterial activity of coastal medicinal plants against isolated bacterial fish pathogens, *Int J Pharma Research and Devel.*, 3(4) (2011) 109-116.
10. Kirtikar KR, Basu BD, Indian Medicinal Plants. Dehradun: International Book Distributors, 4, 2005,2615.
11. Kalariya MV, Rakesh PP, Parmar SK, Sheth NR, Pharmaconostic evaluation of *Colocasia esculenta* leaves: Dissertation conducted at Dept. of Pharmaceutical Sciences, Saurashtra Uni., Rajkot, India, 2009.
12. Iwashina T, Konishi T, Takayama A, Fukada M, Ootani S, Isolation and identification of the flavanoids in the leaves of taro, Ann Tsukuba Botanical Garden, 18, 1999,71-4.
13. Sheth AK, The Herbs of Ayurveda. Ahmedabad: A.K. Sheth Publishers, 2005, 356.
14. Noda Y, Kaneyuki T, Mori A and Packer L, Antioxidant activities of pomegranate fruitextract and its anthocyanidins: Delphinidin,cyanidin, and pelargonidin, *Journal of Agricultural Food Chemistry*, 50 (2002)166–171.
15. Cambie RC and Ferguson LR, Potential functional foods in the traditional Maori diet, Mutation Research, Fundamental and Molecular Mechanisms of Mutagenesis, 2003,523–524, 109–117.
16. Kowalczyk E, Kopff A, Fijalkowski P, Niedworok J, Blaszczyk J., Kedziora J, Effects of anthocyanins on selected biochemical parameters in rats exposed to cadmium, *Acta Biochimica Polonica*, 50, 2003, 543–548.
17. Anonymous. The Wealth of India: A Dictionary of Indian Raw Materials and Industrial Products. New Delhi: NISCSIR, 2005, 1:225.
18. Khare CP. Indian Medicinal Plants. New Delhi: Springer, 2007, 167.
19. Anonymous. The Wealth of India: A Dictionary of Indian Raw Materials and Industrial Products. New Delhi: NISCSIR, 2, 2001,157.
20. Huang AS, Tanudjaja LS, Application of anion-exchange high-performance liquid chromatography in determining oxalates in taro (*Colocasia esculenta*) corms, J Agric Food Chem, 40, 1992, 2123-6.

21. Nakayama TO, Harvey TJ, Tsung Hui CK. Anthocyanin composition of taro. J Food Sci 42, 2006,19-21.
22. Singh B, Namrata, Lokendra Kumar, Dwivedi SC, Antibacterial and antifungal activity of *Colocasia Esculenta* aqueous extract: An edible plant, *Journal of Pharmacy Research,* 4 (5) (2011)1459-1460.
23. Bhagyashree RP, Hussein MA, Antihepatotoxic activity of *Colocasia esculenta* leaf Juice *International Journal of Advanced Biotechnology and Research*, 2, 2011, 296-304 (http://www.bipublication.com)
24. Kumawat NS, Chaudhari SP, Wani NS, Deshmukh TA, Patil VR, Antidiabetic activity of ethanol extract of *Colocasia esculenta* leaves in alloxan induced diabetic rats International Journal of Pharm Tech. 2(2) (2010) 1246-1249.
25. Antidiabetic activity of ethanol extract of *Colocasia esculenta* leaves in alloxan induced diabetic rats, Kumawat NS, Chaudhari SP, Wani NS, Deshmukh TA, Patil VR, International Journal of Pharm Tech Research, 2(2) (2010) 1246-1249.
26. Bhagyashree RP and Hussein M, Anti-Lipid Peroxidative Activity of *Colocasia esculenta* leaf Juice against CCl_4 and Acetaminophen Mediated Cell Damage, *International Journal of Pharmaceutical Applications*, 2, 2011, 141-149.
27. Kundu N, Campbell P, Hampton B, Lin CY, Ma X, Ambulos N, Zhao XF, Goloubeva O, Holt D, Fulton AM, Antimetastatic activity isolated from *Colocasia esculenta* (taro). Anticancer drugs, 23(2) (2012) 200-11.
28. Yang AH, Yeh KW, Molecular cloning, recombinant gene expression and antifungal activity of cystain from taro, Planta Med, 22, 2005, 333-41.
29. Shah BN, Nayak BS, Bhatt SP, Jalalpure SS, Sheth AK. The anti-inflammatory activity of the leaves of Calocasia *esculenta*. Sau Pharm J,15,2007, 3-4.
30. Kirtikar KR, Basu BD, Indian medicinal plants. Dehradun: International Book distributors; 4, 2005, 2615
31. Kalariya M, Parmar S, Sheth N. Neuropharmacological activity of hydroalcoholic extract of leaves of *Colocasia esculenta*. Pharm Biol,48, 2010, 1207-12.

32. Grindley BA, Omoruyi F, Asemota HN, Morrisona A, Carbohydrate digestion and intestinal ATPases in streptozotocin-induced diabetic rats fed extract of yam (*Dioscorea cayenensis*) or dasheen (*Colocasia esculenta*), Nut Res, 22,2002, 333-41.
33. Pawar HA, Kamat SR, Choudhary PD, An Overview of Natural Polysaccharides as Biological Macromolecules: Their Chemical Modifications and Pharmaceutical Applications, Biol Med (Aligarh), 6, 2015, 224.
34. Soumya M, Chowdary YA, Swapna VN, Prathyusha ND, Geethika R, Jyostna B, Krishna Mohan KS. Preparation and optimization of sustained release matrix tablets of metoprolol succinate and taro gum using response surface methodology, Asian J Pharm, 8, 2014, 51-7.
35. Gurpreet Arora, Karan Malik,Inderbir Singh. Formulation and evaluation of mucoadhesive matrix tablets of Taro gum: Optimization using response surface methodology. *Polimery Medycynie* 41(2) (2011) 23-34.
36. Chukwu KI, Udeala OK, Binding effectiveness of *Colocasia esculenta* gum in poorly compressible drugs-paracetamol and metronidazole tablet formulations, Boll. Chim. Farm., 139 (2) (2000) 89–97.

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Figure 1: Picture of parts of *Colocasia esculenta* plant.