Pharmaceutical approach of Taro (*Colocasia esculenta*)

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ABSTRACT:
Colocasia esculenta is a widely cultivated plant belonging to the family Araceae. It is commonly known as "Taro" the name was given to this family's tubers and roots. It is an annual herbaceous plant with a long history of uses in traditional medicine and as a food in several countries. Taro is an extremely valuable source of carbohydrates as an energy source. It is rich in mucilage and starch granules. Traditionally, it has been employed in the treatment of asthma, arthritis, diarrhea, neuro disorders, and skin disorders. It possesses ingredients having antitumor, anti-diabetic, anti-microbial, anti-bacterial, anti-hepatotoxic, and anti-melanogenic properties. The literature survey carried out revealed that taro can serve as a potential film-forming agent, disintegrant, diluent, and granulating agent. The review revealed that taro can be used in the pharmaceutical industry for its various properties. Taro mucilage was found to be a suitable alternative to conventional mucilage's in formulations and development. Also in this review, we described different extraction techniques used to extract mucilage from the corms of the taro plant. The review concluded that all parts of the taro plant are useful and have a variety of health benefits. The starch and the gum obtained from the corms of *C. esculenta* can be used in the pharmaceutical industries for its various properties such as in the form of binder, matrix forming agent etc.

KEYWORDS: Taro, *Colocasia esculenta*, Mucilage, Starch, Gum.

INTRODUCTION:

Nature is the source number of medicinal agents for thousands of years. Plant materials are utilized throughout evolved and evolving nations as home medications, over the counter drug products and raw materials for the pharmaceutical industry and represent a concrete proportion of the global drug market[1]. Today, the whole world is greatly interested in natural drugs and excipients. These natural materials have many advantages over synthetic ones as they're chemically inactive, nontoxic, less expensive, biodegradable, enrich the shelf life of product and are widely available[2]. Either the whole plant is utilized or some parts of the plant are useful. One such example is Taro (*Colocasia esculenta*) which belongs to the family *Araceae*.

Taro is a tropical plant grown primarily for its edible corms. Other parts of the plant such as leaves, leaf stalks, and petioles are also used as a vegetable. It is often referred to as "elephant ears" they can reach up to 1-2 m in height during the growth period[3]. *Colocasia esculenta* is vegetatively propagated using the corms and a lesser extent the cormels. As food for human consumption, the nutritional value of the various parts of cocoyam is primarily caloric. The underground corms provide starch which is easily digestible and the leaves are nutritious and give a lot of minerals, vitamins, and thiamine[4]. Taro is used as food in a variety of dishes. In India various dishes are prepared from different parts of the taro plant such as Patrode prepared from taro leaves, Teanghoi prepared from corms, etc[5].

All parts of the plant are useful taro and could be considered as a zero-waste food crop. Calcium oxalate, a component of the taro plant causes throat inflammation and burning when eaten fresh and has resulted in a restriction of the usage of taro. Tubers are also processed to produce chips, starch, and flour, and are an important ingredient in many baby food products due to their nutritious value. Environmentally sustainable biodegradable films based on Taro and glycerol can be used as packaging material[5].

Table 1: Taro parts used in dishes

Country/ Region	Plant part	Dishes
India	Leaves	Patrode, Anishi
	Corms	Taro curry, Teanghoi, Tunkhon, Teangwan, Pan iromba, Arvi curry

	Leaves + Petioles + Corms	Khati bhuji/ garyalibhuji
	Petioles	Teangyakhoi, Shouhwan, Dolhou
Fiji	Leaves	Baseisei, Rourou
Cameroon	Corms	Achu
	Leaves	Khùkùëkassala
Nigeria	Corms	Fufu
Hawaii	Corms	Poi

Depending on the extraction method it has been reported that taro is a potential source of about 3 to 19 mucilage and 70 to 80% starch[6]. With an estimated annual production of around 229, 088 tonnes, taro is the second most important staple root crop in terms of consumption after sweet potato and the fourth most important root crop concerning production by weight after cassava, potato, and sweet potato. The crop is grown all over the world, primarily by resource-poor farmers, in different ecological conditions ranging from 1, 300 to 2, 300m above sea level. Its compatibility with various types of limited input farming methods, as well as its reliability under conditions such as drought, excessive rainfall, and low soil fertility, have made it an appealing crop to farmers. The most essential characteristics of taro are its flexibility, disease resistance, and ability to generate a high yield in a variety of conditions, particularly in the tropical environment[7].

Fig 1: Structure of some of the major amino acids

The chemical composition of taro mucilage consists of carbohydrates such as glucose, galactose, mannose, xylose, and arabinose and proteins which include major amino acids such as leucine, isoleucine, cysteine, tryptophan, and lysine.

Various factors such as maturity stage, distribution, molecular size, degree of branching, structural linkages, presence of hydrophobic components, and monomeric compositions also affect the functional properties of taro mucilage. The physiological stages of taro rhizomes showed variation in the yield of mucilage. Higher starch content was noted six months after planting and was reduced in the eighth month, whereas a high amount of dry matter was found at the physiological maturity stage of taro, and high protein content was found before the maturity stage[6].

The bakery industry is now searching for alternatives for wheat flour to produce gluten-free food items for gluten-allergic people, so it has a lot of promise in the food processing industry[5]. Various reports have been published on the effect of taro mucilage on baked food products. Taro mucilage in sliced bread is a stabilizing or thickening agent, resulting in reduced fat levels in high-quality bread. Since the emulsifying properties of taro mucilage were found to be beneficial for the quality and desirable production of bread[6].

Also, the emulsifying property of taro mucilage was studied by L A Andrade et al and the study concluded that the emulsifying property of the mucilage mainly results from the protein content, with the presence of weak-polar amino acids, especially leucine, isoleucine, and tryptophan[8].

Hydrocolloids, such as taro mucilage (*Colocasia esculenta*), can present similar characteristics to emulsifiers. The presence of arabinose and galactose in the taro mucilage is responsible for the formation of a complex with proteins, called Proteoglycan arabinogalactan that could present substantial emulsifying power, consequently favoring gas retention in the alveoli[9]. Starches are widely available and have been very useful in tablet production due to their inertness, cheapness, and utilization as fillers, binders, disintegrants, and glidants. Pre gelatinized taro starch is used as a filler for Thiamine Hydrochloride tablets. *C. esculenta* polysaccharide can be used as a disintegrant in the formulation of orally disintegrating tablets[10]. Corm juice is demulcent, laxative, and anodyne. The juice extracted from the corm of the plant is used in alopecia, as an expectorant, stimulant, appetizer, and astringent. The leaves of this plant have been studied to possess anthelminthic, anti-diabetic, and anti-inflammatory actions. There have also been reports proving the hypoglycemic efficacy of *C. esculenta* due tothe presence of cyanoglucoside. The juice of the plant leaf is rubefacient, stimulant, and styptic and is useful in internal hemorrhages, adenitis, otalgia, and buboes. The gum as well as starch obtained from the tuber of the *C. esculenta* plant can be used as an effective binder and muco-adhesive matrix-forming agent. 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[11]. The mucilage was characterized by various physicochemical properties such as solubility, pH, swelling index, and preliminary phytochemical studies. Taro mucilage exhibited good flow properties (Angle of repose 25°), Swelling index was 27% and pH was found to be 6.5. Extracted mucilage swells in water and is slightly soluble in organic solvents. It has acceptable pH and organoleptic properties so can be easily used in various dosage forms[12].

Taxonomy and Morphology:

Taxonomy:

(*Colocasia esculenta L*) known as Taro belongs to the family Araceae. The cultivated species of *Colocasia esculenta* and *Colocasia antiquorum* have been described by Linnaeus. Taro is related to Xanthosoma and Caladium, plants commonly grown as ornamentals, and like them, it is sometimes loosely called elephant ear. Different vernacular names of taro are listed

below[13]:

Table 2: Different vernacular names of C. esculenta

Sr. No.	Language	Names
1	English	Taro
2	Hindi	Aravi
3	Sanskrit	Alupam
4	Marathi	Alu
5	Gujarati	Alavi
6	Tamil	Sempu

Table 3: Botanical classification of C. esculenta

Rank	Scientific Name
Kingdom	Plantae (Plants)
Subkingdom	Tracheobionta (Vascular plants)
Super division	Spermatophytes (Seed plants)
Division	Magnoliophyta (Flowering plants)
Class	Liliopsida (Monocotyledons)
Subclass	Arecidae
Order	Arales
Family	Araceae (Arum family)
Genus	Colocasia Schott
Species	*Colocasia esculenta* (L.) Schott

Morphology:

Taro is naturally a perennial monocotyledonous herb, but for practical purposes is harvested after 5-12 months of growth. It grows to a height of 1-2m consisting of a central corm, lying just below the soil surface, from which leaves grow upwards, roots grow downwards, while corms, daughter corms, and runners grow laterally. It has heart-shaped green or purple leaves together with long petioles, fibrous roots, and a cylindrical or often irregular nutrient storage organ (corm), and the nature of flowering, fruiting, and seed production by wild or cultivated taros (*Colocasia esculenta*) has not been fully understood. Inflorescences of females are short, and those of males are long, and cylindrical, usually with interposed neuters be female inflorescence short, and male inflorescence long, and cylindrical, usually interposed neuters between the two[13].

Leaf:

The taro leaves rich in protein content (23%) found might be favorably complemented by the high carbohydrate contents (87%) found in the tuber part of the plant as a source of human food The leaves of taro have been reported to be rich in minerals like Ca, P, Fe, and vitamins. The high level of dietary fiber found in the taro leaf is also advantageous for its active role in the regulation of intestinal transit, increasing dietary bulk and feces consistency due to its ability to absorb water[13].

Root:

Nutritionally, roots and tubers have a great potential to provide economical sources of dietary energy, in the form of carbohydrates. The energy from tubers is about one-third of that of an equivalent weight of rice or wheat due to the high moisture content of tubers. However, high yields of roots and tubers give more energy per land unit per day compared to cereal grains In general the protein content of roots and tubers is low ranging from 1 to 2% on a dry weight basis. The corm of taro contains more than twice the carbohydrate content of potatoes and yields 135 kcals per 100g and 11% crude protein on a dry matter (DM) basis[13].

Nutritional value of taro:

Carbohydrate (expressed as the nitrogen-free extract, NFE) content reported has been estimated by subtracting the moisture, crude protein, ash, fiber, and fat from 100. Zinc and iron content has been analyzed following the AOAC (1990) dry ashing procedure and a standard analytical method for atomic absorption spectrophotometry[13].

Phytochemical Contents:

The total phenolic content was determined by the Folin-Ciocalteu Assay while the total tannin analysis was conducted using the modified vanillin method[13].

Carbohydrate:

The high level of carbohydrate content observed in raw taro, taro powder, noodles, and cookies agree with the findings reported by FAO that the main nutrient supplied by taro, as with other roots and tubers, is dietary energy provided by the carbohydrates[13].

Starch:

Taro corm has been reported to have 70–80% (dry weight basis) starch with small Granules. Because of the small sizes (1–4m in diameter) of its starch granules, taro is highly digestible and as such has been reported Taro starch is easily digestible, the starch grains are fine and very small, it has hypoallergenic nature and also the starch is gluten-free Taro starch is also good for peptic ulcer patients, patients with a pancreatic disease, chronic liver problems, and inflammatory bowel disease and

good for peptic ulcer patients, patients with a pancreatic disease, chronic liver problems, and inflammatory bowel disease and gall bladder disease[13].

Moisture:

Since taro is root crop its moisture content is very high and accounts for two third of the total weight of the fresh crops. Moisture content of taro varies with variety, growth condition and harvest time. In general, the moisture content of taro ranges from 60- 83%[13].

Protein:

Taro composes a higher protein content than root crops because of the presence of symbiotic soil. Bacteria in the root and rhizome part of taro. Additionally, these bacteria fix atmospheric bacteria and increase nitrogen accumulation in the corm and leaf. In addition, these bacteria are used as plant growth enhancers, as they release growth hormones into the root and all parts of the plant. The free-living nature of these soils bacterial also helps the taro crop to grow at different environmental and ecologic conditions. Economically and ecologically, these properties are important to the environment[13].

Total Ash:

Taro contains a relatively high amount of ash. This indicates that it contains good mineral content. The ash contents of taro ranged from 3.54 - 7.78%[13].

Chemical constituents:

Different chemical constituents are found in various parts of Taro plant which are mentioned in Table 4**.** Pharmacologically active group of flavonoids is found in leaf extracts of Taro which consists of Orientin, Iso – Orientin, Vicenin – 2, Iso – vitexin, Orientin 7-O-glucoside, Iso-vitexin 3'-O-glucoside, Vitexin X" -O-glucoside, Luteolin 7-O-glucoside. The leaves also contain various minerals (Calcium, phosphorus, etc), Calcium oxalate, fibres. Phytochemical studies have revealed presence of Anthocyanins such as Cyanidin-3-rhamnoside, Cyanidin-3-O-glucoside and Pelargonium-3-O-beta-D-glucoside. These Anthocyanins possess antioxidant and hepatoprotective properties[11]. Tubers of Taro plant contains maximum amount of starch around 73-76% and the starch yields are in the range of 51-58%.

Table 4: Chemical constituents of different parts of *C. esculenta*

Plant part	Chemical constituents
Leaves	Calcium oxalate, minerals like calcium, phosphorus, fibres, starch, vitamin A, B, C. Apigenin Luteolin Anthocyanin • Cyanidin-3-rhamnoside • Cyanidin-3-O-glucoside • Pelargonium-3-O-beta-D-glucoside Flavonoids • Orientin • 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 %) Natural polysaccharides Amino acids (13-23 %) Nitrogen content (0.34-1.35 %) Lipid (0.23-0.52 %) Phosphate monoester derivatives Dihydroxy sterols Beta – sitosterol Stigmasterol Nonacosane Cyanidine 3-glucoside Aliphatic compounds Octadecenoic acid Enzymes
Petioles	Anthocyanins (3.29 %)

Nutritional value:

Taro's underlying food consistency characteristics include nutritional as well as other phytochemicals with a variety of biological activities. Taro is a good source of starch, dietary fibres, sugars, and ash and it provides higher energy, carbohydrates, and vitamin A[14]. Table 5 shows Taro corms contain more amount of carbohydrates than Leaves and Shoot. Various minerals such as Calcium, Potassium and Mangnesium, etc with varying amount are found in different parts of Taro plant. Taro leaves and corms contain significantly more calcium, magnesium, and potassium than other tuber crops. Its leaves also have the highest concentrations of zinc, copper, manganese, and selenium. Vitamins such as Vitamin A, C, B6, etc are found in various parts of Taro plant. Taro leaves are rich in vitamin-A as compared to corms and shoots[14].

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Bioactive compounds:

Various Bioactive compounds have been identified in recent studies for their use in different ailments such as asthma, hypertension, pneumonia, internal hemorrhaging, and neurological and skin disorders. Secondary metabolites of the taro that function as bioactive compounds with antioxidant, anti-cancerous, anti-diabetic, immunomodulatory, and anti-microbial attributes are given in Table 6[14].

Table 5: Nutritional value of different parts of *C. esculenta* per 100g of dry weight

	Corms amount	Shoot amount	Leaves amount
Proximate composition			
Water	70.64 g	95.82 g	85.66 g
Energy	112 kcal	11 kcal	42 kcal
Protein	1.5 g	0.92 g	4.98 g
Total Lipid	0.2 g	0.09 g	0.74 g
Ash	1.2 g	0.85 g	1.92 g
Carbohydrate	26.46 g	2.32 g	6.7 g
Dietary fibers	4.1 g	12 mg	3.7 g
Sugars	0.4 g	0.6 mg	3.01 g
Minerals			
Calcium	43 mg	8 mg	107 mg
Iron	0.55 mg	28 mg	2.25 mg
Magnesium	33 mg	332 mg	45 mg
Phosphorus	84 mg	1 mg	60 mg
Potassium	591 mg	0.51 mg	648 mg
Sodium	11 mg	1 mg	3 mg
Zinc	0.23 mg	0.51 mg	0.41 mg
Copper	0.172 mg	0.088 mg	0.27 mg
Manganese	0.383 mg	0.122 mg	0.714 mg
Selenium	0.7 micro g	0.9 micro g	0.9 micro g
Vitamins			
Vitamin A	76 IU	50 IU	4825 IU
Thiamin	0.095 mg	0 04 mg	0.209 mg
Riboflavin	0.025 mg	0.05 mg	0.456 mg
Niacin	0.6 mg	0.8 mg	1.513 mg
Pantothenic acid	0.303 mg	0.075 mg	0.084 mg
Vitamin B6	0.283 mg	0.111 mg	0.146 mg
Vitamin C	4.5 mg	21 mg	52 mg

Table 6: Bioactive compounds found in C. esculenta and their pharmaceutical functions.

Bioactive compound	Plant part	Activity
Astilbin	Leaves	Anti-microbial
Iso-orientin	Leaves	Antioxidant
Orientin	Leaves	Anti-diabetic
Stigmasterol	Corms	Estrogenic
Vicenin-2	Leaves	Antioxidant
2, 3-Dimethylmaleic anhydride	Corms	Insecticidal and Anti-inflammatory

Extraction:

Taro mucilage is extracted from different parts of a plant and has various applications and characteristics based on their functional and structural components. Various extraction techniques are used namely enzyme-assisted, ultrasonication, microwave-assisted, aquatic, and solvent extraction methods.

Studies found that high purity (98%) mucilage from taro corms can be extracted using a low-temperature method, also found that taro mucilage can be extracted in five different conditions i.e.

a) At room temperature.
b) At room temperature with ethanol precipitation.
c) At high temperatures.
d) At high temperature with ethanol precipitation
e) At low temperature with ethanol precipitation[6].

A higher yield (8.05%) was obtained at room temperature, and the highest emulsifying activity and stability were found in condition b) mucilage extracted at room temperature with ethanol precipitation. Additionally, Taro mucilage is extracted from five different taro varieties by solvent extraction treatment. The studies showed that the protein content of mucilage was found to be higher (30-51%) due to the use of saline buffer during the extraction and hence different growth conditions of taro can affect the protein content[6].

Various extraction methods that were studied during literature review are given below.

Table 7: Different extraction methods of C. esculenta

Table 7: Different extraction methods of C. esculenta.

Sr. No.	Extraction method	Part of plant	References
1	*Colocasia esculenta* tubers (100g) weigh; outer covering removed, then fleshly portion was collected then mashed with double distilled water and filtered later treated with 90% dimethyl ketone and refrigerated for 10hr, centrifuge at 400 rpm for 30 min afterwards purified by hot dialysis method using orchid scientific dialysis apparatus. Dried in vacuumdesiccator passed through sieve #200 to get uniform particles and evaluated.	Tubers	[15]
2	Taro tubers were collected. Starch was extracted by three methods 1. Extraction by simple process 2. Wet milling process 3. Centrifugation process	Tubers	[16]
3	Taro tubers and leaves were collected and extracted by methanol for 3-4 hrs. solvent was evaporated by vacuumdried sample stored at 4^{o}C.	Tubers and leaves	[17]
4	Fresh corms are subjected to peel of their skin, cut into pieces and dried and made into flour was steeped into water at 35^{0}C for 12 Hrs. Slurry homogenises for 30 min using blender then suspension is obtained which is screened using 150 µm sieve and kept for sedimentation for 24 hrs centrifuge at 3000 rpm	Fresh corms	[18]
5	Fresh corms washed with water, peeled, sliced into cubes then suspended in 300ml distilled water; let to stand for 30 min followed by heating 80^{0}C for 2 hrs cooled. Then separation by muslin cloth. To filtrate add acetone then dried it in tray dryer.	Fresh corms	[19]

LITERATURE REVIEW:

Table 8: List of various research and review articles published.

Name of article	API	Type of dosage form	Treatment	Correlations	References
1. Formulation and in vitro characterization of phenytoin loaded mucoadhesive biofilms of *Colocasia esculenta* for translabial drug delivery system	Phenytoin	Mucosadhesive biofilm	Antiepileptic agent	*Colocasia esculenta* biomaterial can serve as a potential film forming agent for transmucosal drug delivery system	[15]
2.Physic-mechanical properties of edible films based on taro starch with glycerol addition	Taro with glycerol	Edible films	Food protector from microbial contamination	Combination of 3% taro starch and 25%glycerol gives good thickness, tensilestrength, elasticity and transparency	[20]
3.Extraction of starch from Taro and evaluating further using Taro starch as Disintegrating agent in tablet formulation	-	Tablet (Placebo)	-	Taro starch is better disintegrant than potato and corn starch placebo tablets. Cosmetic formulations like face powder and in dusting preparations which use aerosol dispensing system.	[21]
4.Cytotoxicity and antimicrobial property of *Colocasia esculenta*	-	-	-	Anti-microbial and anti-oxidant effect of taro tuber and leaf was checked as well as cytotoxicity against human osteocarcoma cell line.	[22]
5.Evaluation of *Colocasia esculenta* starch as an alternative tablet excipient to maize starch: Assessment by preformulation and formulation studies	Paracetamol Aspirin	Tablet		Preformulation studies results shown that *Colocasia esculenta* starch has similar properties like maize starch and has compatibility with paracetamol and aspirin.	[23]
6.Formulation and evaluation of mucoadhesive matrix tablets of taro gum: Optimization using Response surface Methodology	Domperidone	Mucoadhesive matrix Tablet	Anti-dopaminergic drug used to treat motion sickness	Taro gum has dominating effect on mucoadhesive strength and tensile strength. The drug release follows first order kinetics and shows best linearity with higuchi equation.	[19]
7.Development and evaluation of Mouth dissolving film of Ondansetron hydrochloride using HPMC E5 with Taro gum.	Ondansetron hydrochloride	Mouth dissolving Film	3-HT_3 receptor blocker	Novel polymer Taro was found to enhance the properties such as tensile strength, in-vitro disintegrant time and in vitro release of film	[24]
8.Preparation and optimization of sustained matrix tablets of metaprolol succinate and taro gum using response surface methodology	Metaprolol succinate	Sustained release matrix tablets	-	Tablets evaluated for various compression parameters such as tablet hardness, friability, weight variation , drug content, and results found to be within acceptable limits.	[25]
9.The effect of pregelatinized Taro starch (*Colocasia esculenta*(L)schott) temperature as filler on Thiamine	Thiamine hydrochloride	Tablet	-	Pregelatinizing is used to modify structure of starch by heating at certain temperature. Increasing temperature causes the starch to absorbs water and	[10]

hydrochloride tablet				swell quickly to obtain a large particle size.Pregelatinized taro starch is used as diluent tablets with wet granulation method.	
10.Formulation of Edible films from Fenugreek mucilage and Taro starch	-	Edible film	-	Pure fenugreek mucilage and pure taro starch films had more influence on film properties compared to combinations of mucilage and starch films	[26]
11.In vitro Evaluation of Native Taro Boloso-I Starch as a Disintegrant in tablet formulations	Paracetamol	Tablet	-	This study was aimed at evaluating and optimizing native Taro Boloso-I starch as a tablet disintegrant.The findings revealed that the tablets could comply with the pharmacopoeial disintegration time requirements for orodispersible tablets.	[27]
12.Study on Tablet Binding and Disintegrating properties of alternative starches prepared from Taro and Sweet potato Tubers	-	Tablet	-	To evaluate Taro starch and sweet potato starch as granulating agents and disintegrants, tablets with controlled compression loads were prepared by incorporating a starch candidate with dibasic calcium phosphate in paste and powders , respectively. It was found that the binding and disintegrating performance of both Taro starch and sweet potato starch was similar to that of commercial corn starch.	[28]
13.Taro corms mucilage/HPMC based transdermal patch: An efficient device for delivery of Diltiazem hydrochloride	Diltiazem hydrochloride	Transdermal Patch	-	The aim of this work is to examine the effectiveness of mucilage/HPMC based transdermal patch as a drug delivery device. In vitro drug release time of mucilage –HPMC based transdermal patches is prolonged with increasing mucilage concentration in the formulation.	[29]
14.Taro corms mucilage alginate microsphere for the sustained release of Pregabalin: In vitro and In vivo evaluation	Pregabalin	Microsphere	-	It is concluded that blended microspheres has greater bioavailability for pregabalin with sustained release effect.	[30]
15.Taro mucilage: Extraction, Characterization and Application in cosmetic Formulations	-	-	-	The mucilage demonstrates potential for application in cosmetic products and its commercial use as an ingredient in cosmetics could be a strategic tool for the creation of a new product chain and adding value to the culture of *Colocasia esculenta*.	[31]
16.Orally Disintegrating Tablet Using *Colocasia esculenta* Tuber polysaccharide as a disintegrant and its comparison with commercially available superdisintegrant.	Valsarton	Orally disintegrating agent	Antihypertensive agent	The present research work was aimed at the development and characterization of orally disintegrating tablet of valsartan using natural disintegrant to produce rapid onset of action and patient compliance.*Colocasia esculenta* polysaccharide can be used as a disintegrant in the formulation of orally disintegrating tablets. Its disintegrating property was found to be comparable with that of the commercially availablesuperdisingrants.	[32]

Mucoadhesive drug delivery systems influence the attraction between the mucus and polymeric drug carriers. Mucoadhesive are artificial or natural polymers, that will interact with the mucus layer which is present in the body at buccal cavity, and gastric mucosal layers[33]. The sustained release tablet provides uniform discharge of drug over a elongate period of time. Controlled release dosage form covers a broad range of prolonged action formulation which provides continual delivery of their active ingredient at a destined rate and time. A matrix tablet is the oral solid dosage form in which the drug or active ingredient is homo- geneously dispersed throughout the hydrophilic or hydrophobic matrices which serve as release rate retardants[34]. Disintegrants are the substances that causes the rapid disintegration of the capsules or tablets into smaller particles that dissolved and are employed to enhance the efficacy of solid dosage forms. This is attained by decreasing the disintegration time which is more in absence of disintegrants[35]. Binders are added to tablet formulation to give plasticity and thus amplify the interparticulate adhesion strength within the tablet. The evolution of new excipients for potential use as binding agent in tablet formulations continues to be of interest[36].

Current Aspects of Research on Taro:

During the review on taro gum as a polymer, we set up that the maturity of the papers were concerned with studies on tuber and leaves. Taro's phrasings, assiduity, processing, application, and product were other motifs that were of the experimenter's interest. similar as Karan Malik etal. carried out a study aimed to explore the mucoadhesive and release retardant parcels of taro goo and to optimize the medicine (Domperidone) release profile andbio-adhesion using response face methodology. The tablets were prepared and estimated for Hardness, Friability, Weight variation, Tensile strength, in vitro medicine release, and ex vivo bio tenacious strength. Also, Soumya M etal. carried out a study aimed to develop a sustained- release matrix tablet

of metoprolol succinate and optimize the expression using RSM. The tablets were prepared and estimated for medicine content, Tensile strength, Hardness, Friability, and Weight uniformity[19].

Harshal Ashok Pawar etal. carried out the development and evaluation of the Mouth Dissolving Film of Ondansetron Hydrochloride Using HPMC E5 in Combination with Taro Gum and other commercially available epoxies. All the flicks formulated using the natural polymer and HPMC E5 with glycerin by solvent casting system showed a decomposition time of lower than 60 sec. Also, they aimed at the development and characterization of an orally disintegrating tablet of Valsartan using taro as a disintegrant to produce rapid-fire onset of action and case compliance[24]. Another recent taro- grounded expression is grounded on comestible flicks. AshishM. Mohite and Divya Chandel carried out a study on comestible flicks on fenugreek gum and taro bounce. flicks were estimated grounded on optic, textural, morphological, microbiological, color, and thermal parcels.

Table 9: Latest research work on C. esculenta.

Sr. No.	Name of article	API	Dosage form	Treatment	Reference
1.	Formulation and evaluation of Mucoadhesive matrix tablets of taro gum: optimization using response surface methodology	Domperidone	Controlled release muco-adhesive matrix tablet	Motion sickness, anti-dopaminergic	[19]
2.	Orally disintegrating tablets using *Colocasia esculenta* Tuber polysaccharide as a disintegrant and it's comparison with commercial available super disintegrant	Valsartan	Orally disintegrating tablet	Antihypertensive	[32]
3.	Preparation and optimization of sustained release matrix tablets of metoprolol succinate and taro gum using response surface methodology	Metoprolol succinate	Sustained release matrix tablet	Antihypertensive	[25]
4.	Formulation and in vitro characterization of phenytoin loaded Mucoadhesive biofilms of Colocasia e sculenta for trans-labial drug delivery system	Phenytoin	Muco-adhesive biofilm	Antiepileptic	[15]
5.	Development and evaluation of Mouth dissolving film of Ondansetron hydrochloride using HPMC E5 with Taro gum.	Ondansetron hydrochloride	Mouth dissolving Film	3-HT3 receptor blocker	[24]
6.	The effect of pregelatinized Taro starch (*Colocasia esculenta*(L)schott) temperature as filler on Thiamine hydrochloride tablet	Thiamine hydrochloride	Tablet	–	[10]
7.	Taro corms mucilage/HPMC based transdermal patch: An efficient device for delivery of Diltiazem hydrochloride	Diltiazem hydrochloride	Transdermal Patch	–	[38]
8.	Formulation of edible films from fenugreek mucilage and taro starch	–	Edible films	primary packaging material for food products	[26]

Table 10: Different marketed formulation of *C. esculenta*.

API	Part of plant	Type of Formulation	Treatment/ Uses	Reference
Diltiazem HCL	Root	Transdermal Patches	Mild to moderate hypertension and angina	[38]
1, 2 –dioleoyl-sn-glycerol-3-phosphothanolamine, cholesterylhemisuccinate and 1, 2-distearyl-sn-glycerol-3- phosphothanolamine-N-folate (polyethylene glycol)	corms	Liposomal Nano capsules	Anticancer agent (Nano carriers) *	[39]
Iprodine	Leaves and plant	Pellets (floating)	Fungicide, Bacterial antagonists (in plants)	[40]
Soya bean and Rice bran	Leaves	Granules / fish burger	Fish diet	[41]
Wheat flour	corm	Cookie	-	[42]
Paracetamol, Aspirin	Roots and Corms	Tablet	Analgesic as Disintegrating agent	[21]
Domperidone	Endosperm of seeds	Mucoadhesive Tablet	Nausea and vomiting as matrix (polymer)*	[19]

The optic parcels similar as translucency and nebulosity set up better results in advanced taro attention flicks. The film set up better results for utmost of the parcels. These comestible flicks can be used as a primary packaging material for food products[26].

Marketed Formulations of *Colocasia esculenta*:

Plants and plant products are directly associated with the existence of human race on earth. Plants are used in several systems of medicine in almost all countries of the world[37]. During the literature review, we found that there are currently few preparations of *Colocasia esculenta* in the Indian market; so, there is a big scope for formulation and development using different parts of *Colocasia esculenta* in India. Some of the formulation of *Colocasia esculenta* which are found in various countries worldwide are given below:

Applications:

Antimicrobial activity:

The aqueous extract of *Colocasia esculenta* have been found to possess good antimicrobial activity against some of bacteria

The aqueous extract of *Colocasia esculenta* have been found to possess good antimicrobial activity against some of bacteria and fungus at low concentration. The studies were carried out for isolates of bacteria namely *Escherichia coli*, *Aeromonas hydrophilia*, *V.cholerae*, Salmonella sp., *Pseudomonas aeruginosa*, etc. The studies found maximam activity against *S.mutans* amongst all the selected strains of microbes[11].

Antifungal activity:
The studies found that recombinant CeCPI protein of the plant had toxic effect on mycelium growth of phytopathogenic fungi by exhibiting strong cysteine protease inhibitory activity[43].

Antidiabetic activity:
Ethanol extract of *C. esculenta* (EECE) leaves for antidiabetic activity was carried out on rats using alloxan induced diabetes model. EECE and metformin were administered orally in alloxan induced diabetic rats. At 4 Hrs the onset of reduction of glucose was observed and anti-hyperglycaemic effect was found to be diminished at 24 Hrs[11].

Hypolipidemic activity:
Studies shown that ethanolic extract of taro plant containing the compounds like monogalactosyldiacylglycerols and digalactosyl diacylglycerols have 28-67% inhibitory activities of human lanosterol synthase to suppress cholesterol biosynthesis[43].

Antihepatotoxic activity:
C. esculenta have found to have hepatoprotective and antihepatotoxic activity. The studies were conducted against two well-known hepatotoxic paracetamol and $_{CCl4}$ using in vitro rat slice method. In presence of CCl_4 and paracetamol, three was an increase in the levels of marker enzymes. Mainly, the leafy extract of *C. esculenta* abnormal declined the leakage of marker enzymes of liver function such as AST, ALP, and ALT in the medium demonstrating integrity of hepatocyte[11].

Anti-inflammatory activity:
Ethanolic extract of leaves of taro possess anti-inflammatory activity when studies were conducted in wister rats by inhibiting the leukocyte migration along with reduced pleural exudates and granuloma weight[43].

Anti-lipid peroxidative activity:
C. esculenta whole leaf was found to have free radical scavenging property. In Vitro studies of this effect were studied on liver cells by using rats' liver slice model. The marked elevations and preventions of depletion of total tissue glutathione were observed in the presence of *C. esculenta* whole leaf juice[11].

Antimetastatic activity:
The studies conducted for antimetastatic activity found that compounds that are derived from roots of the plant of *C. esculenta* has the capability to potentially and specifically inhibit tumour metastasis. Since Breast cancer mortality is due to the occurrence of metastatic disease, it possesses demonstrable activity in a pre-clinical model of metastatic breast cancer. They also found that Taro extract modestly inhibits the proliferation of some, but not all, breast and prostate cancer cell lines and it completely blocks tumour cell migration[11].

Pharmaceutical applications of Taro:
It might be possible to use the starch extracted from *Colocasia esculenta* in oral drug delivery systems as an excipient. Starch obtained from Tubers of *C.esculenta* can serve as an efficient binder, disintegrant, matrix forming agent, film forming agent, etc[4].

Pawar H A et al successfully prepared mouth dissolving films of Ondansetron Hydrochloride Using Taro gum in combination with HPMC E5. They reported that the film formulated using Taro and HPMC E5 compared to film containing only HPMC E5 showed better disintegration time, In- vitro release and tensile strength results[24].

Ahmed A et al studied taro starch as a disintegrating agent by formulating and evaluating placebo tablets using taro starch and other excipients. Formulation of tablets was done by direct compression, Dry granulation and wet granulation and their evaluation results were compared[21].

CONCLUSION:

In recent years, *Colocasia esculenta* have received interest due to its flexibility, disease resistance, and ability to generate a high yield in a variety of conditions, particularly in the tropical environment. Literature review concluded that there is vast scope for formulation developments on *Colocasia esculenta*. Also, it was found that there are currently few preparations of *Colocasia esculenta* in the Indian market; so there is a big scope for formulation and development using different parts of *Colocasia esculenta* in India. Studies revealed that Taro mucilage have good flowing properties, swelling index, pH, solubility it can be widely used in various dosage form. The chemical composition of taro mucilage consists of carbohydrates such as glucose, galactose, mannose, xylose, and arabinose and proteins which include major amino acids such as leucine, isoleucine, cysteine, tryptophan, and lysine.

isoleucine, cystine, tryptophan, and lysine.

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