

A PHYTOPHARMACOLOGICAL REVIEW OF COLOCASIA ESCULENTA: TRADITIONAL USES, BIOACTIVE COMPOUNDS, AND MODERN APPLICATIONS

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ABSTRACT

Colocasia esculenta (L.) Schott, commonly known as taro, is a widely cultivated member of the family Araceae, valued for its edible corms and nutrient-rich leaves. It serves as an important food source in tropical and subtropical regions due to its high carbohydrate, protein, vitamin, and mineral content. Phytochemical studies reveal the presence of flavonoids, saponins, tannins, alkaloids, phenolic acids, terpenoids, steroids, and cyanoglucosides, which contribute to its diverse pharmacological properties. Traditionally, various parts of *C. esculenta* have been used to treat asthma, arthritis, diarrhea, skin diseases, and neurological disorders. Modern research supports its antioxidant, antidiabetic, anti-inflammatory, antimicrobial, hepatoprotective, and anticancer activities. Despite its nutritional and therapeutic importance, taro cultivation faces challenges such as Taro Leaf Blight

(*Phytophthora colocasiae*), though development of disease-resistant varieties offers potential solutions. Overall, *C. esculenta* represents a nutritionally and pharmacologically valuable crop. Future research should focus on exploring its bioactive compounds, developing improved cultivars, and enhancing its utilization in food, pharmaceutical, and nutraceutical industries.

INTRODUCTION

Colocasia esculenta (L.) Schott, commonly known as taro, is an ancient tropical root crop

belonging to the family Araceae. It is one of the earliest cultivated plants in the world and holds immense importance as both a staple food and a medicinal plant across tropical and subtropical regions of Asia, Africa, and the Pacific Islands. The plant is known by several local names such as Arbi, Arvi, or Eddoe in India and Southeast Asia. Taro is primarily cultivated for its starchy corms and edible leaves, which serve as rich sources of carbohydrates, proteins, fibers, vitamins, and essential minerals.

The growing global demand for natural and functional foods has renewed scientific interest in taro due to its nutritional value, phytochemical diversity, and pharmacological potential. Phytochemical investigations have revealed the presence of numerous bioactive compounds, including flavonoids, alkaloids, glycosides, phenolic acids, tannins, saponins, and steroids. These compounds contribute to various therapeutic effects such as antioxidant, antiinflammatory, antidiabetic, antimicrobial, hepatoprotective, anticancer, and neuroprotective activities. Traditionally, *C. esculenta* has been employed in folk medicine to treat a wide range of ailments including asthma, arthritis, diarrhea, skin disorders, wounds, and internal hemorrhage. The plant's hypoglycemic potential is linked to cyanoglucosides, while its high fiber and micronutrient content make it valuable for maintaining cardiovascular and digestive health. Beyond its medicinal uses, taro also plays a crucial role in food security and rural livelihoods, especially in developing countries, due to its adaptability to diverse agro-climatic conditions and resilience against environmental stress. However, taro cultivation faces significant challenges, the most notable being Taro Leaf Blight (TLB) caused by *Phytophthora colocasiae*, which severely impacts yield and quality. Recent advances in genetic improvement, breeding programs, and disease-resistant cultivars have provided promising solutions for sustainable taro production.

Given its multifaceted significance, this review aims to provide a comprehensive overview of *Colocasia esculenta*, emphasizing its taxonomy, phytochemical profile, pharmacological activities, nutritional potential, and pharmaceutical applications. It also highlights the ongoing research efforts, challenges, and future prospects for the development and utilization of this underexploited yet valuable plant species.



BOTANICAL DESCRIPTION AND TAXONOMY

Taxonomical Classification

Kingdom: Plantae Division: Magnoliophyta Class: Liliopsida

Order: Alismatales Family: Araceae Genus: Colocasia

Species: *Colocasia esculenta* (L.) Schott

Colocasia esculenta, commonly known as taro, is a herbaceous perennial plant cultivated mainly for its edible corms and leaves. It is believed to have originated in Southeast Asia or the Indo-Malayan region, from where it spread to Africa, the Pacific Islands, and the Caribbean. Taro is one of the oldest cultivated crops and is considered a staple food for millions in tropical and subtropical regions.

MORPHOLOGICAL DESCRIPTION

The plant typically grows up to 1–2 meters in height and thrives in warm, humid environments with abundant rainfall. It possesses a large underground corm (tuber) surrounded by smaller cormels, which serve as storage organs rich in starch. The corms are generally brown on the outside and white, cream, or light purple internally.

The leaves are large, heart-shaped, and peltate (with the petiole attached near the center of the leaf), giving rise to its popular name “elephant ear.” The leaves are supported by long, thick petioles emerging from the corm. Microscopically, the leaves show a multi-layered palisade tissue and distinct stomatal arrangement, aiding in efficient photosynthesis and water regulation.

The inflorescence is a typical spadix enclosed within a spathe, characteristic of the Araceae family. The spadix bears both male and female flowers, while the spathe is a protective bract. The plant reproduces both vegetatively through cormels and sexually via seeds, although

vegetative propagation is most common in cultivation.

VARIETIES AND DISTRIBUTION

Taro exists in numerous landraces and cultivars, broadly classified into two main types:

1. Dasheen type – produces a large central corm and smaller cormels, typically used as a staple root vegetable.
2. Eddoe type – produces small, multiple cormels with a fibrous texture, more common in subtropical regions.

It is widely distributed in India, China, Japan, Malaysia, Indonesia, the Pacific Islands, Africa, and Central America. In India, it is popularly known as Arbi or Arvi, and is cultivated extensively in states like Maharashtra, West Bengal, Kerala, and Odisha.

Ecological Range and Cultivation Adaptability

Taro thrives in warm, humid climates with well-drained or waterlogged soils and can tolerate a wide range of altitudes. Its adaptability to various agro-climatic conditions makes it a reliable crop for food security, especially in regions with erratic rainfall patterns.

PHYTOCHEMISTRY AND BIOACTIVE COMPOUNDS

Major Phytochemical Classes

The phytochemical profile of *Colocasia esculenta* is characterized by a wide range of secondary metabolites that contribute to its pharmacological versatility. You can present these in your review as follows:

Phenolic Compounds and Flavonoids: The plant is rich in phenolic acids, such as caffeic, chlorogenic, and gallic acids, along with flavonoids including quercetin, rutin, luteolin, and apigenin. These compounds are primarily responsible for the plant's potent antioxidant and anti-inflammatory activities.

Sterols and Terpenoids: Research has identified essential sterols such as B-sitosterol, stigmasterol, cycloartenol, and taraxerol. These constituents are often linked to the plant's immunomodulatory and potentially anticancer properties.

Polysaccharides and Proteins: Taro corms are a significant source of unique polysaccharides (e.g., TPS-1, TPS-2) and bioactive proteins like tarin, which have been studied for their immunomodulatory and anti-tumor effects.

Alkaloids, Saponins, and Tannins: These compounds are present throughout various parts of the plant and contribute to its broad-spectrum antimicrobial and pharmacological profile.

Key Bioactive Molecules

To provide a deeper level of detail, categorize specific molecules that have been the focus of recent research:

Compound Category	Notable Examples	Primary Reported Effects
Proteins	Tarin, Globulins	Immunomodulatory, anticancer
Polysaccharides	TPS-1, TPS-2, Taro-4-I	Immunomodulatory, anti-inflammatory
Phenolics	Quercetin, Rutin, Gallic acid	Antioxidant, neuroprotective
Sterols	B-Sitosterol, Taraxerol	Anti-inflammatory, membrane stability

Nutritional and Structural Constituents

In addition to secondary metabolites, mention the nutritional components that support the plant's status as a functional food:

Starch and Carbohydrates: The tuber is predominantly starch (73–76%), which serves as a major energy source and a functional component in pharmaceutical formulations due to its unique granule morphology.

Vitamins and Minerals: The leaves are notably high in Vitamin C, while the roots provide essential minerals like iron, phosphorus, and zinc, alongside vitamins including thiamine, riboflavin, and niacin.

Oxalates: It is important to note the presence of calcium oxalate, which is a well-documented anti-nutritional factor; modern research emphasizes that proper processing, such as cooking or fermentation, is required to reduce these levels for safe consumption.

By grouping these constituents, you demonstrate both the medicinal promise of the plant (via secondary metabolites) and its role as a nutritional resource. Ensure you cite studies that utilize modern analytical techniques like HPLC or GC-MS to confirm the presence of these specific compounds

PHARMACOLOGICAL ACTIVITIES

Colocasia esculenta (L.) Schott has been extensively studied for its wide spectrum of pharmacological properties, attributed to its rich content of bioactive phytochemicals. Traditional medicinal systems across Asia, Africa, and the Pacific have utilized various parts

of the plant for centuries to treat numerous ailments. Modern pharmacological studies have validated many of these traditional claims, confirming the plant's therapeutic significance.

Antioxidant Activity

Taro extracts exhibit strong antioxidant potential due to the abundance of flavonoids, phenolic acids, and vitamin C. These compounds scavenge free radicals, inhibit lipid peroxidation, and protect cells from oxidative stress. Studies have demonstrated that both corm and leaf extracts of *C. esculenta* show significant DPPH and ABTS radical scavenging activity, suggesting their potential in preventing oxidative stress-related disorders such as aging, diabetes, and cardiovascular diseases.

Antidiabetic Activity

Extracts of *C. esculenta* have shown promising antidiabetic and hypoglycemic effects. The presence of cyanogenic glycosides, flavonoids, and saponins contributes to improved glucose metabolism by enhancing insulin secretion and glucose uptake. Animal studies have reported a reduction in blood glucose levels and improved pancreatic function following administration of taro leaf or corm extracts. The plant's dietary fiber also aids in delaying carbohydrate absorption, helping maintain glycemic control.

Anti-inflammatory and Analgesic Activity

Flavonoids, tannins, and steroids present in taro are responsible for its anti-inflammatory and analgesic effects. Ethanolic and methanolic extracts of taro leaves have been shown to significantly reduce edema and inflammation in experimental models. The inhibition of pro-inflammatory mediators such as prostaglandins and cytokines is believed to contribute to this activity.

Antimicrobial and Antifungal Activity

Taro extracts possess notable antimicrobial properties against a range of Gram-positive and Gram-negative bacteria, including *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*. The leaf and corm extracts also exhibit antifungal activity against pathogens such as *Candida albicans* and *Aspergillus niger*. These effects are linked to the presence of phenolics, saponins, and tannins, which disrupt microbial cell membranes and inhibit enzyme activity.

Hepatoprotective Activity

The hepatoprotective potential of *C. esculenta* has been attributed to its antioxidant and detoxifying compounds. Experimental studies show that taro leaf extract helps restore liver enzyme levels and prevents histopathological damage induced by toxins. This supports its traditional use in managing jaundice and other liver ailments.

Anticancer Activity

Recent studies indicate that *C. esculenta* exhibits anticancer properties, mainly due to its polyphenolic and flavonoid content. Extracts have been found to induce apoptosis (programmed cell death) in certain cancer cell lines and inhibit tumor growth. The antitumor activity is associated with the modulation of oxidative stress and suppression of cancerpromoting pathways.

Antimicrobial and Anthelmintic Activity

In addition to antimicrobial effects, the plant shows anthelmintic activity, particularly from its ethanolic leaf extracts, which effectively paralyze and kill intestinal worms such as *Pheretima posthuma*. This supports its traditional use in treating parasitic infections.

Other Reported Activities

Beyond these major activities, *C. esculenta* has shown:

Hypolipidemic activity: Helps in lowering serum cholesterol and triglycerides.

Neuroprotective effects: May help in managing neurological disorders by reducing oxidative stress in nerve tissues.

Wound healing and skin protection: Due to the presence of saponins and tannins, which promote tissue regeneration and prevent infection.

ETHNOBOTANICAL AND TRADITIONAL USES

Traditional Medicinal Systems

Colocasia esculenta has been utilized for centuries across various indigenous systems of medicine, particularly in India, China, and Polynesia.

Ayurveda: Known in Ayurvedic texts as *Alookam* or *Aloopam*, the plant is used to pacify vitiated doshas and is frequently cited as a remedy for various physiological imbalances.

Folk Medicine: Traditional practitioners have historically utilized the corms, leaves, and

petioles to treat a wide array of conditions, including asthma, diarrhea, constipation, stomatitis, hemorrhages, and liver-related ailments

Topical Applications: The mucilaginous pulp extracted from the petiole is widely recognized for its styptic properties and is traditionally applied to fresh cuts and wounds to stop bleeding and promote healing.

Therapeutic Preparations: In some cultures, corms are chopped, wrapped in cloth, and heated to serve as poultices for treating rheumatism, while the juice extracted from the corm is used as a stimulant, expectorant, and treatment for alopecia.

Cultural Significance and Ethnobotany

Beyond its medicinal profile, *Colocasia esculenta* holds profound cultural and symbolic value in many societies.

Symbolism of Resilience: In various cultures, the plant's ability to thrive in challenging environments and its capacity to regenerate have made it a symbol of life-giving power, survival, and resilience against adversity.

Sacred Status: In Hawaii, the plant—referred to as *kalo*—is considered a sacred ancestor of the Hawaiian people and plays a central role in traditional ceremonies, rituals, and mythology, fostering a deep communal connection to the land.

Sustenance and Community: The crop serves as a dietary staple that brings communities together, and its cultivation, harvesting, and preparation are often accompanied by communal activities that honor natural cycles and ancestral heritage.

PHARMACEUTICAL AND NUTRITIONAL APPLICATIONS

Colocasia esculenta (L.) Schott is not only valued as a staple food crop but also holds significant promise in pharmaceutical, nutraceutical, and industrial applications due to its rich phytochemical and nutritional composition. The plant's corms, leaves, and petioles contain essential nutrients and bioactive compounds that make it an important functional food and a potential source of natural therapeutic agents.

1. Nutritional Applications

The corms and leaves of *C. esculenta* are highly nutritious and serve as an essential component of the human diet in many tropical regions.

- **Energy Source:** The corms are rich in easily digestible starch, providing up to 135 kcal per 100 g, making taro an ideal food for infants, elderly individuals, and patients with digestive disorders.
- **Protein and Fiber Content:** Taro leaves contain up to 11% protein (on a dry-weight basis) and are rich in dietary fiber, which aids digestion, regulates bowel movements, and helps control cholesterol levels.
- **Vitamins and Minerals:** The plant provides essential micronutrients such as calcium, iron, phosphorus, potassium, zinc, vitamin C, thiamine, riboflavin, and niacin — all vital for maintaining metabolic and immune functions.
- **Food Security:** Its adaptability to diverse agro-climatic conditions and ability to thrive in nutrient-poor soils make it an important crop for food security in developing countries. Taro can be processed into flour, chips, noodles, and baby food, enhancing its commercial value.

Moreover, the presence of small starch granules (3–18 μm) gives taro excellent digestibility and functional properties, allowing its use in dietary formulations, gluten-free foods, and pharmaceutical excipients.

2. Pharmaceutical and Medicinal Applications

The bioactive compounds of *C. esculenta* have attracted interest for their therapeutic potential in drug development and disease management.

- **Antioxidant and Anti-inflammatory Formulations:** Extracts of taro leaves and corms are used in herbal preparations to prevent oxidative stress and inflammation-related disorders such as arthritis and cardiovascular diseases.
- **Antidiabetic Agents:** The plant's saponins, flavonoids, and phenolic compounds may be utilized to develop natural hypoglycemic drugs or supplements.
- **Hepatoprotective and Detoxifying Products:** The antioxidant-rich extracts can be incorporated into formulations aimed at liver protection and detoxification.
- **Antimicrobial Preparations:** Phenolic and tannin-rich fractions can be used in topical antiseptics, woundhealing creams, and natural preservatives.
- **Cosmeceuticals:** Due to its antioxidant and skin-protective properties, taro extracts are increasingly being explored for use in anti-aging and moisturizing products.

3. Industrial and Biotechnological Uses

Beyond direct consumption, *C. esculenta* has promising industrial applications:

- Pharmaceutical excipient: Taro starch is used as a natural binder, disintegrant, and filler in tablet formulations due to its fine particle size and high swelling capacity.
- Bioplastic and biofilm production: The starch can be used to create biodegradable materials, supporting sustainable manufacturing.
- Fermentation and nutraceuticals: Taro-based substrates are used in fermentation processes to produce organic acids, enzymes, and probiotics.

SAFETY, TOXICOLOGY, AND CLINICAL GAPS:

Safety and Toxicology

The primary safety concern with *Colocasia esculenta* is its raw state toxicity, which requires careful processing.

Calcium Oxalate Raphides: All parts of the plant, especially wild varieties, contain needle-like calcium oxalate crystals (raphides). These cause immediate mechanical irritation, swelling, and burning of the oral cavity and throat upon ingestion if not properly destroyed via cooking, fermentation, or other processing methods.

Anti-nutritional Factors: Beyond oxalates, the presence of tannins and alkaloids can interfere with nutrient absorption and digestive enzyme activity. Your review should note that while these are “toxic” in excess, they are also studied for their role in plant defense and potential biopesticide applications.

Acute and Subacute Studies: Mention that while some animal models (e.g., rats) have shown the plant is generally safe at doses up to 4000 mg/kg, high-dose, long-term, or chronic ingestion of specific extracts (especially those infected by pathogens) has been linked to potential adverse effects like lung inflammation and respiratory distress in some studies.

Clinical Gaps and Research Needs

This part of your paper provides the opportunity to demonstrate your critical analysis of the current scientific literature.

Lack of Human Clinical Trials: Emphasize that while *in vitro* (test tube) and *in vivo* (animal) studies show promise for anticancer and antidiabetic effects, there is a severe shortage of robust, randomized human clinical trials.

Standardization Issues: Current research is hindered by a lack of standardized extraction methods and dosage guidelines. Without standardized “active” concentrations, it is difficult to determine clinical efficacy or safety limits.

Mechanistic Clarity: Many studies describe that an effect occurs (e.g., “it reduced tumor size”), but they often fail to explain how it happens at the molecular level. Your review should identify this as a major gap for future research.

Varietal Differences: The chemical composition can vary significantly based on soil, climate, and the specific cultivar of *Colocasia*. Future studies need to account for these variables when conducting pharmacological evaluations.

FUTURE PERSPECTIVES

- **Standardized Phytopharmaceutical Development:** Future efforts should focus on identifying and isolating standardized “active” extracts, which are essential for developing consistent, dose-specific, and reliable pharmaceutical formulations.
- **Mechanistic Molecular Studies:** While many effects are well-documented in observational and animal studies, there is an urgent need for more molecular-level research to elucidate the exact pathways (e.g., cell signaling, gene expression) through which bioactive compounds exert their anticancer and anti-inflammatory effects.
- **Bioavailability Enhancement:** Investigate novel drug delivery systems—such as nanotechnology or encapsulation techniques—to improve the bioavailability of taro-derived compounds, ensuring that they can be effectively absorbed and utilized by the human body.
- **Cultivar-Specific Profiling:** Since the chemical composition of taro can fluctuate based on environmental factors and variety, future research should catalog the pharmacological potential of different cultivars, potentially identifying “super-cultivars” specifically for medicinal use.

Industrial and Biotechnological Applications

The versatility of taro extends beyond medicine into broader industrial applications, which adds value to your review.

- **Functional Foods and Nutraceuticals:** Given its rich profile of resistant starch and bioactive proteins, there is significant potential for using taro as a functional ingredient in health foods designed for blood sugar management or gut health.

- Green Synthesis and Biopesticides: Due to its anti-nutritional compounds (like tannins and saponins), taro extracts have untapped potential as natural, eco-friendly biopesticides or antioxidants in the cosmetic and food-packaging industries.
- Biotechnology and Waste Valorization: Future work can explore ways to extract high-value bioactive molecules from taro waste products (such as discarded leaves or skins), promoting a circular economy in agricultural processing.

CONCLUSION

The evidence presented in this review underscores *Colocasia esculenta* as a multifaceted plant with immense potential, bridging the gap between traditional ethnomedicinal practice and modern evidence-based pharmacognosy. Its diverse phytochemical profile—rich in flavonoids, polyphenols, and unique bioactive proteins—provides a scientific basis for the therapeutic claims reported in various indigenous cultures, particularly regarding its anti-inflammatory, antioxidant, and immunomodulatory properties.

However, the transition of *Colocasia esculenta* from a functional food to an effective phytopharmaceutical is currently limited by the lack of standardized human clinical trials, inconsistent dose-response data, and the presence of antinutritional factors that necessitate precise processing. Future research must prioritize the development of bioavailable, standardized extracts and investigate the precise molecular mechanisms of action to ensure safety and clinical efficacy. By adopting a more systematic approach to research, including the use of advanced biotechnological extraction and clinical validation, *Colocasia esculenta* can be fully harnessed as a sustainable, plant-based medicinal resource for global healthcare.

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