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Colocasia esculenta (L.) Schott: Pharmacognostic and pharmacological review

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Abstract
Colocasia esculenta (L.) Schott (Family: Araceae) is an annual herbaceous plant with a long history of usage in traditional medicine for several countries, especially in the tropical and subtropical regions. It is majorly cultivated in Southeast Asia by several common names like Arbi, Arvi, and Eddoe. The young leaves and roots are rich in Vitamin C as well as starch. It contains calcium, phosphorus, thiamine, riboflavin, niacin, oxalic acid, calcium oxalate, sapotoxin and flavones, apigenin, and luteolin. Phytochemical screening also showed the presence of alkaloids, glycosides, flavonoids, terpenoids, saponins, oxalates, phenols. Traditionally it has been used for the treatment of various ailments such as asthma, arthritis, diarrhea, internal hemorrhage, neurological disorders, and skin disorders. This review emphasized the updated phytopharmacological profile of *C. esculenta* such as antimicrobial, antihepatotoxic, anti-cancer, antioxidant, antibacterial, antifungal, anthelmintic activity, antidiabetic, hypolipidemic, anti-melanogenic, estrogenic and neuropharmacological effects. It will provide extensive literate about the *Colocasia esculenta* in future research towards the acceptability of its clinical application.

Keywords: *Colocasia esculenta*, Araceae, phytomedicine, pharmacological activities

Introduction
Nature has a source of medicinal agents for thousands of years and the number of modern drugs has been isolated from natural sources, many based on their traditional climes. Even now, approximately 80% of the world populations are almost entirely dependent on traditional medicines for maintaining general health and combating many diseases. Many medicinal plants and their isolates have shown a wide spectrum of biological activities and used to treat major disorders like liver, cardiovascular, central nervous system (CNS), digestive, and metabolic disorders. Medicinal plants or Herbal drugs, and their extracts containing isolated compounds have shown a wide spectrum of biological activities [1]. One of such a plant with wide applications is *Colocasia esculenta*. It is a tropical plant grown primarily for its edible corms, a root vegetable more commonly known as taro [2]. Taro is a major root crop belonging to the family *Araceae*, sub-family *Aroideae*. It is a wetland herbaceous perennial plant found in tropical and subtropical regions most extensively cultivated in Southeast Asia by several common names like Arbi, Arvi, and Eddode [3]. Moreover, the leaves, leaf stalks, and petioles are also used as a vegetable. It is known by many local names and often referred to as "elephant ears" they can reach up to 1-2 m height during the growth period [4]. Taro has superior nutritional value compared with potato, sweet potato, cassava, and rice. The leaf juice of the plant is stimulants and rubefacient as well as a styptic. It's also useful in internal otalgia, adenitis, hemorrhages, and buboes. The corm juice is demulcent, laxative, and anodyne [5]. The leaves of *C. esculenta* have been reported to be rich in nutrients, including minerals and vitamins such as phosphorus, calcium, vitamin C, iron, riboflavin, thiamine, and niacin. *C. esculenta* fresh edible leaves are rich sources of protein, dietary fiber, ascorbic acid, and some nutritionally important minerals [6]. The corm of taro is relatively low in protein (1.5%) and fat (0.2%). It is a good source of starch (70–80 g/100 g dry taro), fiber (0.8%), and ash (1.2%). The corms contain the cyaniding 3- rhamnoside, cyaniding 3-glucoside, and anthocyanins pelargonidin 3-glucoside. It is used to treat stomach swelling, pain, and fever [7]. The biological properties as well as chemical constituents of *C. esculenta* were widely used in folk medicine. Extracts from this plant have been found to possess various pharmacological activities such as anticancer, antihyperlipidaemic, anxiolytic, wound healing, antimelanogenic, anti-inflammatory, probiotic, antihypertensive, antidiabetic, hepatoprotective, anti-inflammatory, antimicrobial, hypolipidaemic, antihelminthic [8]. This review intends to provide recent updates and comprehensive analysis of botanical, phytochemical, and Pharmacological features of *C. esculenta* in-depth to improve it further wide therapeutic applications.

Plant Taxonomy

Colocasia esculenta (L.) Schott commonly called taro or cocoyam (Family: Araceae), is a perennial herbaceous plant, with large spherical corm from which a few heart-shaped leaves emerge at the tip on long petiole reaching 1-2m height. The leaf Peduncle shorter than the petiole, spathe pale yellow, 15- to 35-cm long; tube greenish, oblong; The lamina is narrowly lanceolate, convolute, acuminate and curved slightly backward in flower. Female inflorescence is short but the male inflorescence is long, cylindrical, and usually interposed neuters between the two. Male flowers 3-6 androus, Female flowers 3-4 gynous; ovary ovoid or oblong. The stem is slightly swollen at the base of the leaf-sheaths [9].

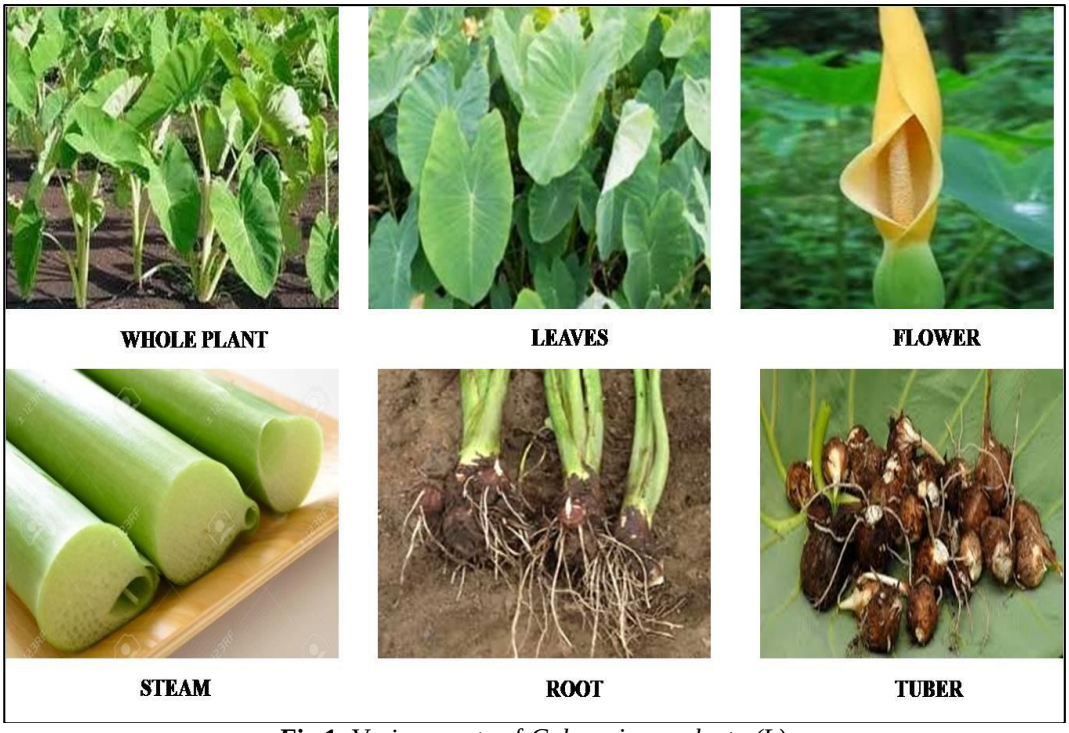

Fig 1: Various parts of *Colacasia ecculenta (L)*

Vernacular Names [10].

English: Taro
Bengali: Alti Kachu, Kachu
Gujarati: Aalavi, Patarveliya
Hindi: Arvi, Kachalu
Kannada: Kesavedantu
Malayalam: Chempu, Madantha, Chempakizhnna
Marathi: Alluu
Sanskrit: Alupam, Alukam
Tamil: Sempu

Taxonomy classification [10, 11].

Kingdom: Plantae
Subkingdom: Tracheobionta
Superdivision: Spermatophytes
Division: Magnoliophyta
Class: Liliopsida
Subclass: Arecidae
Order: Alismatales
Family: Araceae-Arums
Genus: Colacasia schott
Species: *Colacasia esculenta*(L)

Ethnomedical information:

Aerial parts & Whole plant parts *viz*. Leaves, stem, and tubers show different medicinal properties. The entire plant used as an antimicrobial, antihepatotoxic, anti-diabetic, anti-lipid peroxidative action, antimetastatic, antifungal, anti-inflammatory. Leaf juice used for maintaining healthy mucus membranes, skin, vision, and it acts as a good stimulant, expectorant, astringent, appetizer, and otalgia [7]. It also used to protect from lung and oral cavity cancers. A hydroalcoholic extract of the leaf juice used as an anti-depressant, anxiolytic, sedative, and smooth muscle relaxant. The Juice of the corm is used to External- alopecia and body ache. Internally, it acts as a laxative, demulcent, anodyne, galactagogue, and is used in cases of piles and congestion of the portal system [12]. The pressed juice of the petiole is styptic and may be used to arrest arterial hemorrhage. The decoction of the peel is used as anti-diarrheal, increases body weight, prevents excessive secretion of sputum in asthmatic individuals [13].

Phytochemistry

Flavonoids and triterpenoids are the two pharmacologically active compounds mainly present in the *Colocasia* leaf extracts. The isolated flavonoids contain vicenin- 2, iso-vitexin, iso-vitexin 3'-O-glucoside, vitexin X''-O-glucoside, iso-orientin, orientin, orientin 7- O-glucoside, leteolin 7-O-glucoside. The leaves of the plant also contain fibers, calcium oxalate, minerals and starch, Vitamin A, B, C, *etc* [14]. Phytochemical investigations on the *C. esculenta* leaf contain flavones, apigenin, luteolin, and anthocyanins [Figure 2] [15]. *C. esculenta* tubers contain globulins accounting for 80% of the total tuber proteins. Taro corm has been reported to have 70–80% (dry weight basis) starch with small Granules. The high level of carbohydrate content observed in raw taro, taro powder, and total amino acids recorded in the tubers are in the range of 1,380-2,397 mg/100 g [16].

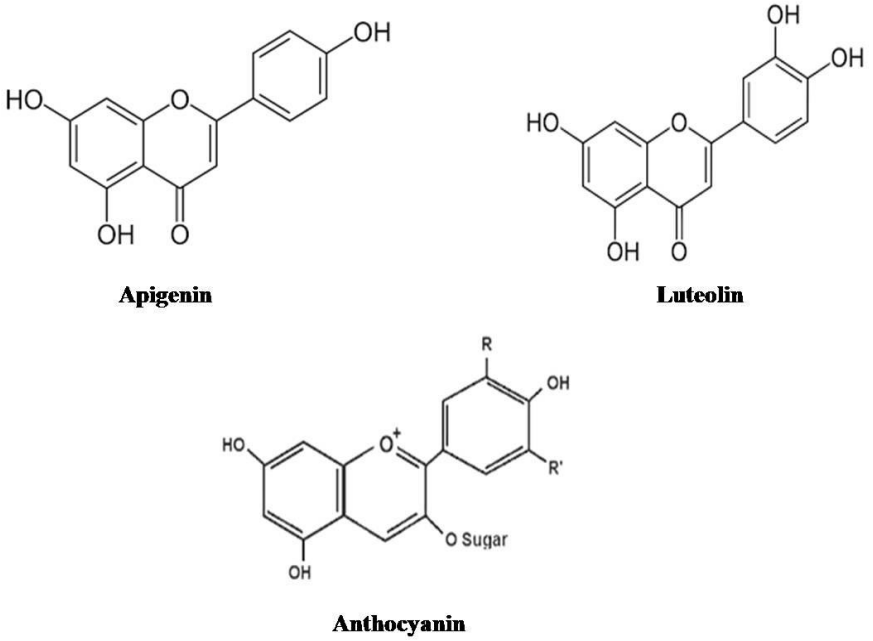

Fig 2: Structure of some flavones derived from *Colocasia esculenta Leaves*

Pharmacological activities

Antimicrobial activity

The *in-vitro* antimicrobial activity in aqueous extract of *Colocasia esculenta* (AECE) leaves was studied against gram-positive bacterial strains i.e. Streptococcus mutans (MTCC-890), Bacillus subtillis (MTCC-121), gram-negative bacterial strains i.e. Klebsiella pneumoniae (MTCC-109), Pseudomonas fragi (MTCC-2458), Escherichia coli (MTCC-483) and fungal strains Aspergillus niger (MTCC-281) Candida albicans (MTCC-227). AECE showed maximum activity at low concentration against *Streptococcus mutans* among the selected microbes. In this study, the antimicrobial activity of the AECE was more effective in bacteria than fungus. Overall the aqueous extract of Colocasia esculenta showed remarkable antimicrobial activity against all the tested microbial strains [17].

Antifungal activity

The *in vitro* antifungal activity of *Colocasia esculenta* was assayed by the food poisoning technique method against two fungal species. The alcoholic leaf extract showed good antifungal activity than the aqueous extract of *Colocasia esculenta*. Alcoholic extract of *colocasia esculenta* showed 100% antifungal action against *Alternaria solani* and *Alternaria ricini* at the 25% concentration. Aqueous leaf extract reduced the growth of fungal pathogen at high concentrations only [18].

Antidiabetic activity

The antidiabetic activity of the ethanol extract of *C. esculenta* (EECE) leaves was reported in an alloxan-induced diabetes model. In this study EECE at the dose level of 100, 200, and 400 mg/kg were administered orally metformin 450 mg/kg was used as a standard against alloxan (120 mg/kg, i.p.) induced diabetic rats. The onset of reduction of blood glucose of EECE was observed at 4 h (96 mg/dl), peak at 6 h (120 mg/dl) but antihyperglycaemic effect waned at 24 h. In the subacute study, the maximum reduction in blood glucose was observed (174.34 mg/dl) at a dose of 400 mg/kg on the 14th day. EECE prevented further loss of body weight. This study results suggest that EECE (400 mg/kg) showed significant anti-hyperglycaemic activity in alloxan-induced diabetic rats [19].

Hepatoprotective activity

An *in vitro* study liver slice study demonstrated that *C. esculenta* leaf juice demonstrated hepatoprotective and anti-hepatotoxic activity against the paracetamol and CCl_4 induced hepatic damage. Marked elevation of liver toxicity marker enzymes AST, ALT, and ALP in the medium due the toxins were remarkably declined at 4th hr in the leaf juice of *C. esculenta* treatment [20].

Anthelmintic activity

The anthelmintic activity of *Colocasia esculenta* aqueous and ethanolic leaf extract was investigated against earthworm. Both the extracts exhibited dose-dependent anthelmintic activity at the concentration range of 10-50 mg/ml. The crude extracts of *C. esculenta* not only demonstrated paralysis but also caused the death of worms especially at higher concentrations. The ethanol extracts exhibits potent paralysis and death time than the aqueous extract of *C. esculenta* against the earthworm [21].

Anti-inflammatory activity

The anti-inflammatory activity property of *C. esculenta* leaf extract was demonstrated on the carrageenan-induced acute paw edema model and the cotton pellet granuloma method. The results exhibited that ethanolic *C. esculenta* leaf extract at the oral dose of 100 mg/kg produced significant inhibition of carrageenan-induced edema, and also showed an inhibitory effect on leukocyte migration and a reduction on the pleural exudates as well as a reduction in the granuloma weight in the cotton pellet granuloma method when compared with standard drug [22].

Anti-Melanogesnic Activity

The isolated fraction from the methanolic extract of the tuber barks of *Colocasia antiquorum* var. *Esculenta* such as monoglyceride, (2'S)-1-O-(9-oxo-10(E), 12(E)-octadecadienoyl) glycerol as well as nine fatty acid derivatives showed inhibitory effects on melanin production

in melan-a cells. Hence it could be used as depigmenting agents and also as good candidates for cosmetic development [23].

Antioxidant activity

An *in vitro* antioxidant assay of aqueous extract of *C. esculenta* corm extract exhibited strong antioxidant potential and free radical scavenging capacity. In this study, *C. esculenta* corm extract antioxidant potential was assayed by seven different assays, *viz.* total phenolic content, total flavonoid content, total flavonol content, reducing power estimation as well as 1,1-diphenyl-2-picrylhydrazyl (DPPH), nitric oxide (NO) and 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) radical scavenging activities. The antioxidant potential of *C. esculenta* corm is mainly due to the presence of its phytoconstituents tannins, saponins, flavonoids, steroids, carbohydrates, proteins, and glycosides [24]. *Colocasia esculenta* whole leaf juice also prevented the elicit of lipid peroxidative reactions caused due to the presence of free radicals generated by the hepatotoxins CCl4 and acetaminophen *in vitro* rat liver slice model [25].

Antimetastatic activity

Kundua M *et al.* described that the water-soluble root extract of *Colocasia esculenta* also known as a water-soluble extract of taro (TE) potently inhibits lung colonizing ability as well as spontaneous metastasis from mammary gland-implanted tumors, in a murine model of highly metastatic ER, PR and Her-2/neu negative breast cancer. It modestly inhibits proliferation of some, but not all, breast and prostate cancer cell lines. Morphological changes including cell rounding were observed. Tumor cell migration was completely blocked by TE. TE treatment also inhibited prostaglandin E2 (PGE2) synthesis and down-regulated cyclooxygenase (COX) 1 and 2 mRNA expression. The isolated compounds protein, tarin, and lectin derived from taro that potently and specifically inhibits tumor metastasis [26].

Neuropharmacological activity

C. esculenta is traditionally used for the treatment of anxiety, depression, and other CNS disorders. A study conducted by Kalariya M *et al.* describes the neuropharmacological effect of hydroalcoholic leaves extract of *Colocasia esculenta* (HECE). The effects of HECE at anxiety, depression, thiopental-induced sleeping time, and rota rod performance were evaluated. Hydroalcoholic leaves extract of *Colocasia esculenta* showed significant dose-dependent anxiolytic, anti-depression, mild neurosedative, and skeletal muscle relaxant effect. The presence of flavonoids, β-sitosterol, and steroids in HECE could be responsible for these observed neuropharmacological activities [27].

Hypolipidaemic activity

Sakano *et al*. studied the cholesterol synthesis suppressing effect of ethanolic extract of *C. esculenta* along with 130 lyophilized vegetables using recombinant human lanosterol synthase (hOSC). Out of 130 samples, twelve showed significant inhibition. Among them, *Colocasia esculenta* (taro) showed the highest inhibition (55% inhibition at 300µg/ml). Results of this study described that Mono galactosyl diacyl glycerols (MGDGs) and digal actosyl diacyl glycerols (DGDGs), were identified as the active constituents in *C. esculenta* responsible for inhibition of human lanosterol synthase [28].

Also, Boban *et al*. studied the hypolipidemic activity of three different isolated mucilages galactomannan from fenugreek seeds, glucomannan from *Dioscorea esculenta* tubers, and arabinogalactan from *Colocasia esculenta* tubers in rats. The rats fed with these mucilages at a dose of 4mg/kg/day for 8 weeks were significantly decreased the total cholesterol and triacylglycerols levels in both the serum and organs. Further studies on the isolated liver from these mucilages fed rats also showed decreases in the synthesis and secretion of apo B-containing lipoproteins mainly VLDL in the liver. Among these isolated mucilages, glucomannan showed maximum hypolipidemic activity, and arabinogalactan showed minimum activity [29].

Estrogenic activity

Rodrigues *et al*., conducted an *in vivo* pharmacological assays to determine the estrogenic effects of *D. odorate* isoflavone extract, *P. angulata* physalin-rich extract, and *C. esculenta* flavonoid glycoside- rich fraction on endocrine glands and reproductive organs of female rats at three different stages of the life cycle. The results indicated that *C. esculenta* fraction (80mg/kg) exhibited better estrogenic activity in prepubescent, pubescent, and adult ovariectomized female rats, while *D. odorate* isoflavones only increased the weight of pituitary gland of prepubescent rats after prolonged treatment and *P. angulata* physalins induced the weight of adrenal glands in ovariectomized rats. Additionally, *C. esculenta* exerted a significant effect on the opening of the vaginal canal in prepubescent rats and on vaginal epithelium. *Colocasia esculenta* fraction also induced hypertrophy of the uterus and pituitary in ovariectomized rats similar to estradiol, mediated by binding with selective estrogenic receptors present in each organ. The overall findings of this study indicated that *C. esculenta* flavonoid glycoside- rich fraction mimics the action of estrogens, with reduced harmful effects on specific tissues [30].

Conclusion

C. esculenta is reported to be used as traditional medicine and dietary supplement in different parts of the world. Whole plants as well as separate parts of plants were found to be utilized for various therapeutic purposes. The present review focused on botanical description, ethnomedicinal uses, Phytochemistry, and Pharmacological activity updates of *C. esculenta*. Various phytochemicals such as alkaloids, glycosides, flavonoids, terpenes, saponins, and phenol steroids have been reported to be present in this plant. The plant also exhibits several pharmacological properties such as antidiabetic, hypolipppidddemic, anticancer, antimelanogenic, anti-inflammatory, antioxidant, hepatoprotective, anti-inflammatory, antimicrobial, antihelminthic, estrogenic and neuropharmacological activities. Further systemic studies are needed to establish the link between the traditional uses, bioactive compounds, and reported pharmacological activities. Clinical studies are also necessary to be conducted to evaluate the safety and efficacy aspect of *C. esculenta* to develop safe and effective dosage forms from this plant.

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