Journal of Experimental Pharmacology

Dovepress
Taylor & Francis Group

Open Access Full Text Article

REVIEW

Colocasia Esculenta as a Potential Plant-Based Medicine: A Review on Its Bioactive Constituents and Pharmacological Activities

Reza Pertiwi[1,2,*], Gofarana Wilar[3,*], Sri Adi Sumiwi[3,*], Jutti Levita[3,*]

[1]Doctoral Program in Pharmacy, Faculty of Pharmacy, Universitas Padjadjaran, Sumedang, Indonesia; [2]Faculty of Mathematics and Natural Sciences, Universitas Bengkulu, Bengkulu, Indonesia; [3]Department of Pharmacology and Clinical Pharmacy, Faculty of Pharmacy, Universitas Padjadjaran, Sumedang, Indonesia

*These authors contributed equally to this work

Correspondence: Jutti Levita, Department of Pharmacology and Clinical Pharmacy, Faculty of Pharmacy, Universitas Padjadjaran, Jl. Raya Bandung-Sumedang km 21, Sumedang, 45363, Indonesia, Tel +6222-84288888 Ext 3510, Email jutti.levita@unpad.ac.id

Abstract: *Colocasia esculenta* (L.) Scott, commonly known as taro, is a tuberous plant widely cultivated and utilized as a food source and traditional medicine in various cultures worldwide. Its ethnopharmacological significance, particularly in Asia, Africa, and the Pacific Islands, has increased scientific interest in exploring its therapeutic potential. This review provides a comprehensive overview of the diverse characteristics of *C. esculenta*, emphasizing its bioactive constituents and reported pharmacological activities. To gather relevant information, articles were retrieved from the PubMed database using the keyword "Colocasia esculenta", with filters applied to full-text articles published between 2015 and 2024. Inclusion criteria comprised studies reporting pharmacological, toxicological, or phytochemical findings, while unrelated agricultural studies were excluded. The evidence suggests that *C. esculenta* exhibits multiple pharmacological activities across various experimental models. In vitro studies have shown this plant has anticancer, antibacterial, anti-inflammatory, antiproliferative, anti-oxidant, and antidiabetic properties. Animal models have demonstrated their anticancer, antidiarrheal, anti-obesity, hepatoprotective, antidiabetic, diuretic, antihyperlipidemic, anti-inflammatory, neuroprotective, and anticonvulsant properties. Flavonoids, phenolic compounds, and alkaloids contribute to the therapeutic effects of *C. esculenta*. Limited human investigations, including studies using the proximity extension assay (PEA) protocol, suggest potential translational applications, although clinical evidence remains scarce. In conclusion, *C. esculenta* demonstrates promising pharmacological activities supported by preclinical evidence, yet significant research gaps persist, particularly regarding varietal differences, standardized dosages, safety profiles, and rigorous clinical validation. Future studies should focus on comparative phytochemical analyses, toxicological evaluations, and well-designed clinical trials to establish its efficacy and safety as a plant-based therapeutic agent.

Keywords: *Colocasia esculenta*, secondary metabolite, pharmacological activity, flavonoid, phenolic

Introduction

Traditional medicine remains a primary pillar in the basic healthcare systems of many developing countries, where a significant portion of the population relies on traditional practitioners and medicinal plants, despite the availability of modern medicine. The popularity of phytomedicine persists because of historical and cultural factors. In developed countries, interest in alternative and complementary therapies, including medicinal herbs, continues to grow as part of a holistic approach to health. Traditional medicine systems have increasingly attracted worldwide attention over the past ten years.[1]

Traditionally, *Colocasia esculenta* or taro has been widely utilized as a food source and as a traditional medicine. In Africa, taro is also considered an important food crop with various health benefits: its corm provides energy, while the leaves contain vitamins and minerals (β-carotene, iron, folate) believed to help protect the kidneys and prevent acidosis and kidney stones.[2] Meanwhile, in Islamic and Mediterranean medieval records, taro (referred to as *qolqas*) was used

Received: 5 July 2025
Accepted: 17 October 2025
Published: 31 October 2025

both as food and medicine, with its distribution noted along the East African coast, Egypt, and Syria, and it was consumed therapeutically after being peeled and boiled to remove its acrid properties.[3] In Asia, particularly India, taro is widely known in different regions under local names such as *eddoe, arvi*, and *arbi*. All parts of the plant (corm, leaves, and petioles) have been employed in traditional medicine to treat general weakness, constipation, baldness, stomatitis, hemorrhoids, liver diseases, and are attributed with laxative, demulcent, styptic, antidiabetic, antidepressant, and anthelmintic effects.[4] In Indonesia, various ethnic communities such as Banjar, Dayak, Kutai, Malay, Bugis, and Toraja have utilized taro corms, petioles, and leaves both as staple food and as traditional remedies, including for lowering blood pressure and as an alternative therapy for diabetes.[5]

In Indonesia, traditional medicine plays a significant role in supporting the public healthcare system. Indonesia has great potential for developing traditional medicines derived from natural products as a tropical country with abundant biodiversity and a diverse ethnomedicinal cultural heritage. One of the natural resources widely grown in various regions of Indonesia, which the community has long utilized as a food source and traditional medicine, is taro, with the botanical name *Colocasia esculenta* (L.) Scott belongs to the Araceae family (see Figure 1).

Colocasia esculenta (L.) Schott, a perennial herb of the Araceae family, is characterized by large peltate leaves and thick underground corms rich in starch, which serve as its main storage organ.[6] The plant is commonly propagated vegetatively through corms, cormels, or stolons, as this approach is more reliable than seed propagation.[7] Botanically, taro is classified into two major types: the eddoe-type, producing numerous side-corms, and the dasheen-type, which has a larger central corm with few side-corms, reflecting differences in physiology and utilization.[7,8] Taro also shows high morphological plasticity, adapting widely across varieties.[8]

Ecologically, taro thrives in tropical and subtropical regions with temperatures of 25–30 °C and high rainfall (2000–2500 mm). It tolerates waterlogging and is often cultivated in paddy fields, wetlands, and riverbanks, although some adaptive varieties can grow under dryland conditions with limited irrigation.[7] Local varietal diversity is evident worldwide: in Indonesia, surveys in Central Java identified landraces such as *beneng, benek, kasduto, wungu*, and *banyu*.[9] In India and South Asia, a wild variant, *var. aquatilis*, produces long stolons and occurs from Southeast Asia to Australia.[8] In Hawaii, commercial cultivars like *Bun Long* and *Maui Lehua* are widely used for cultivation and poi production.[10]

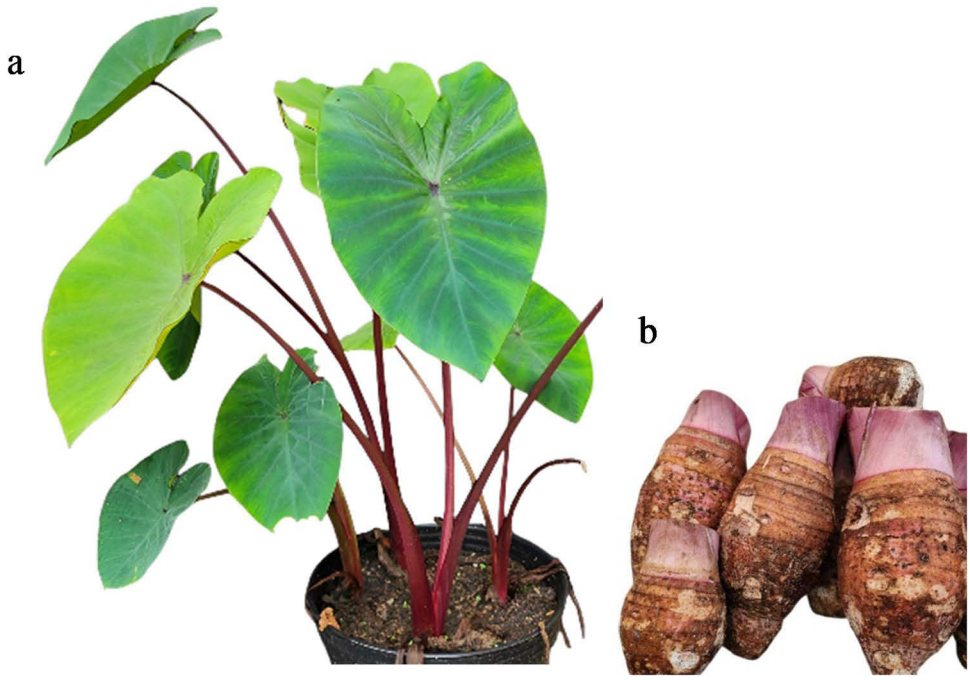

Figure 1 *Colocasia esculenta* (L.) Scott (**a**) plant and (**b**) tubers or corms.

Studies report distinct nutritional and starch profiles in *Moi, Tahitian*, and *Bun-long*, supporting their potential in modern food development.[11]

C. esculenta is a tuber crop that is widely cultivated in South America and Asia, particularly in Indonesia, as a local food source that is rich in carbohydrates and fiber.[12,13] Various taro varieties are distributed throughout the Indonesian archipelago. However, their utilization remains limited to traditional food consumption and has not been widely developed as a raw material for herbal medicine. Considering Indonesia's rich biodiversity and ethnomedicinal heritage, taro has great potential for further development as a functional plant and a natural-based traditional medicine.

C. esculenta has attracted the attention of researchers in various scientific disciplines owing to its pharmacological, nutritional, and agronomic potential. Over the years, the number of studies focusing on this plant has significantly increased. As shown in Figure 2, research on *C. esculenta* has grown steadily from 1990 to the present, showing a linear trend-line with a regression equation of $y = 0.8366x - 1668.3$ and a correlation coefficient of R = 0.8744, thus reflecting the global interest in its applications in health, functional food, and sustainable agriculture. This trend also indicates that research on *C. esculenta* has developed quantitatively and expanded geographically, covering various countries across Asia, Africa, the Americas, and the Pacific Region.

Studies on *C. esculenta* have shown that this plant contains bioactive compounds such as flavonoids, alkaloids, and saponins, which exhibit potential antioxidant, anti-inflammatory, antidiabetic, and antimicrobial properties.[14] Moreover, its abundant phenolics and flavonoids, such as chlorogenic acid, catechin, and quercetin, exhibit high antioxidant activity. These compounds neutralize free radicals by donating an electron or a hydrogen atom, which helps prevent oxidation reactions that could harm cells and tissues.[15] *C. esculenta* is rich in soluble fibres and polysaccharides, slowing glucose absorption in the intestines and regulating blood sugar levels.[16] Additionally, the flavonoid content in *C. esculenta* has been shown to enhance insulin sensitivity by modulating insulin signaling pathways and reducing insulin resistance in individuals with type 2 diabetes.[17] The phenolic and alkaloid compounds in *C. esculenta* disrupt bacterial cell membranes, inhibit bacterial protein synthesis, and interfere with the activity of essential enzymes in pathogenic microorganisms.[18] A deeper understanding of the benefits and active compounds of *C. esculenta* is essential to support its utilization in healthcare and the food industry.[19] Considering all, this article aims to provide insights into the potential of *C. esculenta* as a plant-based medicine by exploring various studies on the pharmacological activities of this plant.

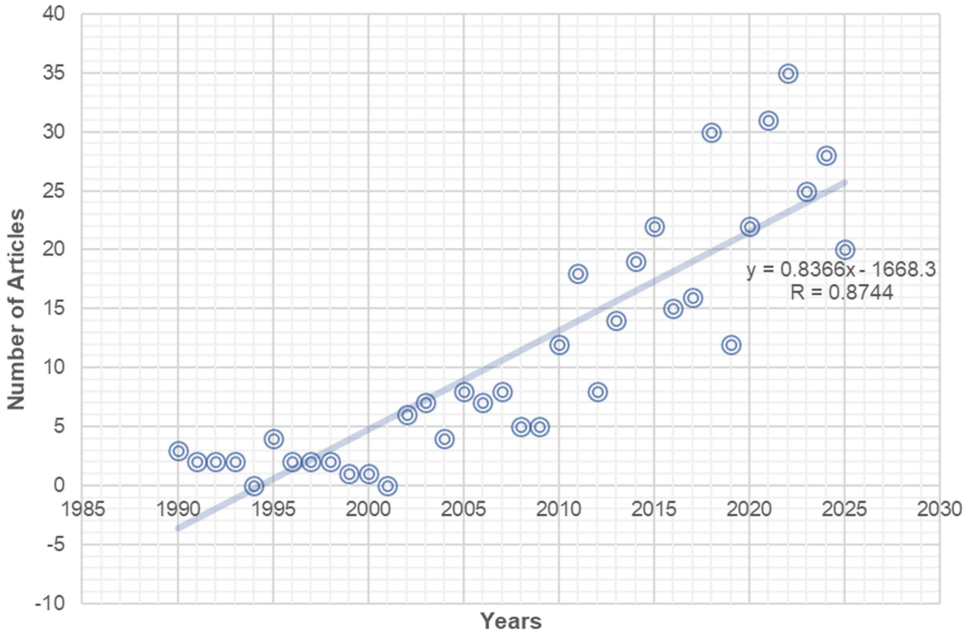

Figure 2 Annual distribution of research on *Colocasia esculenta* searched in the PubMed database in the period between 1990 and 2025, showing a linear trendline with a regression equation of $y = 0.8366x - 1668.3$ and a correlation coefficient of R = 0.8744.

https://doi.org/10.2147/JEP.S550113

The application of *C. esculenta* necessitates careful evaluation of its safety profile and traditional dosage practices. Both corms and leaves contain antinutritional constituents, including calcium oxalate crystals, tannins, and cyanogenic compounds, which may cause gastrointestinal irritation if consumed without appropriate processing. Traditional preparation methods such as boiling, roasting, and fermentation have historically been employed to reduce antinutrient levels and enhance edibility to mitigate these risks.[7,20] Preclinical investigations further indicate a favorable safety margin, as ethanolic leaf extracts did not induce mortality in acute toxicity studies at doses up to 5000 mg/kg. Moreover, antihyperglycemic, antihypertensive, and diuretic effects were observed to be safe within a therapeutic window of 100–400 mg/kg in animal models.[21] These findings underscore the therapeutic promise of *C. esculenta*, highlighting the need for further investigations to establish long-term safety thresholds and robust clinical validation.

Methods

Only peer-reviewed articles reporting pharmacological, phytochemical, or toxicological findings of C. esculenta were included to ensure scientific rigor. Further screening was conducted based on titles and abstracts, excluding unrelated articles, non-English publications, review papers, and duplicates. Studies focusing solely on agricultural or nutritional aspects without pharmacological relevance were excluded. Additional inclusion criteria were: (i) availability of full-text articles, (ii) publication in English, and (iii) publication within the last ten years (2015–2024). Quality assessment was performed by evaluating study design, methodological reproducibility, adequacy of controls, and clarity of outcome reporting.

This review was conducted in accordance with the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews) guidelines to ensure transparency and reproducibility. Relevant articles on *Colocasia esculenta* were retrieved from the PubMed database using the keyword "C. esculenta." Filters were applied to restrict results to English-language articles, free full-text availability, and publications between 2015 and 2024. This initial search yielded 246 records. A total of 204 articles were excluded for being unrelated to pharmacological or phytochemical aspects, being review papers, lacking full-text access, or providing insufficient or irrelevant data. Following the screening and eligibility assessment, 42 articles were included in the final qualitative synthesis. These studies addressed the ethnopharmacology, phytochemistry, pharmacological activities, or toxicological evaluation of *C. esculenta*.

Ethnopharmacology

C. esculenta has long been used in traditional medicine across various cultures because of its diverse bioactive compound content. Ethnopharmacologically, pressed petiole (leaf stalk) juice has styptic properties and is used to stop arterial bleeding. It is also used to treat earache (*otalgia*) and ear discharge (*otorrhoea*), and serves as a stimulant and rubefacient to enhance blood circulation, including in cases of internal hemorrhage. Leaf juice is a stimulant, expectorant, astringent, appetite enhancer, and a remedy for ear pain. Traditionally, the leaf stalk juice mixed with salt has been used as an absorbent to treat inflamed glands and buboes. The cooked *C. esculenta* contains mucilage, which is considered an effective nervine tonic. A decoction made from the peel is used in folk medicine to treat diarrhea. Taro is also believed to promote weight gain and reduce excessive sputum secretion in asthmatic individuals. Corm juice has been topically applied to treat alopecia. Internally, *C. esculenta* corm is used to treat hemorrhoids and portal system congestion as a laxative, demulcent, mild analgesic (anodyne), and galactagogue (a lactation inducer).[22]

The extensive historical use and well-established nutritional profile of *C. esculenta* highlight its potential as a functional food with health-promoting attributes. The starch derived from *C. esculenta* is characterized by its small and fine granule structure, which facilitates high digestibility and renders it appropriate for individuals with compromised or sensitive digestive systems. Furthermore, taro is inherently hypoallergenic and devoid of gluten, positioning it as a suitable carbohydrate source for populations with gluten-related disorders, including celiac disease and non-celiac gluten sensitivity.[23] In the Patuakhali and Barguna districts of southern Bangladesh, the leaves and petioles of *C. esculenta* are traditionally used for their hemostatic properties and in treating wounds to promote healing.[24] Other studies have reported that, traditionally, the tuber of *C. esculenta* is used in the management of diabetes mellitus and the treatment of ringworm, cough, sore throat, and wounds.[25]

C. esculenta, commonly known as "Alu and dasheen", is a food crop in the Caribbean and is used as a traditional food for treating diabetes mellitus. The plant is useful for curing diabetes; it is anthelmintic, demulcent, and helpful for cough, sore throat, and wounds.[26] *C. esculenta* has been utilized in traditional Chinese medicine as a component of tonic formulations and as a therapeutic agent for gastrointestinal disorders, particularly following tumor resection procedures. Tubers are a rich source of resistant starch and are commonly employed as an alternative carbohydrate in various dietary patterns across different countries. Additionally, *C. esculenta* contains several defense-related proteins, including lectins and metallothionein, which play a role in protecting plants against pests, pathogens, and abiotic stressors.[25]

Botanical and Phytochemical Aspects

C. esculenta is a tropical corm plant that includes various cultivars. This herbaceous plant is commonly found in tropical and subtropical regions.[26] *C. esculenta* is one of the Araceae family's most economically and nutritionally essential members, cultivated primarily for its starchy corms, which serve as a staple food in many regions.[27] The plant grows up to 1.5 meters tall, with large, heart-shaped (cordate) leaves that are dark green, glossy, and borne on long petioles extending directly from the corm. Underground corms are thick, cylindrical, or globose, with brown fibrous skin and white, yellow, or purple flesh, depending on the variety. *C. esculenta* produces an inflorescence typical of the family Araceae, which consists of a spadix enclosed by a greenish-yellow spathe. The flowers are unisexual, with male and female flowers arranged separately on the spadix.[28] Flowering is rare in cultivated varieties, but occurs naturally in wild populations. The plants thrive in warm and humid environments with high rainfall and are often grown in flooded or well-drained soils.[29]

Molecular markers, particularly microsatellites, also known as Simple Sequence Repeat (SSR), have become essential tools in plant genetics and breeding because they provide precise information on genetic diversity, genome organization, and trait inheritance. In *C. esculenta*, the development and application of SSR markers facilitate germplasm management, genome mapping, marker-assisted selection, and the conservation of genetic resources, thereby enhancing the efficiency and effectiveness of breeding programs. Previous studies successfully developed SSR markers from *C. esculenta* genomic libraries, and out of 43 primer pairs tested, 16 exhibited polymorphisms with an average of 3.2 alleles per locus. These SSR markers have proven highly useful in various applications, including germplasm collection management, genome mapping, and marker-assisted selection programs. Consequently, they serve as a critical tool to support the breeding and genetic conservation of *C. esculenta*, enabling more effective varietal identification and the selection of desirable traits.[30]

A comprehensive understanding of the pharmacological potential and nutritional significance of *C. esculenta* necessitates a detailed examination of the phytochemical profiles of its distinct plant organs. Leaves, tubers, stems, and flowers harbor diverse bioactive constituents and essential nutrients, underpinning the plant's therapeutic efficacy and health-promoting properties. The subsequent section presents an in-depth analysis of these phytochemical and nutritional components.

The leaves of *C. esculenta* contain various bioactive compounds, including flavonoids and triterpenoids such as quercetin, luteolin 7-rutinoside, vitexin, rutin, kaempferol, orientin, oxalic acid, and acenaphthylene. Additionally, the leaves are rich in nutrients such as calcium oxalate, minerals (calcium and phosphorus), fiber, starch, and vitamins A, B, and C.[38] Other reports also mention the presence of phenolics, alkaloids, glycosides, saponins, terpenoids, and general phenolic compounds.[31] The tubers or corms of *C. esculenta* have a high content of globulin protein (about 80% of total protein), starch (73–80%), polysaccharide polymers (56% neutral sugars and 40% anionic components), as well as minor lipids and monoester phosphate.[32,33] The stems and flowers of *C. esculenta* also contain various phytochemicals, such as alkaloids, flavonoids, glycosides, phenols, saponins, steroids, and tannins. Phenolic compounds are more dominant in the flowers, alkaloids, flavonoids, and saponins are present at fairly high levels, and glycosides and steroids are detected in smaller amounts. Tannins are highly dominant in the stems, with flavonoids and steroids present in low amounts, and the other compounds occur in moderate quantities.[34]

Phenolic compounds identified from the corm (tuber) extracts of *C. esculenta* obtained from Giardino della Minerva in Salerno, Italy, including 3,4,5-tri-*o*-methyl gallic acid, were analyzed using high-performance liquid chromatography equipped with a diode array detector (HPLC-DAD). Their chemical structures were identified through nuclear magnetic

resonance (NMR) and mass spectroscopy (MS) techniques.[35] In contrast, the tubers of *C. esculenta* from Abakaliki, Ebonyi State, Nigeria, revealed the presence of phenolic compounds such as pyrogallic acid, gallic acid, syringic acid, benzoic acid, and vanillic acid.[36] In *C. esculenta* leaves collected from India, chlorogenic acid was identified,[37] while the flowers of *C. esculenta* obtained from the Fulgazi region (Feni District, Chattogram, Bangladesh) were found to contain cyclohexane-1,2-diol 2-(4-methylcyclohex-3-en-1-yl)propan-2-yl propanoate.[38] The flavonoid compounds identified from the tubers of *C. esculenta* collected from Abakaliki, Ebonyi State, Nigeria, include catechin and anthocyanin.[36] Meanwhile, the leaves of *C. esculenta* obtained from India contained quercetin, rutin, vitexin, and kaempferol.[37] The flavonoid content of *C. esculenta* flowers collected from the Fulgazi region (Feni District, Chattogram, Bangladesh) revealed the presence of octyl-β-D-glucopyranoside.[38] Phenolics, flavonoids, and β-sitosterol play a role in antioxidant, anti-inflammation, and other pharmacological activities. *C. esculenta* was collected from the Al Monier Village, Al-Sharkya Governorate, Egypt, and its compounds were isolated using various chromatographic techniques. In addition, compounds such as ergosterol, fonsecinone A, asperpyrone C, and asperpyrone B were also identified.[39] Flavonoid compounds, such as orientin and daucosterol, were isolated from *C. esculenta* leaves collected in Al Monier Village, Egypt, using silica gel column chromatography.[40] Another study reported an isolation of methyl palmitate, stearic acid, elaidic acid, and hexanedioic acid from *C. esculenta* tubers collected at the National Root Crops Research Institute, Umudike, Nigeria.[18] All of the metabolites isolated from *C. esculenta* are summarized in Table 1.

The chemical and nutritional composition of *Colocasia esculenta* exhibits significant variability, influenced by environmental and cultivation factors. Leaf mineral content, including Fe, Cu, Mg, K, and Zn, as well as phytochemicals such as chlorogenic acid, anthraquinones, cinnamic acid derivatives, phenolics, apigenin, catechins, vitexin, and isovitexin, is strongly dependent on plant conditions, including climate, cultivation location, and the variety used.[45] Additionally, as an anti-nutritional factor, oxalate content varies and can be reduced through food processing. This variability is observed at the environmental level and among genotypes. A study on *Colocasia* genotypes from the Eastern Himalayas indicated that multivariate analysis (Principal Component Analysis, PCA) highlighted the primary influence of genotype on traits such as total sugars, anthocyanins, phenolics, antioxidant activity (Ferric Reducing Antioxidant Power, FRAP), and oxalate content (total and insoluble).[46] These findings suggest a trade-off between yield and nutritional or anti-nutritional quality, an important consideration in plant breeding programs.

In silico Studies of *C. Esculenta*

To further elucidate the therapeutic potential of *Colocasia esculenta* in the management of benign prostatic hyperplasia (BPH), an in silico approach was employed to screen and evaluate the bioactivity of its phenolic constituents. This computational method aimed to identify compounds that can inhibit two key proteins involved in BPH pathophysiology, namely 5α-reductase and α1-adrenoceptor.[47] These proteins are well-established pharmacological targets in conventional BPH treatment, with finasteride and tamsulosin serving as standard reference drugs. Among the 22 phenolic compounds analyzed, 14 demonstrated strong binding affinity toward 5α-reductase, resembling the inhibitory action of finasteride, whereas 10 compounds exhibited affinity for the α1-adrenoceptor, analogous to the mechanism of tamsulosin. Molecular docking simulations revealed that CyP20 had the highest binding affinity for both targets, suggesting its potential as a dual-action agent. Furthermore, the interaction of *C. esculenta* phenolics with α1-adrenoceptor showed comparable effectiveness to tamsulosin, indicating that these natural compounds may offer synergistic or alternative pathways for BPH symptom management through the modulation of androgenic activity and smooth muscle contraction.[48]

In vitro Studies of *C. Esculenta*

Research on *C. esculenta* has shown potential progress in recent decades, particularly using in vitro approaches. Its anticancer,[35,49] antibacterial,[50–52] anti-inflammatory,[42,50,53,54] proliferative,[52] radical scavenging,[37,42] and antidiabetic properties have been reported.[38] In vitro methods are widely used because they allow for systematic and controlled preliminary analysis of bioactive compounds in *C. esculenta*, whether from crude extracts or purified fractions. The findings of these in vitro studies provide a critical foundation for further in vivo research and clinical trials to confirm the therapeutic potential of this plant. Various in vitro studies are summarized in Table 2.

Table 1 Metabolites Isolated From the *C. Esculenta* Plant

Name of the Active Metabolite	Chemical Structure or Molecular Formula (PubChem CID)	Plant Part Used, Collection Location, and Isolation Method	Reference
Phenolics			
3,4,5-Tri-O-methyl gallic acid	The PubChem database does not contain information on the chemical structure.	Corm (tuber) extracts of *C. esculenta* were obtained from Giardino della Minerva in Salerno, Italy, and were authenticated by T. Mencherini. The extracts were analyzed using HPLC-DAD, and their chemical structure was identified through NMR and MS techniques.	[35]
Pyrogallic (benzene-1,2,3-triol)	$C_6H_6O_3$ PubChem CID: 1057	*C. esculenta* tubers were purchased from the local market in Abakaliki, Ebonyi State, Nigeria, and authenticated by Prof. Onyekwelu, a taxonomist from the Department of Applied Biology at Ebonyi State University. The extract was prepared using 50% aqueous EtOH for the phenolic profile assay. Quantification of individual phenolic acids was conducted through HPLC analysis. Sample separation was achieved isocratically on an RP-LC 18 column. The mobile phase consisted of sodium phosphate dibasic heptahydrate and MeCN (v/v), with the pH adjusted to 6.5. The column was maintained at 25°C with a flow rate of 0.85 mL/min and an injection volume of 25 µL.	[36]
Gallic acid	$C_7H_6O_5$ PubChem CID: 370		
Syringic acid	$C_9H_{10}O_5$ PubChem CID: 10742		
Benzoic acid	$C_7H_6O_2$ PubChem CID: 243		
Vanillic acid	$C_8H_8O_4$ PubChem CID: 8468		
Chlorogenic acid	$C_{16}H_{18}O_9$ PubChem CID: 17994427	The leaves of *C. esculenta* were gathered from the ICAR-CTCRI farm in India, and Dr. Asha Devi, Principal Scientist at Central Tuber Crops Research Institute, Thiruvananthapuram, verified their botanical name. The polyphenolic components in the EtOH leaf extract of the plant were analyzed by LC-MS, using a C18 column with a mobile phase of 0.1% FA and MeOH, at a flow rate of 0.5 mL/min. A gradient-based separation approach was applied, and the compounds were identified using an MS/MS QTOF.	[37]
Cyclohexane-1,2-diol 2-(4-	$C_{13}H_{22}O_2$ PubChem CID: 62328	The flowers of *C. esculenta* were collected from the Fulgazi region and identified by Prof. Dr. Shaik Bokhtear Uddin from the Department of Botany, University of Chittagong, Bangladesh. The 3D structures of GC-MS/MS-identified compounds were obtained from PubChem. Molecular docking was performed using PyRx AutoDock Vina v. 0.8.	[38]

(*Continued*)

https://doi.org/10.2147/JEP.S501113

Table 1 (Continued).

Name of the Active Metabolite	Chemical Structure or Molecular Formula (PubChem CID)	Plant Part Used, Collection Location, and Isolation Method	Reference
Pyrols			
Diethyl 1-methyl-3-hydroxy-5-phenylpyrrole-2,4-dicarboxylate	$C_{17}H_{19}NO_5$ PubChem CID: 582209	The flowers of *C. esculenta* were collected from the Fulgazi region and identified by Professor Dr. Shaik Bokhtear Uddin from the Department of Botany, University of Chittagong, Bangladesh. The 3D structures of GC-MS/MS-identified compounds were obtained from PubChem. Molecular docking was performed using PyRx AutoDock Vina v. 0.8.	[38]
Phenylpropanoids			
Cinnamic acid	$C_9H_8O_2$ PubChem CID: 444539	*C. esculenta* tubers were purchased from the local market in Abakaliki, Ebonyi State, Nigeria, and identified by Prof. Onyekwelu, a taxonomist from the Department of Applied Biology at Ebonyi State University. The extract was prepared using 50% EtOH for the phenolic profile assay. Quantification of individual phenolic acids was conducted through HPLC analysis. Sample separation was achieved isocratically on an RP-LC 18 column. The mobile phase consisted of sodium phosphate dibasic heptahydrate and MeCN (v/v), with the pH adjusted to 6.5. The column was maintained at 25°C with a flow rate of 0.85 mL/min and an injection volume of 25 µL.	[36]
Salicylic acid	$C_7H_6O_3$ PubChem ID: 338		
Isoferulic acid	$C_{10}H_{10}O_4$ PubChem CID: 736186		
Mandelic acid	$C_8H_8O_3$ PubChem CID: 1292		
Ethyl caffeate	The PubChem database does not contain information on the chemical structure.		
Protocatechuic acid	$C_7H_6O_4$ PubChem CID: 72		
P-coumaric acid	$C_9H_8O_3$ PubChem CID: 637542		
Caffeic acid	$C_9H_8O_4$ PubChem CID: 689043		
Ferulic acid	$C_{10}H_{10}O_4$ PubChem CID: 445858		

3-Chloroacetophenone	$C_8H_7ClO_2$ PubChem CID: 15879	The leaves of *C. esculenta* were collected from the Parks and Gardens of Obafemi Awolowo University, Ile-Ife, Nigeria. Identification and authentication were conducted at the IFE Herbarium, Department of Botany, Obafemi Awolowo University. Leaves were oven-dried at 40°C, ground into a fine powder, and macerated in EtOH at a 1:4 w/v ratio. The EtOAc fraction was further purified using VLC. Fraction analysis was performed using a single quadrupole GC-MS system, incorporating a GC system with an FID. Functional group identification of the purified fraction utilizing FT-IR Spectroscopy with Universal ATR. The purified fraction obtained via open-column chromatography was also analyzed using an HPLC system with a UV/visible detector at 230 nm.	[41]
Oxypurinol	$C_5H_4N_4O_2$ PubChem CID: 135398752		
3′,5′-dihydroxy acetophenone	$C8H_8O_3$ PubChem CID: 103993		
Flavonoids			
Catechin	$C_{15}H_{14}O_6$ PubChem CID: 9064	*C. esculenta* tubers were purchased from the meat market in Abakaliki, Ebonyi State, Nigeria, and identified by Prof. Onyekwelu, a taxonomist from the Department of Applied Biology at Ebonyi State University. The extract was prepared using 50% aqueous EtOH for the phenolic profile assay. Quantification of individual phenolic acids was conducted through HPLC analysis. Sample separation was achieved isocratically on an RP-LC 18 column. The mobile phase consisted of sodium phosphate dibasic heptahydrate and MeCN (v/v), with the pH adjusted to 6.5. The column was maintained at 25°C with a flow rate of 0.85 mL/min and an injection volume of 25 µL.	[36]
Cyanidin coumaroyl (anthocyanin)	The PubChem database does not contain information on the chemical structure.		
Quercetin	$C_{15}H_{10}O_7$ PubChem CID: 5280343	The leaves of *C. esculenta* were gathered from the ICAR-CTCRI farm in India, and Dr. Asha Devi, Principal Scientist at Central Tuber Crops Research Institute, Thiruvananthapuram, verified their botanical name. An LC-MS analysis was conducted to analyze the polyphenolic components in the EtOH leaf extract. The separation was performed using a C18 column with a mobile phase of FA and MeOH, maintained at a flow rate of 0.5 mL/min. A gradient-based separation approach was applied, and the compounds were identified using an MS/MS QTOF 6545.	[37]
Luteolin 7-rutinoside	$C_{27}H_{30}O_{15}$ PubChem CID: 10461109		
Vitexin	$C_{21}H_{20}O_{10}$ PubChem CID: 5280441		
Rutin	$C_{27}H_{30}O_{16}$ PubChem CID:5280805		
Kaempferol	$C_{15}H_{10}O_6$ PubChem CID: 5280863		

(*Continued*)

https://doi.org/10.2147/JEP.S550113

Table 1 (Continued).

Name of the Active Metabolite	Chemical Structure or Molecular Formula (PubChem CID)	Plant Part Used, Collection Location, and Isolation Method	Reference
Flavonoid Glycosides			
Thermoposide	$C_{22}H_{22}O_{11}$ PubChem CID: 11294177	Leaves of *C. esculenta* collected in Al Monier Village, Egypt. The plant was botanically identified and authenticated based on the morphological characters by Prof. Emad Farahat at the Faculty of Science, Helwan University. Isolation method: The n-butanol fraction was fractionated using silica gel column chromatography with a step gradient of DCM/MeOH. Further purification was achieved using successive silica gel columns and Sephadex LH-20 with various solvent systems.	[40]
Chrysoeriol 7-O-β-D-neohesperidoside 5,7-dihydroxy-2-(4-hydroxy-3-methoxyphenyl) chromen-4-one	$C_{16}H_{12}O_6$ PubChem CID: 5280666		
Orientin	$C_{21}H_{20}O_{11}$ PubChem CID: 5281675		
Steroid Glycosides			
Daucosterol	$C_{35}H_{60}O_6$ PubChem CID: 5742590	Leaves *C. esculenta* collected in Al Monier Village, Egypt, were botanically identified and authenticated based on the morphological characters by Prof. Emad Farahat at the Faculty of Science, Helwan University. Isolation method: The n-butanol fraction was fractionated using silica gel column chromatography with a step gradient of DCM/MeOH. Further purification was achieved using successive silica gel columns and Sephadex LH-20 with various solvent systems.	[40]
Octyl-beta-D-glucopyranoside	$C_{14}H_{28}O_6$ PubChem CID: 62852	The flowers of *C. esculenta* were collected from the Fulgazi region and identified by Professor Dr. Shaik Bokhtear Uddin from the Department of Botany, University of Chittagong, Bangladesh. The 3D structures of GC-MS/MS-identified compounds were obtained from PubChem. Molecular docking was performed using PyRx AutoDock Vina v. 0.8.	[38]
Thiol/Sulfide			
3,3′-Thiodipropanol	$C_6H_{14}O_2S$ PubChem CID: 66358	The flowers of *C. esculenta* were collected from the Fulgazi region and identified by Professor Dr. Shaik Bokhtear Uddin from the Department of Botany, University of Chittagong, Bangladesh. The 3D structures of GC-MS/MS-identified compounds were obtained from PubChem. Molecular docking was performed using PyRx AutoDock Vina v. 0.8.	[38]

Lipid			
Cis-Vaccenic acid	$C_{18}H_{34}O_2$ PubChem CID: 5282761	*C. esculenta* specimens were collected from the Rupandehi District, Nepal. The plant material was identified and authenticated by Mr. Subodh Khanal, Assistant Professor at the Institute of Agriculture and Animal Science, Paklihawa. GC-MS spectroscopic analysis on EtOH leaf extracts was used to identify their phytoconstituents.	[42]
Tannins			
Tannic acid [2,3-dihydroxy-5-[[(2R,3R,4S,5R,6S)-3,4,5,6-tetrakis[[3,4-dihydroxy-5-(3,4,5-trihydroxybenzoyl)oxybenzoyl]oxy]oxan-2-yl]methoxycarbonyl]phenyl] 3,4,5-trihydroxybenzoate	$C_{76}H_{52}O_{46}$ PubChem CID: 16129778	*C. esculenta* tubers were purchased from the local market in Abakaliki, Ebonyi State, Nigeria, and identified by Prof. Onyekwelu, a taxonomist from the Department of Applied Biology at Ebonyi State University. The extract was prepared using 50% aqueous EtOH for the phenolic profile assay. Quantification of individual phenolic acids was conducted through HPLC analysis. Sample separation was achieved isocratically on an RP- LC 18 column. The mobile phase consisted of sodium phosphate dibasic heptahydrate and MeCN (v/v), with the pH adjusted to 6.5. The column was maintained at 25°C with a flow rate of 0.85 mL/min and an injection volume of 25 µL.	[36]
Alkaloids			
Decanedione	$C_{10}H_{18}O_2$ PubChem CID: 546170	The leaves of *C. esculenta* were collected from the Parks and Gardens of Obafemi Awolowo University, Ile-Ife, Nigeria. Identification and authentication were conducted at the IFE Herbarium, Department of Botany, Obafemi Awolowo University. Leaves were oven-dried at 40°C, ground, and macerated in EtOH at a 1:4 w/v ratio. The EtOAc fraction was further purified using VLC. Fraction analysis was performed using a single quadrupole GC-MS system, incorporating a GC system with an FID. Functional group identification of the purified fraction utilizing FT-IR Spectroscopy with Universal ATR. The purified fraction obtained via open-column chromatography was also analyzed using an HPLC system with a UV/visible detector at 230 nm.	[41]
Oxalic acid	$C_{14}H_{22}N_2O_6$ PubChem CID: 14896498		
Reticuline, 6′-methyl	$C_{20}H_{25}NO_4$ PubChem CID: 606045	*C. esculenta* specimens were collected from the Rupandehi District, Nepal. The plant material was identified and authenticated by Mr. Subodh Khanal, Assistant Professor at the Institute of Agriculture and Animal Science, Paklihawa. This study performed GC-MS spectroscopic analysis on EtOH leaf extracts to identify their phytoconstituents. The analysis utilized an Agilent 7890A spectrometer system equipped with a fused silica column, interfaced with a GC-MS 5975C inert mass selective detector featuring a triple-axis detector. Helium gas was used as the carrier at a 1 mL/min flow rate.	[42]

(*Continued*)

https://doi.org/10.2147/JEP.S550113

https://doi.org/10.2147/JEP.S501113

Table 1 (Continued).

Name of the Active Metabolite	Chemical Structure or Molecular Formula (PubChem CID)	Plant Part Used, Collection Location, and Isolation Method	Reference
Terpenoids			
Acenaphthylene	$C_{12}H_8$ PubChem CID: 9161	The leaves of *C. esculenta* were collected from the Parks and Gardens of Obafemi Awolowo University, Ile-Ife, Nigeria. Identification and authentication were conducted at the IFE Herbarium, Department of Botany, Obafemi Awolowo University. Leaves were oven-dried at 40°C, ground, and macerated in EtOH at a 1:4 w/v ratio. The EtOAc fraction was further purified using VLC. Fraction analysis was performed using a single quadrupole GC-MS system, incorporating GC system with an FID. Functional group identification of the purified fraction utilizing FT-IR Spectroscopy with Universal ATR. The purified fraction obtained via open-column chromatography was also analyzed using an HPLC system with a UV/visible detector at 230 nm.	[41]
(+)-Valencene	$C_{15}H_{24}$ PubChem CID: 9855795	*C. esculenta* specimens were collected from the Rupandehi District, Nepal, identified and authenticated by Mr. Subodh Khanal, Assistant Professor at the Institute of Agriculture and Animal Science, Paklihawa. This study performed GC-MS spectroscopic analysis on EtOH leaf extracts to identify their phytoconstituents. The analysis utilized an Agilent 7890A spectrometer system equipped with a fused silica column, interfaced with a GC-MS 5975C inert mass selective detector featuring a triple-axis detector. Helium gas was used as the carrier at a 1 mL/min flow rate.	[42]
Sesquiterpenoids			
Dimedone	$C_8H_{12}O_2$ PubChem CID: 550967	The leaves of *C. esculenta* were collected from the Parks and Gardens of Obafemi Awolowo University, Ile-Ife, Nigeria. Identification and authentication were conducted at the IFE Herbarium, Department of Botany, Obafemi Awolowo University. Leaves were oven-dried at 40°C, ground, and macerated in EtOH at a 1:4 w/v ratio. The EtOAc fraction was further purified using VLC. Fraction analysis was performed using a single quadrupole GC-MS system, incorporating a GC system with an FID. Functional group identification of the purified fraction utilizing FT-IR Spectroscopy with Universal ATR. The purified fraction obtained via open-column chromatography was also analyzed using an HPLC system with a UV/visible detector at 230 nm.	[41]

Cyclodecanone	$C_{10}H_{18}O$ PubChem CID: 73918	The flowers of *C. esculenta* were collected from the Fulgazi region and identified by Professor Dr. Shaik Bokhtear Uddin from the Department of Botany, University of Chittagong, Bangladesh. The 3D structures of GC-MS/MS-identified compounds were obtained from PubChem. Molecular docking was performed using PyRx AutoDock Vina v. 0.8.	[38]
Steroids			
Ergosterol	$C_{28}H_{44}O$ PubChem CID: 444679	*C. esculenta* was collected from Al Monier Village, Al-Sharkya Governorate, Egypt. Prof. Emad Farahat, a Professor of Plant Ecology at the Faculty of Science, Helwan University, identified the plant. The isolation and purification of secondary metabolites from the EtOAc extract were done using column chromatography, TLC, and preparative TLC with Silica Gel 60 F254 glass plates. NMR spectra were recorded on an NMR spectrometer at 400 MHz for ^{1}H NMR and 100 MHz for ^{13}C NMR. Mass spectrometry in positive ion acquisition mode was conducted using a triple quadrupole instrument. The analysis was performed using a C18 column with a flow rate of 0.2 mL/min.	[39]
β-Sitosterol	$C_{29}H_{50}O$ PubChem CID: 222284		
Cycopentane			
1-Silacyclopenta-2,4-diene, 3-ethy-l-1,1,2,5-tetramethyl-	The PubChem database does not contain information on the chemical structure.	The leaves of *C. esculenta* were collected from the Parks and Gardens of Obafemi Awolowo University, Ile-Ife, Nigeria. Identification and authentication were conducted at the IFE Herbarium, Department of Botany, Obafemi Awolowo University. Leaves were oven-dried at 40°C, ground, and macerated in EtOH at a 1:4 w/v ratio. The EtOAc fraction was further purified using VLC. Fraction analysis was performed using a single quadrupole GC-MS system, incorporating a GC system with an FID. Functional group identification of the purified fraction utilizing FT-IR Spectroscopy with Universal ATR. The purified fraction obtained via open-column chromatography was also analyzed using an HPLC system with a UV/visible detector at 230 nm.	[41]
1-di(isopropyl)-1-silacyclobutan	$C_9H_{20}Si$ PubChem CID: 559221		
1-n-butoxy-1-chloro-1-silacyclopentane	$C_8H_{17}ClOSi$ PubChem CID: 591100		
Amino-2-methyl-6,7,8,9-tetrahydro-pyrrolo[3,4-c]-quinoline-1,3-dion	$C_{12}H_{13}N_3O_2$ PubChem CID: 686678		

(*Continued*)

https://doi.org/10.2147/JEP.S550113

https://doi.org/10.2147/JEP.S550113

Table 1 (Continued).

Name of the Active Metabolite	Chemical Structure or Molecular Formula (PubChem CID)	Plant Part Used, Collection Location, and Isolation Method	Reference
Alcoholic derivates			
Methyl palmitate	$C_{17}H_{34}O_2$ PubChem CID: 8181	*C. esculenta* tubers were sourced from the National Root Crops Research Institute, Umudike, Nigeria. Their identification was confirmed by Dr. G. O. Chukwu, from the National Root Crops Research Institute, Umudike, along with Mr. Ibe, a taxonomist from Michael Okpara University of Agriculture, Umudike, Nigeria. The *C. esculenta* flour was soaked in MeOH for 24 h and filtered. The filtrate underwent a 3 h extraction process using a Soxhlet apparatus. After extraction, the solution was cooled and concentrated using a rotary evaporator. The extract was reconstituted in water, placed in a separatory funnel, and re-extracted with chloroform. The extract was then filtered, concentrated using a rotary evaporator, diluted with MeOH at a 1:10 (v/v) ratio, filtered again, and a specific volume (1 µL) was analyzed for phytochemical composition using the GC-MS technique.	[43]
Stearic acid	$C_{18}H_{36}O_2$ PubChem CID: 5281		
9,12-Octadecadienoyl chloride	$C_{18}H_{31}ClO$ PubChem CID: 98987		
11-Octadecenoic acid methyl ester	$C_{19}H_{36}O_2$ PubChem CID: 74738		
Elaidic acid	$C_{18}H_{34}O_2$ PubChem CID: 637517		
3–Hexadecyloxycarbonyl-5-(2-hydroxyethyl)	The PubChem database does not contain information on the chemical structure.		
4-Methylimidazolium ion	$C_{24}H_{45}N_2O_3$ PubChem CID: 155562647		
Hexanedioic acid bis(2-ethylhexyl) ester	$C_{22}H_{42}O_4$ PubChem CID: 7641		
3,5-Di-t-butyl phenol	$C_4H_{22}O$ PubChem: Not described		
Ethyl decanoate	$C_{12}H_{24}O_2$ PubChem CID: 8048	*C. esculenta* specimens were collected from the Rupandehi District, Nepal. The plant material was identified and authenticated by Mr. Subodh Khanal, Assistant Professor at the Institute of Agriculture and Animal Science, Paklihawa. This study performed GC-MS spectroscopic analysis on EtOH leaf extracts to identify their phytoconstituents. The analysis utilized an Agilent 7890A spectrometer system equipped with a fused silica column, interfaced with a GC-MS 5975C inert mass selective detector featuring a triple-axis detector. Helium gas was used as the carrier at a 1 mL/min flow rate.	[42]

Dimeric naphtho-γ-pyrone			
Fonsecinone A	$C_{32}H_{26}O_{10}$ PubChem CID: 10325700	*C. esculenta* was collected from Al Monier Village, Al-Sharkya Governorate, Egypt. Prof. Emad Farahat, a Professor of Plant Ecology at the Faculty of Science, Helwan University, identified the plant. The isolation and purification of secondary metabolites from the EtOAc extract were done using column chromatography, TLC, and preparative TLC with Silica Gel 60 F254 glass plates. NMR spectra were recorded on an NMR spectrometer at 400 MHz for ^{1}H NMR and 100 MHz for ^{13}C NMR. Mass spectrometry in positive ion acquisition mode was conducted using an XEVO TQD triple quadrupole instrument. The analysis was performed using a C18 column with a flow rate of 0.2 mL/min.	[39]
Asperpyrone C 5-hydroxy-7-(5-hydroxy-8,10-dimethoxy-2-methyl- 4-oxobenzo[h]chromen-6-yl)-6,8-dimethoxy-2-methylbenzo[g]chromen-4-one	$C_{32}H_{26}O_{10}$ PubChem CID: 10995389		
Asperpyrone B	$C_{32}H_{26}O_{10}$ PubChem CID: 11114482		
Amides			
9-Octadecenamide	$C_{18}H_{35}NO$ PubChem CID: 1930	The flowers of *C. esculenta* were collected from the Fulgazi region and identified by Professor Dr. Shaik Bokhtear Uddin from the Department of Botany, University of Chittagong, Bangladesh. The 3D structures of GC-MS/MS-identified compounds were obtained from PubChem. Molecular docking was performed using PyRx AutoDock Vina (version 0.8).	[38]
d-Gala-l-ido-octonic amide	$C_8H_{17}NO_8$ PubChem CID: 552061		
Lignans			
Isolariciresinol	$C_{20}H_{24}O_6$ PubChem CID: 160521	Corm extracts of *C. esculenta* were obtained from Giardino della Minerva in Salerno, Italy. One of the authors, T. Mencherini, verified the plant material. The Colocasia corms were analyzed using HPLC-DAD and their chemical structure was identified through NMR and MS techniques.	[35]
Dehidrodikoniferyl alkohol-9-O-β-Dglucopyranoside	The PubChem database does not contain information on the chemical structure.		
Americanol A 4-[(2R,3R)-3-(hydroxymethyl)-6-[(E)-3-hydroxyprop-1-enyl]-2,3-dihydro-1,4-benzodioxin-2-yl]benzene-1,2-diol	$C_{18}H_{18}O_6$ PubChem CID: 637304		

(*Continued*)

https://doi.org/10.2147/JEP.S501113

Table 1 (Continued).

Name of the Active Metabolite	Chemical Structure or Molecular Formula (PubChem CID)	Plant Part Used, Collection Location, and Isolation Method	Reference
Aesculetin 6,7-dihydroxychromen-2-one	$C_9H_6O_4$ (PubChem CID: 5281416)	*C. esculenta* tubers were purchased from the local market in Abakaliki, Ebonyi State, Nigeria, and authenticated by Prof. Onyekwelu, a taxonomist from the Department of Applied Biology at Ebonyi State University. The extract was prepared using 50% aqueous EtOH for the phenolic profile assay. Quantification of individual phenolic acids was conducted through HPLC analysis. Sample separation was achieved isocratically on an RP-LC 18 column. The mobile phase consisted of sodium phosphate dibasic heptahydrate and MeCN (v/v), with the pH adjusted to 6.5. The column was maintained at 25°C with a flow rate of 0.85 mL/min and an injection volume of 25 µL.	[36]
Undescribable compounds			
Cyclotrisiloxane hexamethyl-4-methyl-2-trimethylsilyloxyacetophenone	The PubChem database does not contain information on the chemical structure.	*C. esculenta* specimens were collected from the Rupandehi District, Nepal. The plant material was identified and authenticated by Mr. Subodh Khanal, Assistant Professor at the Institute of Agriculture and Animal Science, Paklihawa. This study performed GC-MS spectroscopic analysis on EtOH leaf extracts to identify their phytoconstituents. The analysis utilized an Agilent 7890A spectrometer system equipped with a fused silica column, interfaced with a GC-MS 5975C inert mass selective detector featuring a triple-axis detector. Helium gas was used as the carrier at a 1 mL/min flow rate.	[42]
Cyclotrisiloxane hexamethyl-cyclotrisiloxane, hexamethyl-2-(acetomethyl)-3-(methoxycarbonyl) biphenylene			
Cyclotrisiloxane hexamethyl-benzo (h) quinoline, 2,4-dimethyl-1,2-benzenediol, 3, 5-bis (1,1-dimethylethyl)			
Cyclotrisiloxane hexamethyl-silicic acid, dimethyl bis (trimethyl lsilyl) ester			
N-Heptanoyl-L-homoserine lactone N-[(3S)-2-oxooxolan-3-yl] heptanamide	$C_{11}H_{19}NO_3$ PubChem CID: 443437	The flowers of *C. esculenta* were collected from the Fulgazi region and identified by Professor Dr. Shaik Bokhtear Uddin from the Department of Botany, University of Chittagong, Bangladesh. The 3D structures of GC-MS/MS-identified compounds were obtained from PubChem. Molecular docking was performed using PyRx AutoDock Vina v. 0.8.	[38]
2, 3-Dimethylmaleic anhydride	$C_6H_6O_3$ PubChem CID: 13010	The MeOH extract derived from the rootstock of *C. esculenta* underwent three successive rounds of fractionation using silica gel column chromatography. The purified compound's structural characterization was done using NMR and MS data.	[44]

Abbreviations: ATR, absorbance transmittance resonance; DCM, dichloromethane; EtOAc, ethyl acetate; EtOH, ethanol; FA, formic acid; FID, flame ionization detector; FT-IR, Fourier-transform infrared; GC-MS/MS, gas chromatography in tandem with mass spectroscopy/mass spectroscopy; HPLC, high-performance liquid chromatography; HPLC-DAD, high-performance liquid chromatography with diode-array detection; ICAR-CTCRI, Indian Council of Agricultural Research-Central Tuber Crops Research Institute; LC, liquid chromatography; MeCN, acetonitrile; MeOH, methanol; MS, mass spectroscopy; MS/MS QTOF, tandem mass spectrometry quadrupole time-of-flight; NMR, nuclear magnetic resonance; RP-LC, reversed-phase liquid chromatography; TLC, thin-layer chromatography; VLC, vacuum liquid chromatography.

Table 2 In vitro Studies of *C. Esculenta*

Part of the Plant, Collected in and Authenticated by	Extraction Method	Phytochemical Analysis	Type of Cell or Bacteria	Model Category, Methods, and Parameters Assessed	Control the Drug and Dosage	Statistical Analysis	Results	Reference
Anticancer								
Leaves and corms were collected at Giardino della Minerva, Salerno (Italy). T. Mencherini identified the plant material.	Ground corms and leaves were defatted with n-hexane and chloroform, extracted with MeOH at room temperature, and evaporated at 40°C to obtain the dried corm (CCM) and leaves (CLM). CCM was fractionated with MeOH, followed by RP-HPLC to purify the bioactive fractions.	Analysis was performed using HPLC-DAD with a C18 column at a 1 mL/min flow rate and an injection volume of 20 µL. The mobile phase consisted of H_2O + 1% HCOOH (solvent A) and MeOH + 1% HCOOH (solvent B) in a gradient. Absorbance was monitored at 280 and 270 nm.	AGS cells were grown in RPMI medium.	Cell cycle analysis was performed by culturing the cells for 24 h, and during the last 2 h, MTT solution was added, followed by overnight dissolution in a solubilization solution. Absorbance was measured at 570–650 nm. Apoptosis analysis was performed by culturing the cells (2×10^4 cells/cm^2) and treating them according to groups for 24 h, with 0.2% DMSO. Cells were collected, fixed with 70% EtOH, and stained with PI in PBS containing DNase-free RNase. Western blot analysis was performed by loading the protein onto a 10–12% SDS-PAGE, followed by transfer to a nitrocellulose membrane and incubation with specific antibodies (α-tubulin, Erk1/2, p-IkBα, CDK2, cyclin A, and caspase 3). The membrane was then incubated with an HRP-conjugated secondary antibody. Detection was carried out using ECL and analyzed with the Chemidoc™ MP System and ImageLab v6.1.	Not described	Data were expressed as means ± SD and analyzed for significance via a 1- or 2-way ANOVA for independent groups, followed by Tukey's post hoc correction for multiple comparisons. $p < 0.05$ was considered statistically significant.	CCM and fractions II and III at concentrations of 50 and 100 µg/mL increased the number of dead cells. The crude extract and isolated fractions II and III affected cell viability in a dose-dependent manner by modulating key proteins involved in cell proliferation, apoptosis, and cell cycle processes, thus indicating the antitumor activity against gastric cancer.	[35]
The corms were purchased at a local Niterói municipality, Southeastern Brazil market.	The crude extract was fractionated using the affinity chromatography resin Cibacron Blue 3G-A.	Not described	U-87 MG cells and MDA-MB-231 cells.	The viability of MDA-MB-231 and U-87 MG was determined using the resazurin redox method. Cells were seeded in culture bottles and incubated at 37°C with 5% CO_2, detached, and counted.	Not described	The results were compared through an ANOVA followed by multiple comparisons using Tukey's method.	*C. esculenta* (in the form of liposomal tarin nano-capsules) inhibited the proliferation of the MDA-MB-231 and the U-87 MG cell lines, indicating its potential as a chemotherapeutic adjuvant.	[49]
Antibacterial								
Plant extract powder was purchased from Korea Plant Extract Bank at the Korea Research Institute of Bioscience and Biotechnology (Daejeon, Korea).	The plant powder was extracted using MeOH through 30 cycles at room temperature using an ultrasonic extractor. The extract was then filtered and dried under reduced pressure. A stock solution of the extract was prepared in DMSO.	Not described	*P. gingivalis*	*P. gingivalis* was cultured in brain heart infusion medium supplemented with 1% hemin, 1% menadione, and 5% sheep blood at 37°C under anaerobic conditions for 72 h. Subsequently, the *P. gingivalis* suspension was dispensed into each well plate, followed by the addition of the test extract at 0, 125, 250, and 500 µg/mL. After incubation for 72 h, bacterial growth was quantified by measuring the absorbance at 600 nm. Antibacterial activity was assessed using the agar diffusion method.	Not described	Data were evaluated through a one-way ANOVA, followed by Duncan's multiple range test ($\alpha = 0.05$) for post hoc comparisons.	*C. esculenta extract* directly inhibited the growth of *P. gingivalis* and showed antibacterial activity at a concentration of 500 µg/mL.	[50]

(*Continued*)

Table 2 (Continued).

Part of the Plant, Collected in and Authenticated by	Extraction Method	Phytochemical Analysis	Type of Cell or Bacteria	Model Category, Methods, and Parameters Assessed	Control the Drug and Dosage	Statistical Analysis	Results	Reference
Plant extract powder was purchased from Korea Plant Extract Bank at the Korea Research Institute of Bioscience and Biotechnology (Daejeon, Korea).	The plant powder was extracted with 75% EtOH through 30 ultrasonic cycles at room temperature using an ultrasonic extractor. The extract was then filtered and dried under reduced pressure. A stock solution of the extract was prepared at 50 mg/mL in DMSO.	Not described	*P. gingivalis*	For the antibacterial activity assay, 100 μL of extract solution at serial concentrations ranging from 1.95 μg/mL to 125 μg/mL was added to a well plate. Each well was then inoculated with 100 μL of *P. gingivalis* suspension for 48 h of incubation, and the MIC was determined by measuring optical density at 600 nm. For MBC determination, 100 μL samples from the MIC concentration and higher were inoculated onto 5% sheep blood agar plates and incubated at 37°C under anaerobic conditions for 7 d. The lowest concentration at which no *P. gingivalis* growth was observed was defined as the MBC.	Sulfamethoxazole 870 μg/mL Trimethoprim 170 μg/mL Garglin ZeroTM as a commercial product control	The data were analyzed using independent t-tests and one-way ANOVA, followed by multiple comparison tests. $p < 0.05$ was considered statistically significant.	*C. esculenta* extract showed antibacterial activity against *P. gingivalis*.	[51]
The tuber extract (CET) powder was obtained from PT. Sentra Biogen Bandung, Indonesia.	CET powder was dissolved in deionized water, stirred overnight at room temperature, and centrifuged at 5000 rpm for 5 min. The supernatant was freeze-dried.	The protein content in the CET powder was analyzed using Bradford's method. BSA was used as a reference standard.	*S. aureus* (Gram-positive) and *E. coli* (Gram-negative)	The antibacterial activity was evaluated based on the ATCC 100–2012 test method. Bacterial strains were incubated overnight at 37°C in MHB. The samples were then diluted with 5 mL of PBS solution at concentrations ranging from 10^{-1} to 10^{-8}. From each dilution level, 0.5 mL was taken and placed into a sterile petri dish, followed by the addition of 15 mL of MHA solution. The petri dishes were incubated at 37°C overnight, and bacterial colonies were counted to assess antibacterial activity.	Not described	Data were evaluated through a one-way ANOVA. $p < 0.05$ was considered statistically significant.	CET powder exhibited antibacterial activity of more than 90% against *S. aureus* (Gram-positive) and *E. coli* (Gram-negative) bacteria, underscoring its potential as an effective bioactive material for wound dressing use.	[52]

Anti-Inflammatory activity								
Fresh leaves were collected from the Rupandehi district. The plants were verified and certified by Mr. Subodh Khanal, Assistant Professor and Course In-charge of Medicinal and Aromatic Plants, Department of Soil and Environmental Science, Institute of Agriculture and Animal Science, Paklihawa, Rupandehi, Nepal.	Fresh leaves were freeze-dried using liquid nitrogen. 70% EtOH was mixed with the freeze-dried sample for 5 min, followed by centrifugation at 4500 rpm for 10 min. The supernatant was then collected and filtered. The remaining residue was re-extracted following the same procedure, and the obtained supernatants were combined. Subsequently, the combined supernatant was dried using a rotary evaporator at 40°C.	Analysis of the extract was done using GC-MS with a triple-axis detector. This spectroscopy used helium gas at a flow rate of 1 mL/min.	Not described	Protein Denaturation Assay: A total of 0.10 mL of the extract dissolved in DMSO was used separately at 100–2000 μg/mL concentrations. The mixture was mixed again with 2.40 mL of 3.5% BSA. A 1N HCL solution with a pH of 6.3 was prepared and added to the extract solution. After that, the solution was incubated at 37° C for 20 min. The mixture was incubated at 37°C for 20 min, then heated at 71°C for 1 min. After cooling, 2.5 mL of PBS (pH 6.3) was added, and absorbance was measured at 660 nm. Membrane Stabilization:(1) RBC Suspension: Blood samples from healthy volunteers were centrifuged for 10 min at 1500 rpm, and the RBCs were washed three times with PBS (pH 7.4). The buffy coat layer and supernatant were removed after each wash. The RBCs were then resuspended in PBS at a concentration of 20% (v/v); Heat-Induced Hemolysis: The extract (100–2000 μg/mL) was mixed with 0.05 mL RBC suspension and 2.95 mL PBS (pH 7.4), then incubated at 54°C for 20 min with shaking. After centrifugation at 2500 rpm for 3 min, the absorbance of the supernatant was measured at 540 nm. Proteinase Inhibitory Activity: A mixture of 0.06 mg trypsin, 1 mL Tris-HCl buffer (20 mM, pH 7.4), and 1 mL plant extract (100–2000 μg/mL) was incubated at 37°C for 5 min, added with 1 mL of 0.7% casein solution, and incubated for 20 min. Then, 1 mL of 70% perchloric acid was added to stop the reaction. The reaction mixture was centrifuged at 3000 rpm at 4°C for 10 min. The absorbance of the supernatant was measured at 210 nm. LOX Inhibition Assay: Linoleic acid was used as the substrate, and the 5-LOX was used in this assay. A solution mixture containing 1 mL of sodium borate buffer (0.1M, pH 8.8) and 10 μL of LOX (8000 U/mL) was incubated with 1 mL of plant extract at concentrations of 100–2000 μg/mL. The reaction mixture was then incubated at room temperature (30 ± 2°C) for 5 min. After that, 10 μL of linoleic acid (10 mmol) was added to initiate the reaction. The absorbance was measured at 234 nm.	Indomethacin, aceclofenac, etoricoxib, and aspirin.	Data analysis was performed using GraphPad Prism v. 5.0 and 8.0. The mean was compared using one-way ANOVA followed by Tukey's multiple comparison test. The values were considered statistically significant at three levels: ***$p < 0.001$, **$p < 0.01$, and *$p < 0.05$, but not significant if $p > 0.05$.	The extract of *C. esculenta* exhibits significant antioxidant and anti-inflammatory activity.	[42]

(*Continued*)

https://doi.org/10.2147/JEP.S501113

Table 2 (Continued).

Part of the Plant, Collected in and Authenticated by	Extraction Method	Phytochemical Analysis	Type of Cell or Bacteria	Model Category, Methods, and Parameters Assessed	Control the Drug and Dosage	Statistical Analysis	Results	Reference
The plant extract used in this research was obtained from the Korea Plant Extract Bank at the Korea Research Institute of Bioscience and Biotechnology (Daejeon, Korea).	The plant powder was extracted using 99.9% MeOH through 30 cycles at room temperature using an ultrasonic extractor. The extract was then filtered and dried under reduced pressure.	Not described	RAW 264.7 cells	The cells were cultured in 60-mm dishes, treated with *C. antiquorum var. esculenta* (0, 3, 10, 30 μg/mL), and after 2 h, were stimulated with 1 μg/mL LPS for 1 d. Supernatant was collected to measure IL-6 and TNF-α levels. Additionally, NO levels were determined using the Griess reaction, followed by incubation at room temperature for 10 min. Absorbance was measured at 540 nm.	Not described	Data analysis was performed using IBM SPSS through one-way ANOVA, followed by Duncan's multiple range test (α = 0.05) for post hoc comparisons.	LPS stimulation significantly increased the production of the pro-inflammatory cytokines IL-6 and TNF-α, as well as NO, in RAW 264.7 cells. Treatment with *C. antiquorum var. esculenta* showed a reduction in TNF-α production and inhibition of IL-6 secretion. *C. antiquorum var. esculenta* also exerted an inhibitory effect on NO production.	[50]
Roots of *C. esculenta* plants were collected from Udalguri District, Assam, India, and were authenticated by the Department of Botany, Gauhati University, Guwahati, Assam.	The root powder was soaked with 70% MeOH for 48 h, filtered, and the filtrate was concentrated using a rotary evaporator. The MeOH extract of *C. esculenta* was designated as CEMRE.	CEMRE was analyzed using a Q-TOF LC/MS system, with ESI ionization. Each sample fraction was diluted in water and 98% acetone and was injected into a C18 column. Spectral data were recorded in both positive and negative ionization modes within an m/z range of 60 to 1600.	RAW 264.7 cells (National Centre for Cell Science, Pune, India)	The cells were cultured in 100 mm dishes at a density of 10^6 cells/cm² and incubated for 16 h. After incubation, the medium was discarded, and the cells were pretreated with medium containing CEMRE (17 μg/mL) or CEMRE (34 μg/mL) for 12 h, except for the control and LPS groups. Then, the medium was discarded, and the cells were stimulated with 1 μg/mL LPS for 24 h, except for the control group. Total NO production and PGE2 were measured.	Indomethacin 20 μM	All values were statistically compared using one-way ANOVA with post-hoc analysis, followed by Tukey's multiple comparison test. $p < 0.05$ was considered statistically significant.	CEMRE exhibited effective anti-inflammatory activity in LPS-induced RAW 264.7 cells by reducing the production of NO and PGE2 and downregulating the mRNA expression of COX-2 and iNOS.	[53]
Fresh corms *of C. esculenta* were purchased from a local supermarket (Dunedin, Otago, New Zealand).	The water-soluble non-starch polysaccharides of *C. esculenta* corms (Tc-WS-NSP) were extracted using CE and ICE. In both methods, distilled water was mixed with sliced corms at a 1:1 ratio. In the CE method, the mixture was homogenized, filtered, extracted, and centrifuged for 10 min at 4°C. The obtained supernatant was concentrated using a rotary evaporator at 40°C, filtered, centrifuged, and precipitated with 95% EtOH at a 3:1 ratio for 8 h. The precipitate was collected, washed with 95% EtOH and acetone, and the solvents were evaporated using nitrogen gas. In the ICE method, the mixture was frozen at −30°C for 12 h, thawed at 25°C for 4 h, filtered, extracted, and centrifuged for 10 min at 4°C. The supernatant was concentrated, ultrafiltered, precipitated, and freeze-dried.	Not described	HT-29 cells	The cells were incubated, washed, and treated with 200 μL of complete medium (without antibiotics) containing the inflammatory stimulant TNF-α (10 ng/mL). Subsequently, the cells were incubated with sterilized Tc-WS-NSP-CE or Tc-WS-NSP-ICE samples, each combined with live probiotics, and synbiotic mixtures containing heat-killed *Klebsiella oxytoca* or non-pathogenic *Escherichia coli* in bacterial pellet form. The plate was incubated for 24 h at 37°C with 95% humidity and 5% CO_2. After 24 h of incubation, IL-8 produced in the supernatant was analyzed.	Not described	ANOVA followed by Tukey's test was used to evaluate significant differences ($p < 0.05$) among treatments.	The Tc-WS-NSP-CE or Tc-WS-NSP-ICE downregulated IL-8 production by the TNF-α stimulated HT-29 cells induced by a necrotising enterocolitis positive associated pathogenic bacterium, *K. oxytoca*. Tc-WS-NSP-CE or Tc-WS-NSP-ICE formulations may serve as potential therapeutic agents for gastrointestinal disorders characterized by dysregulated pro-inflammatory cytokine production in response to *K. oxytoca* colonization.	[54]
Proliferative activity								
The tuber extract (CET) powder was obtained from PT. Sentra Biogen Bandung, Indonesia.	CET powder was dissolved in deionized water, stirred overnight at room temperature, and centrifuged at 5000 rpm for 5 min. The supernatant was freeze-dried.	The protein content in the CET powder was analyzed using Bradford's method. BSA was used as a reference standard.	Human skin fibroblast cell line	Cell proliferation on the crosslinked electrospun nanofibers was determined using the PrestoBlue assay (n = 3). After culturing the cells for 1, 3, 5, and 7 d, the samples were rinsed with PBS solution and incubated with 10% PrestoBlue reagent in PBS solution for 2 h at 37°C. The PrestoBlue solution with PBS was then transferred to a 96-well tissue culture plate. The absorbance was measured at 570 and 600 nm.	PEO, average Mw = 600 kDa, CS, ≥ 75% deacetylation degree	Data were evaluated through a one-way ANOVA. $p < 0.05$ was considered statistically significant.	CET protein in the crosslinked nanofibers enhances their capacity to support cell proliferation.	[52]

Radical scavenging								
Four varieties of leaves of *C. esculenta* (Sree Kiran, Sree Rashmi, Sree Pallavi, and Muktakeshi) were collected from the ICAR-CTCRI farm in India. Dr. Asha Devi, Principal Scientist at CTCRI, Thiruvananthapuram, identified the four varieties.	The extract powder was extracted with acetone and EtOH using a Soxhlet extractor for 8 to 10 h.	LC-MS analysis was used to detect polyphenolic components in the ethanolic leaf extract. The column used for the analysis was C18, with the mobile phase consisting of 0.1% FA: MeOH at a flow rate of 0.5 mL/min. Separation was performed using a gradient method, and the compounds were detected using MS/MS QTOF 6545.	Not described	Antioxidant activity was assessed using the DPPH assay by mixing 100 μL of 0.008% DPPH with 100 μL of sample at various concentrations in a 96-well plate. After 30 min incubation at 25°C, absorbance was measured at 517 nm. MeOH served as the blank control. NO scavenging activity was assessed by incubating 5 mM sodium nitroprusside in PBS with various concentrations of the extract at 25°C for 30 min. Then, 1.5 mL of Griess reagent was added to 1.5 mL of the incubated solution. The absorbance of the mixture was measured at 546 nm.	Ascorbic acid was used as a standard.	Data analysis was performed using the Tukey post hoc multiple comparison test and one-way ANOVA applied to compare variables between solvents in pairs ($p \leq 0.05$).	Antioxidant test on 4 varieties of *C. esculenta* showed radical scavenging activity, and the EtOH extract of Muktakeshi exhibited the highest radical scavenging activity (88.3 ± 0.58%) with an IC_{50} value of 49.8 ± 1.32 μg/mL. In the NO assay, all varieties of *C. esculenta* showed inhibitory activity against NO, with the highest inhibition percentage and the lowest IC_{50} value demonstrated by the ethanolic extract of Muktakeshi, with values of 84.6 ± 0.79% and 76.1 ± 1.71 μg/mL, respectively.	[37]
Fresh leaves were collected from the Rupandehi district. The plants were verified and certified by Mr. Subodh Khanal, Assistant Professor and Course In-charge of Medicinal and Aromatic Plants, Department of Soil and Environmental Science, Institute of Agriculture and Animal Science, Paklihawa, Rupandehi, Nepal.	Leaves were frozen using liquid nitrogen to undergo the freeze-drying process. EtOH (70% v/v) was mixed with the freeze-dried sample for about five min, followed by centrifugation at 4500 rpm for 10 min. The supernatant was then collected and filtered. The remaining residue was re-extracted, and the obtained supernatants were combined. Subsequently, the combined supernatant was dried using a rotary evaporator at 40°C.	Analysis was done using a GC-MS system with a fused silica column, connected to an inert mass spectrometry with a triple-axis detector. Helium was used as the carrier gas at a flow rate of 1 mL/min.	Not described	The antioxidant activity of *C. esculenta* extract was evaluated using various methods, including DPPH free radical scavenging activity, ferrous (Fe^{2+}) ion chelating agent, ferric (Fe^{3+}) ion reducing power, nitric oxide (NO^{-}) radical scavenging activity, hydroxyl radical scavenging activity, hydrogen peroxide scavenging activity, and total antioxidant activity.	Ascorbic acid, BHT, and BHA were used as standards	The mean was compared using a one-way ANOVA followed by Tukey's multiple comparison test. The values were considered statistically significant at three levels: $^{***}p < 0.001$, $^{**}p < 0.01$, and $^{*}p < 0.05$, but not significant (NS) if $p > 0.05$.	The extract of *C. esculenta* exhibits significant antioxidant and anti-inflammatory activity.	[42]
Antidiabetic								
The flowers were collected from the Fulgazi region (District Feni, Chattogram, Bangladesh). It was identified by Professor Dr. Shaik Bokhtear Uddin, Department of Botany, University of Chittagong, Bangladesh.	The dried flowers were ground into powder, macerated with 95% MeOH for 3 d, and the process was repeated with the residue. The extract was filtered, and the solvent was evaporated using a rotary evaporator.	Not described	Not described	Alpha-Amylase Inhibitory Assay: A 0.1% w/v starch solution was prepared by dissolving 0.1 g of starch in 100 mL of NaAc sodium acetate buffer containing 16 mmol of sodium acetate. An alpha-amylase enzyme solution was prepared by dissolving 27.5 mg of alpha-amylase enzyme in 100 mL of distilled water. Equal amounts of starch and alpha-amylase solutions were mixed with test samples at 250, 500, 750, and 1000 μg/mL concentrations. The mixture was then incubated for 10 min at 37°C. Afterward, 3,5-dinitrosalicylic acid was added, and absorbance was measured at 540 nm. Alpha-Glucosidase Inhibitory Assay: 1 mL of starch substrate solution (2% w/v maltose or sucrose) in 0.2 M Tris buffer (pH 8.0) and 1 mL of test samples at concentrations of 250, 500, 750, and 1000 μg/mL were used to measure the inhibitory activity of α-glucosidase. The extract was diluted using Tween 80 and distilled water. The samples were incubated separately for 5 min at 37°C. Then, 1 mL of α-glucosidase enzyme (1 U/mL) was added and incubated for 40 min at 35°C. After adding 2 mL of 6 N HCl to stop the reaction, the absorbance was measured at 540 nm.	Acarbose	An independent *t*-test was conducted to determine whether there was a significant difference between them.	Both the the extract and standard acarbose exhibited significant concentration-dependent inhibitory activity in the alpha-amylase assay. The highest inhibition was observed at a dose of 1000 μg/mL. In the α-glucosidase assay, the extract exhibited significant activity, with the highest inhibition observed at a concentration of 1000 μg/mL. The results indicate that *C. esculenta* flowers hold promise as a natural therapeutic candidate for diabetes due to its ability to regulate blood glucose levels	[38]

Abbreviations: AGS, gastric adenocarcinoma cells; ANOVA, analysis of variance; ATCC, American type culture collection; BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene; CCM, *Colocasia* corm methanol; CDK, cyclin-dependent kinase; CE, conventional extraction; CEF-ME, *C. esculenta* flowers-methanol extract; CEMRE, *C. esculenta* methanol root extract; CET, *C. esculenta* tuber; CFU, colony forming unit; CLM, *Colocasia* leaves methanol; CLR, cell lines and reagents; COX-2, cyclooxygenase-2; CS, chitosan; DMEM, Dulbecco's modified eagle medium; DMSO, dimethyl sulfoxide; ECL, enhanced chemiluminescence; ELISA, enzyme-linked immunosorbent assay; ERK, extracellular signal-regulated kinase; EtOH, ethanol; GA, glutaraldehyde; GC-MS, gas chromatography in tandem with mass spectroscopy; HPLC-DAD, high-performance liquid chromatography with diode-array detection; HRP-conjugated secondary antibody, horseradish peroxidase-conjugated secondary antibody; HT, heat treatment; HT-29, human colorectal adenocarcinoma epithelial cell line; ICE, improved extraction method with freeze-thaw treatment; IL, interleukin; LC, liquid chromatography; LPS, lipopolysaccharide; LOX, lipoxygenase; MBC, minimum bactericidal concentration; MDA-MB-231, a highly aggressive, invasive and poorly differentiated triple-negative breast cancer cell line that lacks estrogen receptor and progesterone receptor expression, as well as HER2 (human epidermal growth factor receptor 2) amplification; MeOH, methanol; MG, mammary gland; MHA, Mueller-Hinton agar; MHB, Mueller-Hinton broth; MIC, minimum inhibitory concentration; MS, mass spectroscopy; NO, nitric oxide; NOS, nitric oxide synthase; iNOS, inducible nitric oxide synthase; PBS, phosphate-buffered saline; PEO, poly-ethylene oxide; PGE, prostaglandin E; PI, propidium iodide; Q-TOF LC/MS, quadrupole time-of-flight liquid chromatography/mass spectroscopy; RAW 264.7, a macrophage cell line that was established from a tumor in a male mouse induced with the Abelson murine leukemia virus; RBC, red blood cells; RPMI medium, Roswell Park Memorial Institute medium, a commonly used cell culture medium, especially for growing mammalian cells in suspension; SD, standard deviation; SDS-PAGE, sodium dodecyl sulfate-polyacrylamide gel electrophoresis; TNF, tumor necrosis factor; U-87 MG, a human glioblastoma cell line that is commonly used in brain cancer research; UV, ultraviolet.

Anticancer Activity

Research on the anticancer activity of *C. esculenta* raw ethanol extract has shown that it inhibits T-cell leukemia, colon cancer, prostate cancer, and breast cancer by suppressing cell proliferation and significantly reducing metastasis.[55] Corms of *C. esculenta* were collected from Giardino Della Minerva (Salerno, Italy), and the antimetastatic effectiveness originates from the suppression of tumor cell migration by directly downregulating the COX-1/2/PGE pathway, and indirectly by stimulating the antitumor immune response. Unlike methanol extracts from its leaves, they exhibited cytotoxic effects against gastric adenocarcinoma cells. This effect was mediated by apoptosis, which was driven by increasing caspase-3 activity. *C. esculenta* extract and its fractions were found to activate apoptosis markers and modulate the phosphorylation status of proteins essential for cell proliferation and tumor development. Further analysis of the active fraction led to the identification of the first bioactive phenolics: 3,4,5-tri-O-methyl-gallic acid, isolariciresinol, and dehydrodiconiferyl alcohol-9-O-β-D-glucopyranoside.[35]

Research on the effectiveness of liposomal tarin nanocapsule lectin derived from *C. esculenta* corms encapsulated in liposomes has shown that tarin can effectively inhibit the proliferation of glioblastoma and breast adenocarcinoma cancer cells in both the free and encapsulated forms. Moreover, tarin exhibited no toxicity toward healthy cells, including mouse bone marrow cells and L929 fibroblasts. Additionally, the encapsulated tarin exhibited a proliferative effect on healthy cells, which was suspected to be related to the increased production of cytokines or growth factors. Liposomal tarin nanocapsules successfully inhibited glioblastoma cell growth in cancer cell efficacy tests. However, free tarin did not exhibit cytotoxic effects on cancer cells, indicating that the encapsulation process enhanced its effectiveness by increasing its internalization within tumor cells. In addition to its anticancer effects, tarin has potential as an immunomodulatory agent capable of protecting hematopoietic cells from the toxic effects of chemotherapeutic drugs such as cyclophosphamide.[49]

Antibacterial Activity

C. esculenta has been studied for its potential antibacterial properties, inhibiting the growth of various bacteria, such as *Porphyromonas gingivalis*,[50,51] *Staphylococcus aureus*, and *Escherichia coli*.[52] The details are described below.

The methanol extract of *C. antiquorum* var. *esculenta* from the Korea Plant Extract Bank can suppress the growth of *Porphyromonas gingivalis* at concentrations of 125 μg/mL and 250 μg/mL, with inhibition reaching about 20%, and at a concentration of 500 μg/mL, resulting in approximately 40% inhibition.[50] Further evaluation of its effects on *P. gingivalis* revealed that the 75% ethanol extract of *C. antiquorum* var. *esculenta* possesses antibacterial activity, with a minimum inhibitory concentration (MIC) of 31.3 μg/mL and a minimum bactericidal concentration (MBC) of 62.5 μg/mL. The results showed that the 75% ethanol extract was more potent than the methanol extract.[55]

C. esculenta tuber protein–chitosan–poly (ethylene oxide) cross-linked nanofibers have antibacterial activity against Gram-positive (*Staphylococcus aureus*) and Gram-negative (*Escherichia coli*) bacteria. The tubers of *C. esculenta* were obtained from PT. Sentra Biogen Bandung, Indonesia. The findings revealed a significant decrease in bacterial colonies, with a reduction rate exceeding 98% for *S. aureus* and 90–95% for *E. coli*. Based on the bacterial colony reduction rate, this activity was classified as bacteriostatic.[52]

Another findings highlight the antibacterial activity of *C. esculenta* against *Enterococcus faecalis* (ATCC 29212), which is attributed to the presence of secondary metabolite compounds such as phenolics, flavonoids, saponins, alkaloids, tannins, and triterpenoids. Saponins exert antibacterial effects by disrupting the permeability of bacterial cell wall.[56]

Anti-Inflammatory Activity

The anti-inflammatory activity of *C. esculenta* and its variants is exerted through the inhibition of pro-inflammatory mediators such as prostaglandin E_2 (PGE_2), nitric oxide (NO), interleukin-6 (IL-6), IL-8, and tumor necrosis factor (TNF)-α, along with the downregulation of inducible nitric oxide synthase (iNOS) and COX-2 expression.[50,53,54,57] Further details are provided below.

A study showed that administration of *C. esculenta* root methanol extract from Udalguri District, Assam, India, to LPS-stimulated murine macrophage RAW 264.7 cells significantly reduced PGE2 and NO levels while downregulating

iNOS and COX-2 mRNA expression.[53] Another study from Dunedin, Otago, New Zealand, demonstrated that water-soluble non-starch polysaccharides from *C. esculenta* corms (TC-WS-NSP) can reduce IL-8 production in TNF-α stimulated HT-29 cells infected with *Klebsiella oxytica*.[54] Response to infection by enteropathogenic bacteria or their toxins in the digestive tract triggers epithelial cells to secrete IL-8 and other pro-inflammatory cytokines.[58] The reduction in IL-8 levels following TC-WS-NSP treatment suggests that this prebiotic interferes with the adhesion of *K. oxytica* to HT-29 cells stimulated by TNF-α, thereby decreasing IL-8 secretion in response to bacterial infection.

Furthermore, the administration of *C. antiquorum* var. *esculenta* from Namwonsi, Jeollabuk-do, Korea, significantly inhibited the production of the pro-inflammatory cytokines IL-6 and TNF-α, as well as NO, in RAW 264.7 cells stimulated with LPS. The anti-inflammatory effects of *C. antiquorum* var. *esculenta* through the mechanism of inhibition of TNF-α, IL-6, and NO. *C. antiquorum* var. *esculenta* did not exhibit cytotoxic effects, indicating that its anti-inflammatory activity was due to specific mechanisms inhibiting inflammation rather than cytotoxicity.[54] *C. antiquorum* var. *esculenta* contains various single compounds, such as N-trans-feruloyl-tyramine and β-sitosterol, which have been reported to have anti-inflammatory properties.[59,60]

Proliferative Activity

The potential of *C. esculenta* to enhance cell proliferation was assessed by formulating nanofiber membranes to stimulate skin cell regeneration using the human skin fibroblast cell line (BJ cell, ATCC CRL-2522) as the model. Proteins from *C. esculenta* tubers were sourced from PT. Sentra Biogen Bandung, Indonesia, integrated into nanofiber membranes, and thought to improve cell adhesion and stimulate BJ cell growth.[52] The primary amino acid in *C. esculenta* tuber protein is arginine, which has been shown to accelerate the proliferation of mouse embryonic fibroblast cells (NIH-3T3) and human dermal fibroblast (HDF) cells.[61] In addition, the *C. esculenta* tuber protein contains glycine and proline, which are key protein components of connective tissues that form collagen.[62] The increased *C. esculenta* tuber protein in the nanofiber membrane significantly promoted BJ cell proliferation. This finding is consistent with previous studies showing that *C. esculenta* tuber protein enhances fibroblast cell growth after 24 hours of incubation.[52] Since proliferation is a crucial phase of wound healing characterized by fibroblast proliferation, extracellular matrix deposition, angiogenesis, and re-epithelialization, these results highlight the potential role of *C. esculenta* in supporting tissue regeneration and wound closure.[63]

Radical Scavenging Activity

The PubMed search revealed the radical scavenging activity of *C. esculenta*, which resulted in two documents, both of which described the 2,2-diphenyl-1-picrylhydrazyl (DPPH) and the NO techniques.[37,42] The details are described below.

The DPPH radical scavenging activity test showed that the ethanolic extract of *C. esculenta* leaves from India inhibited 88.3% of DPPH radical, as reported by Varghese et al.[37] Similarly, a related study reported that the methanolic extract of taro leaves had a scavenging activity of 81.77%, in comparison, the tuber extract showed 78.73%.[18] Further research has highlighted the antioxidant potential of *C. esculenta* from Rupandehi district, Nepal, showing an IC_{50} value for a total antioxidant activity level of 5.84 μg/mL and DPPH scavenger activity of 8.91 μg/mL.[42] The NO assay results showed that the ethanolic leaf extract exhibited higher activity than the acetone leaf extract. All samples showed a gradual increase in scavenging activity as concentration increased from 12.5 to 200 μg/mL. The ethanolic extract inhibited 84.6 ± 0.79% of scavenging activity, with an IC_{50} value of 76.1 ± 1.71 μg/mL.[37] The radical scavenging activity assay of 30 genotypes of *C. esculenta* cultivated at the Horticulture Experimental Farm of ICAR-Research Complex for North-Eastern Hill Region, Umiam, Meghalaya, was performed during the years 2022 to 2023 using the DPPH method. The results showed that all taro genotypes exhibited radical scavenging activity. However, there were differences in the level of activity among the genotypes, with IC_{50} values ranging from 0.71 ± 0.06 mg/mL to 1.13 ± 0.07 mg/mL dry weight. The total phenolic content of the 30 *C. esculenta* genotypes varied significantly, ranging from 78 ± 4.08 mg GAE/100 g to 100 ± 4.88 mg GAE/100 g dry weight.[64]

Antidiabetic Activity

Traditionally, the extracts of the root and leaves of *C. esculenta* have therapeutic benefits and have been widely used in the management of diabetes and hypertension.[65] Research on the methanol extract of *C. esculenta* has demonstrated that this extraction method effectively isolates various bioactive compounds with pharmacological potential, such as phenols, alkaloids, flavonoids, and saponins.[66]

Diabetes is a long-term metabolic disorder caused by inadequate insulin production or the inability of the body to use insulin effectively, resulting in increased glucose levels.[67] The presence of an imbalance causes persistent hyperglycemia, which is further intensified by the enhanced activity of key digestive enzymes, such as α-amylase and α-glucosidase.[68] These enzymes are responsible for breaking down carbohydrates into simple sugars that are readily absorbed into the bloodstream. The presence of enzyme inhibitors can slow carbohydrate digestion, decrease glucose absorption, and regulate postprandial blood glucose spikes.[69]

The methanol extract of *C. esculenta* collected from the Fulgazi region, Feni District, Chattogram, Bangladesh, strongly inhibited α-amylase and α-glucosidase, highlighting its potential as an antidiabetic agent. By blocking these enzymes, the methanol extract of *C. esculenta* slows carbohydrate breakdown and decreases intestinal glucose absorption, ultimately leading to low post-meal blood glucose levels.[38] Research indicates that natural extracts with potent enzyme-inhibiting properties can effectively help regulate diabetes by preventing sharp increases in blood glucose after meals. Similar plant-based extracts have been found to significantly reduce glycemic indices in animal studies, underscoring the role of these inhibitors in diabetes management.[70,71]

In vivo Studies of *C. Esculenta*

C. esculenta has been the subject of various in vivo studies investigating its pharmacological activities, as summarized in Table 3.

Anti-Benign Prostatic Hyperplasia (BPH) Agent

A study by Eleazu et al demonstrated that *C. esculenta* tubers collected from Abakaliki, Ebonyi State, Nigeria, when administered as a 50% ethanol extract to testosterone propionate (TP)-induced animals, had significantly reduced testosterone concentration, the expression of IL-10 in the prostate of rats, and prostatic protein concentration. In contrast, there was an increase in superoxide dismutase (SOD) levels in the rat prostate, showing antioxidant activity.[36] An increase in serum prostate-specific antigen (PSA) was observed after TP was administered to male Wistar albino rats. However, co-administration of TP with the ethanol crude tuber extract of *C. esculenta* and its various fractions, including hexane, dichloromethane, ethyl acetate, and aqueous fractions, resulted in a decrease in serum PSA levels, except for the butanone fraction (BF), which did not show a significant reduction.[48] Additionally, fractions of *C. esculenta* from Nigeria increased total serum protein and decreased testis weight relative to body weight. Histopathological analysis of the prostate revealed mild proliferation of glandular prostate cells and decreased secretion of prostatic fluids. Furthermore, the prostatic gland structure appeared normal, showing reduced prostate gland epithelial cells and an elevated presence of eosinophilic secretions in the glandular center.[72]

Studies have shown that the methanol/chloroform extract contains many phenolic compounds,[79] some of which have been reported to exhibit antioxidant, anti-inflammatory, 5-α-reductase inhibitory, anemiagenic, antitumor, immunostimulatory, leukotriene-D4 inhibitory, anti-androgenic, lipoxygenase inhibitory, and hypocholesterolemic properties.[36]

Anticancer Activity

Recent studies have highlighted the therapeutic potential of *C. esculenta*, particularly in cancer prevention and treatment. Moreover, one article mentioned its potential biological, biochemical, and therapeutic applications, further supporting its relevance as a multifunctional medicinal plant.[80] Recent studies suggest that various bioactive compounds found in *C. esculenta*, such as flavonoids and phenolic compounds, contribute to anticancer activity. The ability of *C. esculenta* to fight cancer has been shown in a study showing that a soluble component isolated from cooked *C. esculenta* possesses inhibitory properties against the growth of colon adenocarcinoma cells.[81] An additional in vivo study identified a water-

Table 3 In vivo Studies of *C. Esculenta*

Part of the Plant, Collected in and Authenticated by	Extraction Method	Phytochemical Analysis	Animal, Ethical Approval Committee	Model Category, Methods, and Parameters Assessed	Control Drug	Statistical Analysis	Results	Reference
Anti-Benign Prostatic Hyperplasia								
Mature (6–8 months old) fresh tubers were collected from selected farmers and local authorities, and a taxonomist verified the specimen, Professor S.O. Onyekwelu from the Department of Applied Biology, Ebonyi State University.	*C. esculenta* tuber powder was extracted with 50% EtOH overnight, with occasional stirring at room temperature. The mixture was then filtered and air-dried for 24 h.	Not described	The study used 45 male Wistar albino rats, approximately 6 weeks old, obtained from the Animal House of Ebonyi State University, Nigeria. This study was supervised and approved by the Office of Research, Innovation, and Institutional Ethics Committee of Ebonyi State University, Nigeria (EBSU/BCH/ET/21/001).	This study randomly divided the test animals into 9 groups of 5 rats. **Group 1 (normal control)** received olive oil and normal saline. **Group 2 (BPH untreated group)** was given 3 mg/kg of testosterone propionate (TP) and normal saline. **Group 3 (positive control)** received 3 mg/kg of TP and 5 mg/kg of finasteride. Treatment **groups 4, 5, 6, 7, 8, and 9** each received 3 mg/kg of TP and a 200 mg/kg dose of ETECE and the hexane, dichloromethane, butanone, ethyl acetate, and aqueous fractions of ETECE, respectively, for 28 d. After fasting overnight, rats were anesthetized and sacrificed for the collection of liver, kidneys, heart, prostate, and testes for histopathology. Hematological parameters, including RBC, hemoglobin, HCT, MCV, MCH, MCHC, and platelets, were also assessed.	Finasteride 3 mg/kg	The data were statistically analyzed using Prism software to assess significance. A Dunnett's ANOVA test was conducted to compare the mean values of each group with the control at $p < 0.005$. The results are the mean ± SD for five rats per group.	A decrease in testis weight in the untreated BPH group may be due to the exogenous effect of TP, which is known as a potential male contraceptive candidate. ETECE and its fractions could mitigate this negative effect on testis weight. ECTECE and its fractions were found to normalize hematological and immunological parameters, demonstrating the safety of this extract. The study results indicate that *C. esculenta* has the potential to be used as a nutraceutical in the treatment of benign hyperplasia.	[48]

(*Continued*)

https://doi.org/10.2147/JEP.S550113

Table 3 (Continued).

Part of the Plant, Collected in and Authenticated by	Extraction Method	Phytochemical Analysis	Animal, Ethical Approval Committee	Model Category, Methods, and Parameters Assessed	Control Drug	Statistical Analysis	Results	Reference
Fresh tubers were purchased from the meat market in Abakaliki, Ebonyi State, Nigeria. Their identification was confirmed by Professor S.O. Onyekwelu, a taxonomist from the Department of Applied Biology at Ebonyi State University (EBSU), Abakaliki, Nigeria.	The flour was extracted overnight in 50% aqueous EtOH with occasional stirring at room temperature. It was then sieved, and the filtrate was air dried for 48 h.	HPLC analysis for quantitation of the individual phenolic acids was carried out isocratically on a reversed-phase LC 18 column 5 µM. The mobile phase consisted of 40 nm sodium phosphate dibasic heptahydrate and 20% acetonitrile (v/v), (pH 6.5, adjusted with 85% phosphoric acid). The column was equilibrated at 25 °C at a flow rate of 0.85 mL/min. The injection volume was 25 µL.	Male albino Wistar rats (approximately 6 weeks old) were obtained from a commercial rat breeder in Abakaliki, Ebonyi State, Nigeria. The study was approved by the Board of the Department of Biochemistry, Ebonyi State University, by the National Research Council (NRC) (1985) guidelines for the care and use of laboratory animals.	The rats were divided into six groups (five rats per group) as follows: **Group 1** (Control): Administered 1 mL/kg olive oil (subcutaneously) + 1 mL/kg normal saline (orally); **Group 2** (BPH): Administered 3 mg/kg testosterone propionate (TP) subcutaneously + 1 mL/kg normal saline orally; **Group 3** (BPH + Finasteride): Administered 3 mg/kg TP subcutaneously + 5 mg/kg finasteride orally; **Group 4** (BPH + Low Dose): Administered 3 mg/kg TP subcutaneously + 100 mg/kg 50% ETECE orally; **Group 5** (BPH + Intermediate Dose): Administered 3 mg/kg TP subcutaneously + 200 mg/kg ETECE orally; **Group 6** (BPH + High Dose): Administered 3 mg/kg TP subcutaneously + 400 mg/kg ETECE orally. After 28 d of experimentation, the rats were fasted overnight and then sacrificed under anesthesia. Blood collection was performed via cardiac puncture, and the blood was placed into tubes without anticoagulant and left to clot. Serum was separated within 1 h after blood clotting by centrifugation at 3000 g for 5 min, then frozen until required for lipid profile analysis. The prostate glands were harvested, blotted, and weighed. Two prostates from each group were selected, and their ventral lobes were dissected and fixed in formalin for histopathological analysis. The remaining three prostates from each group were homogenized in ice-cold TRIS buffer (pH 7.8) and then used for the analysis of PSA, testosterone, IL-10, total protein, antioxidant activities (CAT, SOD, GSH), and lipid peroxidation/MDA.	Finasteride 5 mg/kg	Results were reported as the means ± standard deviation of duplicate experiments. A one-way ANOVA, followed by the Duncan Multiple Range test, was used to compare the means. Results were significant when $p < 0.05$.	Rats treated with *C. esculenta* extract showed a reduction in prostate weight, reduced PSA expression, decreased prostatic testosterone levels, and reduced IL-10, indicating anti-inflammatory effects. *C. esculenta* extract increased antioxidant enzyme levels and decreased MDA levels. BPH rats showed prostate hyperplasia (increased cell proliferation), and *C. esculenta* extract showed improvements in prostate histology. The study showed the potential of *C. esculenta* tuber in managing BPH.	[36]

Mature (6–8 months old) fresh tubers were collected from select local farmers. This was followed by authentication by a taxonomist, Professor S.O. Onyekwelu, at the Department of Applied Biology, Ebonyi State University.	1280 grams of powdered tuber was extracted using 8 liters of 50% ethanol with occasional stirring at room temperature and left overnight. The mixture was then filtered, and the resulting filtrate was air-dried for 24 h. The crude EtOH extract was mixed with distilled water, underwent sequential extraction using solvents starting with hexane, dichloromethane, ethyl acetate, and butanol. The obtained fractions were then air-dried until solid fractions were formed. These solid fractions were redissolved in distilled water before being administered to the test animals.	Not described	Male Wistar albino rats, approximately 6 weeks old. This study was approved by the Institutional Ethics Committee of Ebonyi State University, Nigeria (EBSU/BCH/ET/21/001).	The rats were divided into nine groups of five. **Group 1** (Normal Control) received 1 mL of olive oil orally. BPH was induced in Groups 2–9 by administering 3 mg/kg TP subcutaneously. **Group 2** (BPH) did not receive any treatment; **Group 3** (Finasteride) was treated with 5 mg/kg finasteride; **Group 4** was treated with 200 mg/kg BW of ETECE; **Group 5** was treated with 200 mg/kg b.w of n-hexane fraction; **Group 6** was treated with 200 mg/kg BW of dichloromethane fraction; **Group 7** was treated with 200 mg/kg BW of ethyl acetate fraction; **Group 8** was treated with 200 mg/kg BW of butanol fraction; and **Group 9** was treated with 200 mg/kg BW of aqueous fraction. The extract, fractions, or finasteride were administered orally, and all rats were given food ad libitum. After 28 d, the rats were fasted overnight, sacrificed under anaesthesia, and blood was collected through cardiac puncture using a 5 mL syringe. The blood was then placed in EDTA vacuum tubes to analyse PSA concentration. PSA concentration was measured using an ELISA.	Finasteride 5 mg/kg BW	Data were analyzed using Prism software to determine statistical significance. The results are shown as mean ± SD of 5 rats per group. $p < 0.05$ was considered statistically significant.	The administration of TP with ETECE, hexane fraction, dichloromethane fraction, butanol fraction, ethyl acetate fraction, and aqueous fraction in male rats significantly reduced serum PSA levels. Interestingly, a significant reduction in serum PSA levels was observed in all fractions except the butanol fraction. This study indicates that *C. esculenta* can potentially be a chemotherapeutic agent for managing BPH.	[72]
Anticancer								
The part of the plant used in this study is the corm. The collection location and authenticator are not described.	Two extraction procedures were used in this study. Method 1: The tuber was mixed with PBS (1:3), blended at increasing speed until liquefied, then centrifuged at 1200 rpm for 15 min at 4°C. The supernatant was further centrifuged at 15,000 rpm for 20 min at 4°C and sterilized by filtration. This method is referred to as TE. Method 2: The tuber was cut into 1 cm pieces, mixed with standard PBS solution (1:1), then blended at high speed for 2 min and centrifuged at 4000 rpm for 20 min. The supernatant was further centrifuged at 15,000 rpm for 20 min at 4°C. The extract was then separated into three fractions using ultrafiltration.	Not described	Syngeneic Balb/cByJ female mice were purchased from Jackson Laboratories (Bar Harbor, ME). Fox Chase severe combined immune-deficient female mice were purchased from Charles River (Newark, DE). All animal experiments were approved by the Institutional Animal Care and Use Committee of the University of Maryland School of Medicine and carried out strictly per the guidelines in the Guide for the Care and Use of Laboratory Animals of the National Institutes of Health (United States).	PBS, TE, TE-M2, or TE-M2F1 was administered via i.p injection in a volume of 200 μL into syngeneic female Balb/cByJ or Fox Chase SCID mice from d 1 to 4. On day 4, 1–2 × 10^5 line 66.1 or 410.4 tumor cells were injected into the lateral tail vein. Treatment continued daily for an additional 6 d. Between d 14 and 21 post-tumor cell injection, when control animals began to exhibit a moribund condition, the mice were euthanized, and tumor colonies on the lung surface were counted using a dissecting microscope. For bioluminescent imaging, female Balb/cByJ mice received daily treatment with TE (400 μg/200 μL) or PBS for 10 d. On day 4, 2 × 10^5 66.1-luc cells were injected into the lateral tail vein. These cells were then detected using bioluminescent imaging in anesthetized mice injected i.p with 100 μL of D-luciferin (7.5 mg/mL) on d +1, +4, and +15 relative to tumor cell injection.	PBS buffer	Data were summarized using descriptive statistics, including mean, standard error, median, and range. Depending on the data distribution, the Student's *t*-test or its non-parametric alternative, the Wilcoxon test, was used to compare the distribution of metastases between treatment groups. $p < 0.05$ was considered statistically significant.	Administration of water-soluble TE (400 μg/200 μL/day) significantly inhibited up to 99% of lung metastases in TNBC models and reduced the viability of breast and ovarian cancer cell lines in both human and murine models. TE also suppressed ALDH1 activity in cancer stem cells (CSCs) and enhanced B and NK cell populations without significantly affecting T cells. The TE-M2F1 variant exhibited similar morphological changes and maintained strong anti-metastatic activity. These findings confirm the promising anti-metastatic potential of water-soluble TE.	[55,73]

(*Continued*)

https://doi.org/10.2147/JEP.S501113

Table 3 (Continued).

Part of the Plant, Collected in and Authenticated by	Extraction Method	Phytochemical Analysis	Animal, Ethical Approval Committee	Model Category, Methods, and Parameters Assessed	Control Drug	Statistical Analysis	Results	Reference
Antidiarrheal								
Peels collected in Deko Kebele, Wonago Woreda, Southern Nations, Nationalities, and Peoples Region of South Ethiopia and authenticated by Mr. Abiyu Eniyew Molla, Botanist, Department of Biology, College of Natural and Computational Sciences, University of Gondar.	The plant powder was extracted by cold maceration in 80% MeOH (1:5 w/v) at room temperature for 72 h with periodic shaking. The remaining solid material was re-extracted twice with fresh solvent. The combined extracts were filtered, evaporated using a rotary evaporator at 40°C, then further dried in a hot air oven. The extract was freeze-dried into powder. 120 g of the crude extract underwent successive fractionation using diethyl ether, chloroform, and distilled water (ratio 1:5).	The 80% MeOH extract and various solvent fractions underwent standard screening tests to determine the presence of flavonoids, tannins, anthraquinones/ steroids, glycosides, phenols, terpenoids, alkaloids, and saponins.	Healthy adult Swiss albino mice, both male and female, aged 8–12 weeks and weighing between 20 and 30 g, were obtained from the animal unit of the Department of Pharmacology, University of Gondar. The research was approved by the Department Graduate Committee of Pharmacology at the University of Gondar with reference number Sop4/103/2013.	The study involved three models and included the 80% methanol extract and each solvent fraction. The mice were assigned into five groups of six per model. **Group I** served as the negative control and received 10 mL/kg of 2% Tween 80 in all models; **Group II**, as the positive control, received loperamide at a dose of 3 mg/kg (10 mL/kg) for the castor oil-induced diarrhea and intestinal fluid accumulation test; For the gastrointestinal motility test, Atropine sulfate was administered i.p at a dose of 5 mg/kg as a positive control; and **Groups III, IV, and V** received *C. esculenta* peel extract at doses of 100 mg/kg, 200 mg/kg, and 400 mg/kg, respectively. Each mice was given 0.5 mL of castor oil one h after extract administration, using the gavage technique. The mice were then individually placed in metabolic plastic cages lined with non-wetting transparent paper, which was replaced whenever the mice defecated. Mice were then observed individually for four h, including the onset of diarrhea, frequency of wet feces, total number of defecations, wet and dry stool weight, and fecal consistency.	**Loperamide** at a dose of 3 mg/kg (10 mL/kg) for the diarrhea test. **Atropine sulfate** was administered intraperitoneally at a dose of 5 mg/kg for the gastrointestinal motility test.	The research results were statistically analyzed using SPSS version 26.0. Group comparisons were evaluated using a one-way ANOVA, followed by a post hoc Tukey's test. Probability values below 0.05 were considered statistically significant.	The 80% MeOH extract and solvent fractions of *C. esculenta* peel produced a significant reduction in both the number and weight of wet stools at all tested doses. A significant delay in the onset of diarrhea was observed only at the highest dose (400 mg/kg BW) for both the crude extract and all fractions. In the antenteropooling test, both the 80% extract and solvent fractions significantly reduced the weight and volume of intestinal contents, particularly at 200 and 400 mg/kg BW. In the antimotility test, the crude extract significantly reduced intestinal motility at all doses, while the solvent fractions showed a significant effect only at 400 mg/kg BW. These data support that the extract and solvent fractions of *C. esculenta* peel possess strong antidiarrheal potential, likely through mechanisms involving inhibition of intestinal secretion, motility, and reduction in stool frequency and weight.	[74]

Anti-Obesity and Hepatoprotective								
Fresh leaves were plucked from farms within Enugu metropolis. Plant material was identified and authenticated by comparison with the voucher specimen [UNH No.379a] deposited at the herbarium section of the Department of Plant Science and Biotechnology, University of Nigeria, Nsukka.	The dried leaves were macerated in distilled water for 5 h, then filtered and evaporated. To obtain the crude saponin and alkaloid fractions, 2 kg of ground dried leaves were first defatted by maceration in 4 L of petroleum ether for 72 h. The extracted residue was dried and macerated with 10 L of 95% MeOH. The mixture was intermittently shaken for 48 h and then filtered. The resulting filtrate was evaporated to yield a semi-solid mass.	Not described	Male albino Wistar rats weighing between 90–110 g were divided into five groups (n=6) based on their body weight. Care and handling of the animals were carried out diligently in accordance with Institutional and International guidelines for the care and use of animals in scientific research.	After the acclimatization period, animals in groups B-E were given an HFD for 70 d. Groups A (normal control) and B (HFD control) were fed only a normal diet and HFD, respectively. On day 42 (week 6), drug administration began in test groups C, D, and E, with doses of 10 mg/kgBW SPF, 10 mg/kgBW ALF, and 400 mg/kgBW CEAE, respectively, administered orally once daily for 28 d (four weeks). The body weight (grams) of each rat was recorded on day 0 and at weekly intervals. The animals received the final treatment dose on day 69. On day 70, after fasting for 8 h, each animal was anesthetized, and a blood sample (4 mL) was blood samples were collected under anesthesia for biochemical analysis. The rats were sacrificed under diethyl ether anesthesia. The wet white adipose tissues [perirenal (retroperitoneal) and epididymal], liver, and kidneys of each rat were isolated and weighed immediately. Liver and adipose tissues were fixed in 10% formalin, sectioned at 5 μm, and stained with hematoxylin and eosin for histological examination.	The drug control was not used in this study.	Hypothesis testing was conducted using one-way ANOVA followed by Tukey-highest significant difference post-hoc test to determine the statistical significance of the differences in the parameters among the groups. Significance levels at $p<0.05$ were considered to indicate statistical significance.	This study investigated the effects of *C. esculenta* leaf extracts on high-fat diet-induced obesity and liver damage in rats. The results demonstrated that both the CEAE and specific fractions, particularly the ALF, significantly reduced weight gain in rats fed a high-fat diet. Furthermore, the CEAE and its fractions effectively lowered biochemical markers of liver damage and reduced adipocyte size in white adipose tissue. Notably, the SPF and CEAE exhibited the best preservation of liver tissue structure. These findings suggest that *C. esculenta* leaves possess weight-attenuating and hepatoprotective properties, potentially attributed to the presence of alkaloids and saponins, respectively.	[75]
Antidiabetic								
The root was obtained from the National Root Crops Research Institute in Umudike, Nigeria. Mr. Ibe identified the plant and deposited it in the herbarium of Michael Okpara University of Agriculture in Umudike.	The samples were peeled, soaked in water for about 10 m, rinsed, and oven-dried at 70°C to a constant weight before being processed into flour. The processed flour was then pelletized and oven-dried at 80° C until a constant weight was obtained.	The gravimetric method was used to determine alkaloids, while the Association of Official Analytical Chemists method was used to determine other phytochemical constituents.	48 male albino rats of the Wistar strain (133.28–242.79 g) obtained from the University of Nigeria, Nsukka, Enugu State, Nigeria, were used in this study. The experimental animals were housed in metabolic cages in the animal house of the Department of Biochemistry, Michael Okpara University of Agriculture, Umudike, Nigeria. The animals were acclimatized to their diets for 2 weeks before the experiment commenced and maintained at a room temperature of 27–30°C. The ethics committee of Michael Okpara University of Agriculture, Umudike, approved all animal research protocols.	The STZ-treated rats with stable diabetic conditions were then divided into subgroups (groups 2–5) comprising of six animals per group while the non-diabetic group formed the first group as follows: **Group 1**: Non-diabetic rats fed standard rat feeds/pellets (non-diabetic control); **Group 2**: diabetic control rats fed standard pellets; **Group 3**: diabetic rats fed *C. esculenta* pellets (810 g/kg); **Group 4**: diabetic rats fed with unripe plantain pellets (810 g/kg); **Group 5**: diabetic rats fed *C. esculenta* + unripe plantain pellets (405:405 g/kg). Their diets and water were administered ad libitum for 28 d, after which the rats were stunned by the blow, sacrificed, and blood was drawn from the heart using 10 mL syringes and poured into heparin tubes for HbA1C assays.	The drug control was not used in this study.	Results were presented as the means ± standard deviations of triplicate experiments. One-way ANOVA was used to compare the means. Differences between means were considered significant at $p<0.05$ using the New Duncan Multiple Range Test.	The serum glucose levels of diabetic rats fed with *C. esculenta* were significantly lower compared to diabetic control rats. There was also a significant decrease in HbA1C levels in diabetic control rats compared to non-diabetic rats. The HbA1C levels of diabetic rats fed with *C. esculenta* were significantly lower compared to diabetic control rats. However, the HbA1C levels in this group remained significantly higher compared to non-diabetic rats. This study demonstrated the antidiabetic activity of *C. esculenta*.	[71]

(*Continued*)

https://doi.org/10.2147/JEP.S550113

Table 3 (Continued).

Part of the Plant, Collected in and Authenticated by	Extraction Method	Phytochemical Analysis	Animal, Ethical Approval Committee	Model Category, Methods, and Parameters Assessed	Control Drug	Statistical Analysis	Results	Reference
Diuretic								
The flowers were collected from the Fulgazi region (District Feni, Chattogram, Bangladesh). It was identified by professor, Dr. Shaik Bokhtear Uddin, Department of Botany, University of Chittagong, Bangladesh.	The dried flowers were ground into powder. 500 g of the powder was macerated with 2 litres of 95% methanol for 3 d, and the process was repeated with the residue. The combined extracts were filtered and the solvent was evaporated using a rotary evaporator to obtain a semisolid mass.	Not described	Male Wistar rats weighing 200–250 g were purchased from the animal research division, Comilla University, Comilla, Bangladesh. The rats were kept in polycarbonate cages with a 12-h light/dark cycle and standard settings (25 ± 2◦C and 55–60% humidity). Throughout the study, the animals had free access to food and water. The Institutional Animal Ethics Committee of the Department of Pharmacy at the University of Science and Technology, Chittagong, Bangladesh, authorized all experimental protocols (Permission number USTC/AEAC/23/023).	The rats were fasted overnight and pretreated with normal saline (15 mL/kg orally) before being randomly divided into six groups. The extract was diluted using Tween 80 and distilled water: **Group 1**: Control group (received vehicle only); **Group 2**: Treated with Urea (10 mg/kg BW); **Group 3**: Standard furosemide group (10 mg/kg BW).; **Group 4**: CEF-ME dose 250 mg/kg BW; **Group 5**: CEF-ME dose 500 mg/kg BW; and **Group 6**: CEF-ME dose 750 mg/kg BW. After treatment, urine was collected during the first urination and at the fifth, twelfth, and twenty-fourth h. For electrolyte analysis, urine was stored at −20°C. Rats were kept in metabolic cages without access to food or water, and Na^+, K^+, and Cl^- levels were measured.	Furosemide at a dose 10 mg/kg BW	Statistical analysis was performed using GraphPad Prism software (version 5.2). An independent *t*-test was conducted to determine whether there was a significant difference between them.	The study results demonstrated the diuretic activity of CEF-ME. They showed a significant increase in urine volume at all doses, particularly at doses of 500 mg and 750 mg, with volumes reaching 4.87 ± 0.67 mL and 5.78 ± 0.33 mL, respectively, at the 12-h mark. The 750 mg dose of CEF-ME achieved a urinary excretion percentage of 95%, comparable to the standard diuretic furosemide, which reached 105%. Based on the electrolyte profile, CEF-ME 750 mg increased sodium (Na^+) and chloride (Cl^-) levels.	[38]
Anti-hyperlipidemia								
The root was obtained from the National Root Crops Research Institute in Umudike, Nigeria. Mr. Ibe identified the plant and deposited it in the herbarium of Michael Okpara University of Agriculture in Umudike.	The samples were peeled, soaked in water for about 10 min, rinsed, and oven-dried at 70°C to a constant weight before being processed into flour. The processed flour was then pelletized and oven-dried at 80° C until a constant weight was obtained.	The gravimetric method was used to determine alkaloids, while the Association of Official Analytical Chemists method was used to determine other phytochemical constituents.	48 male albino rats of the Wistar strain (133.28–242.79 g) obtained from the University of Nigeria, Nsukka, Enugu State, Nigeria, were used in this study. The experimental animals were housed in metabolic cages in the animal house of the Department of Biochemistry, Michael Okpara University of Agriculture, Umudike, Nigeria. The animals were acclimatized to their diets for 2 weeks before the experiment commenced and maintained at a room temperature of 27–30°C. The ethics committee of Michael Okpara University of Agriculture, Umudike, approved all animal research protocols.	The STZ-treated rats with stable diabetic conditions were then divided into subgroups (groups 2–5) of six rats each while the non-diabetic group formed the first group as follows: **Group 1**: Non-diabetic rats fed standard rat feeds/pellets (non-diabetic control); **Group 2**: diabetic control rats fed standard pellets; **Group 3**: diabetic rats fed *C. esculenta* pellets (810 g/kg); **Group 4**: diabetic rats fed with unripe plantain pellets (810 g/kg); **Group 5**: diabetic rats fed *C. esculenta* + unripe plantain pellets (405:405 g/kg). Their diets and water were administered ad libitum for 28 d, after which the rats were stunned by the blow, sacrificed, and blood was drawn from the heart using 10 mL syringes and the blood samples were collected in non-anti-coagulant tubes for serum assay of lipid profile.	The drug control was not used in this study.	Results were presented as the means ± standard deviations of triplicate experiments. One-way ANOVA was used to compare the means. Differences between means were considered significant at $p<0.05$ using the New Duncan Multiple Range Test.	Diabetic rats fed with *C. esculenta* exhibited a significant decrease in TC, triglycerides, and LDL cholesterol and a significant increase in HDL cholesterol. Diabetic control rats experienced a significant decrease in malic enzyme, isocitrate dehydrogenase, and glucose-6-phosphate dehydrogenase levels. This study demonstrated the antihyperlipidemic actions of *C. esculenta*.	[71]

Treatment of Periodontal Disease								
Plant (herba) extract was purchased from the Korea Plant Extract Bank at the Korea Research Institute of Bioscience and Biotechnology (Daejeon, Korea). The plant was collected from Namwonsi, Jeollabuk-do, Korea.	The plant was dried in the shade and powdered. The powder was added to 1 L of ethyl alcohol 75% and extracted through 30 cycles at room temperature using an ultrasonic extractor. After filtration and drying under reduced pressure, the CA total extract was obtained with a yield of 4.74%. A 50 mg/mL CA extract stock solution was prepared in dimethyl sulfoxide and stored at −20 °C.	Not described	Ten-week-old female BALB/cAnNHsd (BALB/c) mice (20–25 g) were purchased from Koatech (Pyungtaek, Korea). The Institutional Animal Care and Use Committee of Wonkwang University approved all animal protocols (approval number: WKU20-17). All mice were housed at (22 ± 2) °C, humidity (55 ± 5)%, under a 12 h light/dark cycle, and received food and drinking water ad libitum.	The mice were randomly divided into seven groups (n = 5/group). After 3 d, the mice were treated with antibiotics (870 μg/mL sulfamethoxazole, 170 μg/mL trimethoprim) for 10 d in drinking water ad libitum. Following a 3-day antibiotic-free period, 10^9 CFU of *P. gingivalis* in 100 μL PBS with 2%. CMC was orally inoculated at 2-day intervals, up to three times. 100 μL PBS with 2% CMC was administered for the NC group. Two h before the first inoculation, VA and VCA groups were anesthetized with urethane and varnish was applied for 15s to both maxillary molars. In the VCA group, varnish was mixed with 15% CA. For the GA and GCA groups, commercially available Garglin ZeroTM and 5% CA in Garglin ZeroTM, respectively, were sprayed at 50 μL orally once per day until the mice were sacrificed. The DW group received 1 w/v% CA in drinking water from the first oral infection to the end of the experiment. Forty-two d after the last inoculation, all mice were sacrificed to collect maxilla samples.	Garglin Zero™ was orally sprayed at a volume of 50 μL.	Statistical significance was calculated by non-paired t-tests and one-way ANOVA, followed by multiple comparison tests. p-values < 0.05 were considered statistically significant.	The study results showed that microbiome diversity decreased in the PC group. The VA and VCA groups, which received varnish application with or without CA on the teeth, showed higher diversity according to the Shannon index than the GA and GCA groups, which only used mouthwash daily. In the DW group, CA was consistently provided with drinking water. In this study. The oral microbiome diversity decreased in the PC group, but bone loss did not occur. The oral microbiome diversity decreased in the PC group but increased in the VA and VCA groups, similar to that in the NC group. Therefore, when used with varnish, CA is considered to have potential for preventing and treating periodontal disease.	[51]

(*Continued*)

https://doi.org/10.2147/JEP.S550113

https://doi.org/10.2147/JEP.S550113

Table 3 (Continued).

Part of the Plant, Collected in and Authenticated by	Extraction Method	Phytochemical Analysis	Animal, Ethical Approval Committee	Model Category, Methods, and Parameters Assessed	Control Drug	Statistical Analysis	Results	Reference
Anti-inflamation								
Roots were collected from Udalguri District, Assam, India, and then authenticated by the Department of Botany, Gauhati University, Guwahati, Assam.	100 g of shade-dried, finely ground CE root powder was soaked with 70% methanol in water (1000 mL) for 48 h. The solution was filtered, and concentrated using a rotary evaporator. The resulting dry, semisolid crude extract was stored at 4°C.	The CEMRE was examined for the presence of phytoconstituents using the LC/MS System. Each sample fraction (10 microliters), diluted in water and 98% acetone, was injected into a C-18 column. Spectral data were recorded in positive and negative ionization modes within an *m/z* range of 60–1600 at a scanning rate of 2.0 spectra per second. The obtained mass chromatograms were analyzed using the Chemical Entity Database and METLIN Metabolite.	Male Wistar rats (180–220 g), approximately 8 weeks old, were obtained from the animal facility of the Department of Zoology, Gauhati University, Guwahati, Assam, India, and housed in labeled propylene cages with solid bottoms containing sawdust. The rats were maintained under uniform laboratory conditions with a temperature of 27–30° C, relative humidity (75–87%), and a natural light-dark cycle of 12 h each. They were given a standard pellet diet and ad libitum access to water before the experiment. This experiment was approved by the Institutional Animal Ethics Committee of Gauhati University, Guwahati, India (IAEC/PER/2017/RF/BBC/AS/2016–30).	Male Wistar rats were randomly divided into six groups (n = 6). **Group I**: Control rats received 1.0 mL of distilled water; **Group II**: Test rats received an injection of 0.1 mL of 1% carrageenan; **Group III**: Test rats received Indomethacin (10 mg/kg BW orally) as the standard drug and 0.1 mL of 1% carrageenan; **Group IV**: Test rats received 1.0 mL of CEMRE (100 mg/kg BW orally) and 0.1 mL of 1% carrageenan; **Group V**: Test rats received 1.0 mL of CEMRE (200 mg/kg BW orally) and 0.1 mL of 1% carrageenan; and **Group VI**: Test rats received 1.0 mL of CEMRE (400 mg/kg BW orally) and 0.1 mL of 1% carrageenan. The rats were pre-treated orally with CEMRE and Indomethacin. One h after the pre-treatment, 1% carrageenan was freshly prepared in normal saline, and 0.1 mL of this solution was injected into the subplantar region of each rat's left hind paw to induce paw edema. The rats' paw volumes were measured before the carrageenan injection and then gradually at 0 h, 1 h, 2 h, 3 h, 4 h, and 5 h post-induction using a plethysmometer. The increase in paw volume was calculated, and the percentage inhibition of edema was determined for each group.	Indomethacin (10 mg/kg BW)	All values were statistically compared using one-way ANOVA with post hoc analysis, followed by Tukey's multiple comparison test. The statistical significance level for all results was calculated at $P < 0.05$.	The study showed that CEMRE at a dose of 400 mg/kg BW exhibited a significantly better inhibitory effect than CEMRE 100 mg/kg BW and CEMRE 200 mg/kg BW against carrageenan-induced rat paw edema. The experiment demonstrated that the inhibition percentage of CEMRE 400 mg/kg BW was 87.79%. Administration of CEMRE 400 mg/kg BW provided significant inhibition and showed effectiveness comparable to Indomethacin, the standard inflammation treatment drug. The conclusion of this study is that *of C. esculenta* root extract has anti-inflammatory activity.	[53]

The ethanol extract in this study was obtained from the Korea Plant Extract Bank (Korea Research Institute of Bioscience and Biotechnology, Daejeon, Korea). A stock solution (50 mg/mL) was prepared in dimethyl sulfoxide (DMSO) and stored at −20 °C before use.	Not described	Not described	Female BALB/c mice (8 weeks) were obtained from Samtako Bio Korea (Osan, Korea). The experiment received approval from the Wonkwang University Animal Ethics Committee (WKU20-97).	The mice were divided into five groups, each consisting of eight mice (four mice per cage). **Group 1**: Negative control (no bacterial inoculation, no treatment); **Group 2**: Positive control (bacterial inoculation, no treatment); **Group 3**: WCA (bacterial inoculation, 0.5% CA extract in drinking water); **Group 4**: Varnish (bacterial inoculation, varnish); and **Group 5**: CA varnish (bacterial inoculation, varnish mixed with CA). After a 3 d acclimatization, the mice received sulfamethoxazole (870 μg/mL) and trimethoprim (170 μg/mL) in deionized water for 10 d. Three d after antibiotic treatment, P. gingivalis in the log phase was centrifuged and suspended to 1×10^{10} CFU/mL in 2% CMC in PBS. P. gingivalis (100 μL/mouse) was orally inoculated three times every two d in Groups 2, 3, 4, and 5. An oral gavage injected three-quarters of the *P. gingivalis* suspension into the esophagus. At the same time, the remaining portion was inoculated into the oral cavity. For the WCA group, distilled water mixed with 0.5% w/v CA dissolved in 1% ethanol solution was provided as drinking water. For the VCA group, 15% w/w CA was mixed into the varnish. In the V and VCA groups, the prepared varnish and the varnish mixed with CA were applied around the upper molars using a micro-brush for 15 seconds under anesthesia with an intraperitoneal injection of 400 mg/kg chloral hydrate. All mice were euthanized with CO_2 gas 42 d after the last bacterial inoculation.	The drug control was not used in this study.	If the data met normality and homogeneity of variance based on the Shapiro–Wilk and Levene's tests, it was analyzed using one-way ANOVA. Oral microbiome data were tested using the Kruskal–Wallis test. A p-value < 0.05 was considered statistically significant.	The VCA group showed a significantly lower expression level of IL-1β. Higher levels of IL-1β were observed in the WCA group, where CA was metabolized and circulated throughout the body. The concentration used in this study appeared insufficient to demonstrate an anti-inflammatory effect. If CA is administered directly via oral gavage at higher and consistent concentrations, it is expected to exhibit more reliable systemic anti-inflammatory effects. In this study, it was not possible to determine which compounds in the CA extracts were responsible for the anti-inflammatory activities.	[76]

(*Continued*)

https://doi.org/10.2147/JEP.S550113

Table 3 (Continued).

Part of the Plant, Collected in and Authenticated by	Extraction Method	Phytochemical Analysis	Animal, Ethical Approval Committee	Model Category, Methods, and Parameters Assessed	Control Drug	Statistical Analysis	Results	Reference
Nutritious Food Products								
The corms were obtained from Colegio de Posgraduados, Campus Veracruz, Mexico.	Not described	Not described	The animals used were adult CD-1 IGS mice (14 weeks) from the Institute of Biomedical Research, National Autonomous University of Mexico. The test animals were housed in the Multidisciplinary Experimental Laboratory and Animal Facility for 9 weeks under the following conditions: temperature 27 ± 2° C, relative humidity 65 ± 2%, and constant darkness. The feeding period lasted for 9 weeks. The experiment was approved by the Ethics and Biosecurity Committee of the Faculty of Nutrition and Food Sciences of the University of Sciences and Arts of Chiapas.	Adult CD-1 mice were divided into five groups, each consisting of six mice. **Group I**: Raw flour 0%, boiled 15%, and wheat flour 85%; **Group II**: Raw flour 15%, boiled 0%, and wheat flour 85%; **Group III**: Raw flour 50%, boiled 0%, and wheat flour 50%; **Group IV**: Raw flour 0%, boiled 50%, and wheat flour 50%; and **Group V** (Control group): wheat flour 100%. During this period, the mice's average food consumption body weight, and grooming behavior were monitored and recorded for each group.	The drug control was not used in this study.	The data were analyzed using ANOVA with MINITAB statistical software version 16.0 for Windows.	The study results showed that consuming *C. esculenta* with raw flour corms in various concentrations did not significantly affect the changes in mice's body weight between the beginning and the end of the experiment. The same pattern was observed in mice fed with boiled corms. The feed consumption pattern showed that the average feed intake increased exponentially during the first four weeks and remained stable over the following five weeks. All groups exhibited the same consumption pattern, with no significant differences. It can be concluded that the amount of antinutritional factors present in raw flour corms did not affect body weight and did not cause changes in the mice's consumption patterns. In general, normal behaviour was observed in all groups of mice, including the control group, indicating that corms or their components did not induce any adverse effects.	[77]

Neuroprotective								
Leaves were collected from Al Monier Village, Mashtool El Souk, Al-Sharkia Governorate, Egypt. The governorate is in the eastern part of Egypt. The plant was botanically identified and authenticated based on the morphological characters by Prof. Emad Farahat, Professor of Plant Ecology, Faculty of Science, Helwan University.	The air-dried powdered leaves were extracted with 98% MeOH under reflux. The extract was then dried using a rotary evaporator at 40°C to obtain the total ME. The ME was fractionated between distilled H_2O and n-butanol saturated with water, yielding the n-BF.	The phenolic compounds from ME and n-BF were analyzed using HPLC. The separation was performed using an Eclipse C18 column. A total of 70 g of n-BF was initially separated using a silica gel G 60 column (700 g) with a stepwise gradient of DCM/MeOH, increasing polarity by 5% to obtain five collective fractions (I–V). **Fraction I** (15 g, eluted with 100% DCM): Of limited interest based on TLC chromatographic analysis; **Fraction II** (10 g, eluted with 98% DCM/MeOH): Further purified using a silica gel column with stepwise elution, showing no UV absorption (254 and 366 nm); **Fraction III** (15 g, eluted with 95% DCM/MeOH): Subfraction IIIb (20 mg): Purified using a Sephadex LH-20 column; **Fraction IV** (6 g, eluted with 93% DCM/MeOH): Further separated into subfractions IVa and IVb, each yielding compound 3 (8 mg) and compound 4 (6 mg); and Fraction V (5 g, eluted with 90% DCM/MeOH): Rich in phenolic acids and flavonoids, quantitatively analyzed using LC-MS/MS in MRM with mobile phase A (0.1% formic acid in water) and B (acetonitrile, LC grade). MRM analysis was applied using both positive and negative ionization modes.	Adult male Sprague Dawley rats (220–250 g) and Swiss mice (25–30 g) were obtained from the breeding unit of the Egyptian Organization of Biological Products and Vaccines (Helwan, Egypt). The animals were housed in cages (4 animals/cage) under a temperature-controlled environment (25°C ± 2°C). Before the experimental procedures, the animals were acclimatized for seven d. They were given free access to a standard pellet diet and tap water ad libitum. The Research Ethics, Animal Care, and Use Committee approved the research protocol at the Faculty of Pharmacy, Helwan University (Protocol approval no: 09A202). All procedures were conducted by the European Community Guidelines (86/609/EEC) and national regulations on animal care, which comply for the Care and Use of Laboratory Animals.	Sixty-four adult male rats were randomly divided into 8 groups. **Group I**: Control group (vehicle); **Group II**: MSG (2 g/kg, intraperitoneally); **Group III**: ME (250 mg/kg, orally; p.o). + MSG; **Group IV**: ME (500 mg/kg, p.o). + MSG; **Group V**: ME (1000 mg/kg, p.o). + MSG; **Group VI**: n-BF (250 mg/kg, p.o). + MSG.; **Group VII**: n-BF (500 mg/kg, p.o). + MSG; and **Group VIII**: n-BF (1000 mg/kg, p.o). + MSG. Rats in groups III–VIII received oral doses of ME or n-BF once daily for seven d at 08:00 AM. One h later (09:00 AM), MSG (2 g/kg, i.p.) was administered to all groups except the control. Rats were observed for behavioral responses 30 m post-MSG injection, and scored from 0 (calm) to 5 (fighting/aggressive behavior). At the end of the experiment, the rats were anesthetized using sodium thiopental (40 mg/kg/i.p)., and brain isolation was performed on an ice plate. Each brain was divided into two hemispheres, where the right hemisphere was fixed in 10% neutral buffered formalin for histological examination. The left hemisphere was homogenized in ice-cold phosphate buffer (0.1 M, pH 7.4) using an ice-cold Teflon homogenizer to obtain a 10% (w/v) homogenate, then centrifuged for 10 m at 2000 rpm and 4°C. The obtained supernatant was used for biochemical studies.	The drug control was not used in this study	The data were analyzed using a one-way ANOVA, followed by a Tukey's test to determine the statistical significance between various groups. The value $p < 0.05$ was considered as significant.	The ME and its n-BF exhibited significant neuroprotective activity. The aggressivity scores in rats demonstrated this administered ME at doses of 250, 500, and 1000 mg/kg BW, where higher doses resulted in lower aggressivity scores. The n-BF group also showed a reduction in aggressivity scoring. Similar results were observed in the ME 1000 mg/kg and n-BF 1000 mg/kg groups. Histopathological findings revealed that some neurons appeared shrunken and degenerated in the ME-treated groups, whereas in the n-BF group, all neuronal cells remained normal. This study confirms the neuroprotective activity of *C. esculenta* leaves.	[40]

(*Continued*)

https://doi.org/10.2147/JEP.S550113

Table 3 (Continued).

Part of the Plant, Collected in and Authenticated by	Extraction Method	Phytochemical Analysis	Animal, Ethical Approval Committee	Model Category, Methods, and Parameters Assessed	Control Drug	Statistical Analysis	Results	Reference
Anti-compulsive								
The leaves were purchased from a local market. The plant was identified and authenticated by Prof. P. J. Parmar from the Botanical Survey of India, Jodhpur, India.	The leaves were shade-dried, ground, and macerated with 50% ethanol (w/w) for 7 d with occasional shaking. On the 8th day, the macerate was filtered, and the solvent was completely removed under reduced pressure to obtain the HECE. The extract was stored in a refrigerator and freshly dissolved in a SCMC solution before the experiment.	Phytochemical analysis was conducted to identify the presence of flavonoids, steroids, and β-sitosterol.	Adult male Swiss albino mice (22–25 g) were divided into six groups and housed in polypropylene cages in a climate-controlled central animal facility with a temperature of 22 ± 2°C, relative humidity of 60 ± 5%, and a 12-h light/dark cycle. The mice were fed standard rodent chow and provided water ad libitum. They were acclimatized to laboratory conditions for 7 d before the experiments were conducted. The Institutional Animal Ethics Committee of the Committee for Control and Supervision on Experiments on Animals, Ministry of Environment and Forests, Government of India approved all research protocols (SU/DPS/IAEC/9003).	HECE was dissolved in 0.5% SCMC in distilled water and administered via i.p. route. Fluoxetine was dissolved in 0.9% saline solution. HECE was administered at doses of 25 and 50 mg/kg. Animals in the control group received only the vehicle (0.5% SCMC, 1 mL/kg), while the standard group animals received fluoxetine as the reference standard drug (5 mg/kg, i.p.; Selective Serotonin Reuptake Inhibitor (SSRI)). All drugs and extracts were prepared and administered 30 m before the test. Each mice was placed in a plastic cage (21 × 38×14 cm^3) containing 5 cm thick sawdust bedding. Twenty small glass marbles (diameter 10–12 mm) were evenly spaced on the bedding in four rows. After 30 m of exposure, the number of unburied marbles was counted. A marble covered at least two-thirds (2/3) of its size by sawdust was considered "buried." The total number of buried marbles was considered an index of obsessive-compulsive behaviour.	Fluoxetine 5 mg/kg (i.p)	Data was analyzed using one-way ANOVA, followed by the Student Newman–Keuls test. Groups treated with HECE and fluoxetine were compared with the respective vehicle group. p-values < 0.001 were considered statistically significant.	HECE (25 and 50 mg/kg) dose-dependently reduced marble-burying behaviour in mice, and the reduction was significant. This study concludes that HECE shows a dose-dependent anti-compulsive effect.	[78]

Abbreviations: ALDH, aldehyde dehydrogenase; ALF, alkaloid-rich fraction; ANOVA, analysis of variance; BPH, benign prostatic hyperplasia; BW, body weight; CA, *C. antiquorum* var. *esculenta*; CAT, catalase; CE, *Colocasia esculenta*; CEAE, *C. esculenta* aqueous extract; CEF-ME, *C. esculenta* flower-methanol extract; CEMRE, root extract of *C. esculenta*; CMC, carboxymethylcellulose; CO_2, carbon dioxide; d, day; DCM, dichloromethane; ECTECE, ethanol crude tuber extract of *C. esculenta*; EDTA, ethylenediaminetetraacetic acid; ELISA, enzyme-linked immunoassay; ETECE, ethanol extract of *C. esculenta* tuber; GA, gargle; GCA, gargle containing *C. antiquorum* var. *esculenta*; GIT, gastrointestinal tract; GSH, Glutathione reduced form; h, hour; HbA1C, hemoglobin a1c; HCT, hematocrit; HECE, hydroalcoholic extract *C. esculenta*; HFD, high-fat diet; HPLC, high-performance liquid chromatography; IL, interleukin; Ip, intraperitoneal; LC, liquid chromatography; LDL, low-density lipoprotein; m, minute; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; MCV, mean corpuscular volume; MDA, malondialdehyde; ME, methanol extract; MeOH, methanol; MRM, multiple reaction monitoring; MS, mass spectroscopy; n-BF, n-butanol soluble fraction; PBS, phosphate-buffered saline; PSA, prostate-specific antigen; RBC, red blood cell; SCMC, sodium carboxymethyl cellulose; SOD, superoxide dismutase; SPF, saponin-rich fraction; TC, total cholesterol; TE, taro extract; TE-M2, taro extract-method 2; TE-M2F1, taro extract-method 2-purified subfraction; TNBC, triple-negative breast cancer; TP, testosterone propionate; VA, varnish; VCA, varnish added with *C. antiquorum* var. *esculenta*; WCA, water-*Colocasia antiquorum* var. *esculenta*.

soluble extract from raw *C. esculenta* that significantly suppressed breast cancer spread in two preclinical models of triple-negative breast cancer (TNBC).[55] The effectiveness of *C. esculenta* in preventing metastasis was confirmed via treatment in female mice of the Balb/cByJ strain with *C. esculenta* extract (400 µg and 200 µL/day), which suppressed 87% to 100% of lung metastases in two TNBC models (66.1; 410.4). Two representative experiments showed that *C. esculenta* extract inhibited 99% of lung metastases in 66.1 cells and 100% of 410.4 cells. New data indicate that *C. esculenta* extract acts through direct mechanisms (anti-migratory, anti-proliferative, and anti-cancer stem cells) and immunological mechanisms to inhibit metastasis.[73]

Antidiarrheal Activity

C. esculenta has emerged as a promising natural agent in managing diarrhea, owing to its rich phytochemical profile and multifaceted pharmacological actions. Several studies have indicated that its bioactive compounds contribute to anti-diarrheal effects by inhibiting intestinal inflammation,[82] suppressing excessive gastrointestinal motility,[74] and modulating electrolyte balance[83]—these properties position *C. esculenta* as a potential alternative or complementary treatment for diarrhea. The antidiarrheal study utilized castor oil induction, which stimulates faecal excretion and increases intestinal motility by causing irritation and inflammation of the intestinal mucosal lining. Consequently, inflammatory mediators, particularly PGE_2 and NO, inhibit glucose absorption, trigger intestinal mucosal inflammation, cause intestinal smooth muscle contraction, and disrupt ion channels such as Na^+/K^+ ATPase.[82,84]

The administration of *C. esculenta* peel extract, collected from Deko Kebele, Wonago Woreda, Southern Nations, and Peoples of South Ethiopia, in three different fractions, has been proven to reduce the total number of wet stools and total stool output. All solvent fractions significantly delayed the onset of diarrhea and reduced stool fluid content. The percentages of diarrhea inhibition at a 400 mg/kg dose for the aqueous fraction, chloroform fraction, and diethyl ether fraction were 55, 57.7, and 55.94%, respectively.[74] The effects of *C. esculenta* can be attributed to the presence of various phytochemical compounds, particularly alkaloids, tannins, flavonoids, phenols, and terpenoids, which act by inhibiting PG, fluid, and electrolyte secretion, while simultaneously enhancing absorption through various mechanisms. Additionally, the anti-inflammatory effects of this plant may contribute to its efficacy.[83]

Anti-Obesity and Hepatoprotective Activity

C. esculenta has shown promising anti-obesity and hepatoprotective effects, particularly in high-fat diet-induced models, by reducing weight gain and protecting liver tissue. A high-fat diet with 25% fat content can cause a slight increase in the body weight of rats,[85] whereas a 40% fat concentration is recognized for promoting obesity.[86] A high-fat diet is more effective in increasing body weight than a high-carbohydrate diet.[87] In a study using *C. esculenta* leaves collected from farms within Enugu Metropolis, Enugu State, Nigeria, rats fed with a high-fat diet (HFD) experienced a significant increase in body weight and elevated liver enzyme levels (ALT, AST, ALP) compared to the control group that received a standard diet. Administration of the crude aqueous extract and alkaloid fraction from *C. esculenta* leaves to rats fed a high-fat diet significantly reduced weight gain and decreased liver enzyme levels.[75]

Natural products with anti-obesity effects work through various mechanisms, including reduced energy intake, suppression of lipid uptake, prevention of pre-adipocyte differentiation and proliferation, reduction of lipogenesis, enhancement of lipolysis, and increased energy expenditure.[88] Histological examination of liver tissue in rats fed a high-fat diet showed degenerative changes in the liver parenchyma due to lipid accumulation. These histopathological changes occur due to an increased supply of fatty acids to the liver or an increase in endogenous fatty acid synthesis in the liver.[89] Administration of the crude aqueous extract and fraction of saponin from *C. esculenta* leaves showed protective effects on liver tissue by significantly reducing fat accumulation. Overall, *C. esculenta* leaf extract (especially crude aqueous extract) can potentially reduce the body weight and fat accumulation caused by a high-fat diet and protect liver function.[75]

Antidiabetic Activity

C. esculenta has gained increasing attention for its potential role in diabetes management, owing to its rich dietary fiber content,[27] complex carbohydrates,[90] and bioactive compounds that contribute to glycemic control.[91] These properties support its traditional use and highlight its potential as a natural antidiabetic agent.

Research conducted by Eleazu et al showed that the administration of *C. esculenta* to streptozotocin-induced rats reduced serum glucose levels and hemoglobin A1C (HbA1C). HbA1C is a product of the irreversible condensation of glucose with the N-terminal residue of the β-chain of hemoglobin A. HbA1C levels are used to assess glycemic control in individuals with diabetes.[71,92]

This study showed that the diabetic control group had a blood glucose level of 288.60 ± 11.78 mg/dL and an HbA1C level of 9.57 ± 1.63%. In contrast, the group treated with *C. esculenta* from Nigeria had a blood glucose level of 82.25 ± 4.27 mg/dL and an HbA1C level of 7.15 ± 1.21%. Polyphenol content plays a crucial role in antidiabetic activity.[71] Tannins and alkaloids are polyphenolic compounds with antioxidant properties. In addition to scavenging free radicals, polyphenols can engage with cellular receptors and influence signalling pathways, thereby influencing the oxidation-reduction mechanism status of cells and triggering continuous redox reactions. Tannins also inhibit the activity of α-amylase and α-glucosidase, which catalyze carbohydrate digestion into glucose.[91] The ability of *C. esculenta* to reduce triacylglycerol levels may play an indirect role in its anti-hyperglycemic effects by influencing the glucose-fatty acid cycle.[93]

Diuretic Activity

C. esculenta has emerged as a potential natural diuretic agent, with studies demonstrating its ability to promote urine excretion,[38] and regulate fluid and electrolyte balance.[94] This effect is likely attributed to its bioactive compounds, which may act through mechanisms comparable to those of conventional diuretics. Diuretics increase urine production, helping to eliminate excess fluids and electrolytes from the body and making them beneficial in managing hypertension, edema, and kidney disease.[95] One of the activities of the methanol extracts of *C. esculenta* flowers is diuretic activity. Methanol extracts of *C. esculenta* flowers collected from the Fulgazi region, District of Feni, Chattogram, Bangladesh, exhibited notable diuretic activity, as evidenced by a significant increase in urine output at all tested doses. This effect was particularly pronounced at 500 mg and 750 mg, with recorded urine volumes of 4.87 ± 0.67 mL and 5.78 ± 0.33 mL, respectively, after 12 hours of administration. The 750 mg dose resulted in a urinary excretion rate of 95%, closely approximating the effect of the reference diuretic, furosemide, which demonstrated a 105% excretion rate.[38]

Moreover, ensuring an optimal Na/K ratio is crucial for maintaining electrolyte balance. Diuretics cause potassium loss and increased sodium excretion.[96] Maintaining stable Na^+, K^+, and Cl- levels is essential for regulating metabolic and cardiovascular health.[97] The electrolyte profile showed that 750 mg of the methanol extracts of *C. esculenta* flowers increased Na+ and Cl- excretion, demonstrating the extract's effect on fluid regulation. The high K+ content in *C. esculenta* contributes to its significant diuretic effect because enhanced kidney function and higher K+ levels can promote natriuresis (increased urine production).[94]

Studies have shown that carbonic anhydrase inhibitors such as acetazolamide effectively enhance diuresis.[98,99] Cyclohexane-1,2-diol exhibited the highest binding affinity in molecular docking tests, indicating that this compound has the potential to act as a dual-action drug with strong diuretic properties. High binding affinity was also demonstrated by diethyl 1-methyl-3-hydroxy-5-phenylpyrrole-2,4-dicarboxylate, suggesting its possible involvement in managing these conditions. This indicates the effectiveness of the methanol extracts of *C. esculenta* flowers as a source of phytochemicals with therapeutic potential.[38]

Antihyperlipidemic Activity

C. esculenta has shown considerable potential as a natural therapeutic agent for the management of hyperlipidemia, particularly in diabetic conditions. Hyperlipidemia, defined as elevated levels of circulating lipids—primarily cholesterol and triglycerides—is a common complication of diabetes mellitus and a significant contributing factor to the development of cardiovascular diseases, including atherosclerosis, hypertension, and coronary artery disease.[80,100] In diabetic

individuals, increased mobilization of free fatty acids from peripheral tissues is believed to play a central role in the rise of serum lipid levels.[101] Numerous studies have demonstrated the lipid-lowering properties of *C. esculenta*, showing its ability to decrease total cholesterol, triglycerides, low-density lipoprotein (LDL), and very low-density lipoprotein (VLDL), while elevating high-density lipoprotein (HDL). These effects contribute to improvements in lipid metabolism and cardiovascular health.[71]

A study by Eleazu et al reported that the administration of *C. esculenta* extract to diabetic rats significantly improved their lipid profiles. Total cholesterol decreased by 41.7%, triglycerides by 34.1%, VLDL by 34.0%, and LDL by 61.9%, while HDL increased by 46.0%. These results were further supported by a reduction in atherogenic and coronary risk indices, reinforcing the cardioprotective role of *C. esculenta*.[71] These findings highlight the therapeutic potential of *C. esculenta* in regulating dyslipidemia and preventing lipid-related complications, particularly in the context of diabetes.

Treatment of Periodontal Disease

Recent studies have highlighted the potential of plant-derived compounds, such as *C. antiquorum* var. *esculenta*, to promote microbial diversity and support oral health. This therapeutic potential aligns with current strategies for treating and preventing periodontal disease, which require an integrated approach, particularly through modulation of the oral microbiome. Changes in the diversity of oral microbial communities are now recognized as early indicators of periodontal pathology, including dental caries, periodontitis, and systemic diseases such as cardiovascular disorders, cerebrovascular disease, atherosclerosis, and diabetes.[102–104] Under pathological conditions, reduced microbial diversity often leads to the dominance of certain opportunistic organisms, which contributes to the development of periodontitis and dental caries.[105] Therefore, restoring microbial balance has become a central focus in periodontal therapy. See details below.

In this study, the microbiome diversity in the positive control group decreased. In contrast, the groups treated with varnish and varnish containing 15% *C. antiquorum* var. *esculenta* showed an increase in diversity similar to that observed in the normal group. The presence of dominant bacteria such as *Streptococcus* and *Lactobacillus* in these groups indicates their potential to diversify the oral microbiome. In addition, although microbiome diversity decreased in the positive control group, no significant alveolar bone loss occurred, suggesting that changes in the oral microbiome can happen in the early stages of periodontal disease without causing noticeable structural damage. A decrease in microbiome diversity, as observed in the positive control group, is often associated with the dominance of certain bacteria, which can lead to periodontitis and tooth decay. This study demonstrated the effectiveness of *C. antiquorum* var. *esculenta*, obtained from the Korea Plant Extract Bank, Korea Research Institute of Bioscience and Biotechnology, Daejeon, South Korea, as a preventive and therapeutic agent for periodontal disease.[51]

Anti-Inflammatory Activity

C. esculenta has been increasingly recognized for its anti-inflammatory potential, supported by in vivo studies and phytochemical analyses highlighting its interaction with key inflammatory mediators. Several bioactive compounds in this plant have demonstrated the ability to modulate inflammation by affecting both early and late-phase mediators, including serotonin, histamine, prostaglandins, bradykinin, lysozyme,[53] and the proinflammatory cytokine IL-1β.[106] These mediators play crucial roles in the initiation and progression of inflammatory responses, and their modulation suggests that *C. esculenta* may serve as a promising natural source for inflammation management. Further details are provided in the following paragraphs:

It has been reported that *C. esculenta* contains various active compounds and possesses health benefits.[107,108] The methanol extract of the roots of *C. esculenta* collected from Udalguri District, Assam, India, was analyzed by LC-MS and revealed 20 significant phytochemicals with potential anti-inflammatory properties. Animal testing on carrageenan-induced inflammation showed that the groups receiving the methanol extract of *C. esculenta* root at doses of 100 and 200 mg/kg BW exhibited inhibition percentages of 67.66% and 58.95%, respectively. The 400 mg/kg BW dose resulted in 87.79% inhibition. Therefore, the conclusions drawn from this study indicate that a high dose of the methanol extract of *C. esculenta* root (400 mg/kg BW) exerts anti-inflammatory effects by modulating the synthesis of kinins, prostaglandins, bradykinins, and lysozymes.[53] The inflammatory progression caused by carrageenan induction is biphasic, with serotonin

and histamine release in the early phase (first hour). The second phase of swelling, which responds to both steroidal and non-steroidal anti-inflammatory drugs, is caused by the release of prostaglandins, bradykinins, and lysozymes.[109,110]

In a periodontitis model study, *C. antiquorum* var. *esculenta* obtained from the Korea Plant Extract Bank, Korea Research Institute of Bioscience and Biotechnology, located in Daejeon, South Korea, was used. Application of *C. antiquorum* var. *esculenta* extract varnish significantly reduced IL-1β expression in the gingival tissue.[76] IL-1β is an inflammatory cytokine that appears during the initial phases of inflammation.[106] However, this study could not identify the compounds in *C. antiquorum* var. *esculenta* extract that are responsible for its anti-inflammatory activity.

Nutritious Food Products

C. esculenta has gained attention for its medicinal properties and nutritional value,[19] particularly as a potential food source for sensitive populations, such as allergic infants and individuals with gastrointestinal disorders.[12] Its corms can be processed into various food products suitable for these specific dietary needs.[25,90] One drawback of consuming raw *C. esculenta* tubers is the presence of anti-nutritional compounds, including oxalates, throughout the entire plant. Oxalate is the final metabolic product of numerous plant varieties, occurs in both soluble and insoluble forms. Their levels fluctuate based on nutritional types, soil characteristics, and growth stages.[111] Oxalate levels in the Araceae plants can be minimized by peeling, grating, soaking, fermenting, and cooking before consumption. If not properly cooked, oxalates can cause throat irritation and interfere with the distribution of other nutrients, potentially leading to health issues when consumed in excess.[112,113]

Research has demonstrated that consuming food supplemented with raw *C. esculenta* corms from Colegio de Posgraduados, Campus Veracruz, Mexico, at different concentrations (15% and 50%) did not significantly affect changes in the body weight of mice between the start and end of this study. The same pattern was observed in mice fed with cooked *C. esculenta* tubers (15% and 50%). All groups showed the same consumption pattern with no notable differences, indicating that the addition of *C. esculenta* corms (both raw and cooked) did not cause changes in consumption patterns. Therefore, it can be concluded that the amount of anti-nutritional factors, such as oxalates and hydrogen cyanide (HCN), in raw *C. esculenta* corms had no appreciable effect on the body weight of mice, as no statistically significant differences were detected over the 9-week observation period.[77]

Neuroprotective Activity

The neuroprotective potential of *C. esculenta* has attracted increasing scientific interest, particularly owing to its prospective use as an anticonvulsant and in the management of neurodegenerative conditions. Phytochemical constituents from its leaves benefit neural function, indicating their ability to modulate key targets involved in neuronal damage.[41] A study on the neuroprotective activity of *C. esculenta* leaves demonstrated that the methanolic extract and *n*-butanol fraction, when tested in vivo using a rat model induced with monosodium glutamate (MSG) cytotoxicity, could mitigate the detrimental effects of MSG on the nervous system. Decreased aggressiveness scores in rats were evidenced by the administration of the methanolic extract and n-butanol fraction compared to the control group. The effect of *C. esculenta* extract on the histological examination of the cortical region indicated a reduction in degenerating neurons, while the hippocampal CA1 region showed a decrease in degenerating neurons. Molecular docking studies confirmed that the compounds isolated from *C. esculenta* leaves from Al Monier Village, Mashtool El Souk, Al-Sharkia Governorate, Egypt, effectively bind to target sites with a higher binding energy than that of the crystallized ligand, indicating a strong potential for neuroprotection. The polyphenolic compounds from *C. esculenta* leaves and their effective binding in molecular docking studies further highlight their potential for treating neurological conditions.[40] This study confirms that caspase-3 is a key mediator of neuronal death and a standard regulator of several neurodegenerative diseases. The inhibition of caspase-3 may also protect the dopaminergic neurons from various stimuli.[114,115]

Anticonvulsant Activity

Obsessive-compulsive disorder (OCD) is a neuropsychiatric disorder characterized by intrusive, recurrent thoughts and/or ritualistic behaviors that lead to emotional distress and interfere with daily life.[116] The marble-burying test has been

widely utilized as a behavioral paradigm to assess compulsive-like activities through repeated trials. Pharmacological agents such as tricyclic antidepressants and selective serotonin reuptake inhibitors (SSRIs) have been shown to attenuate this behavior.[117,118] Notably, marble-burying is a species-specific, defensive behavioral response in rodents that persists across multiple exposures and is not triggered by immediate physical threats.[119] These characteristics support its interpretation as a model of compulsivity rather than anxiety.[117,120] Building on this framework, Kalariya et al conducted a study employing the hydroalcoholic extract of *C. esculenta* leaves from India, demonstrating that intraperitoneal administration of 25 and 50 mg/kg significantly suppressed marble-burying behavior in mice.[78]

From a pathophysiological perspective, OCD has been associated with dysregulation of the neurotransmitter serotonin, which is thought to be involved in anxiety modulation. According to BBC Science (2014), serotonin interacts with receptor sites on adjacent neurons to induce neurotransmission. It has been hypothesized that patients with OCD have understimulated serotonin receptors. This hypothesis aligns with the findings that many patients with OCD experience improvement with SSRIs, a class of antidepressants that enhance serotonin availability for other nerve cells (https://www.bbc.co.uk/science/humanbody/mind/articles/disorders/causesofocd.shtml).

Hydroalcoholic extract of *C. esculenta* leaves is thought to have an effect similar to that of SSRIs or it may exert a suppressive effect on serotonergic neurotransmission. The anti-compulsive mechanism of the hydroalcoholic extract of *C. esculenta* leaves may involve one of its phytoconstituents (flavonoids, steroids, or β-sitosterol) in serotonergic neurotransmission. Additionally, the steroidal compounds found in the hydroalcoholic extract of *C. esculenta* leaves have lipophilic characteristics, enabling them to traverse the blood-brain barrier. These findings suggest that these compounds may contribute to anti-compulsive effects through molecular interactions within the central nervous system.[121]

Clinical Evidence

A study conducted by Wu et al provided preliminary evidence that *C. esculenta* possesses anticancer potential, particularly as a chemopreventive agent against pancreatic adenocarcinoma (PAAD).[122] These findings support the need for further investigations into its bioactive compounds—such as tarin—and encourage future clinical trials in cancer patients.[123]

In this study, a dietary intervention was conducted in 42 healthy volunteers (19 males and 23 females) from Jingjiang City, Jiangsu Province, China. The biological effects of *C. esculenta* consumption were assessed using the proximity extension assay (PEA), which revealed significant changes in the expression of 22 of 92 cancer-related proteins. Specifically, carcinoembryonic antigen-related cell adhesion molecule 1 (CEACAM1), EPH receptor A2 (EPHA2), and integrin subunit beta-5 (ITGB5) were significantly upregulated, whereas cellular communication network factor 1 (CYR61, also known as CCN1), annexin A1 (ANXA1), and vimentin (VIM) were markedly downregulated following dietary intake of the plant.[122] The involvement of these proteins in carcinogenesis has been well documented. CYR61 is implicated in hormone and growth factor signaling and has been associated with poor prognosis in breast, colorectal, and prostate cancers.[124–126] ANXA1, a calcium-binding protein, plays a regulatory role in the arachidonic acid metabolic pathway and EGFR-mediated tyrosine kinase signaling, and it is frequently overexpressed during early stages of esophageal squamous cell carcinoma and adenocarcinoma.[127] Vimentin, a key marker of epithelial-mesenchymal transition (EMT), is closely linked to tumor progression, particularly in colorectal cancer.[128]

Tarin—a bioactive GNA-related lectin isolated from *C. esculenta*—has demonstrated antiviral, insecticidal, and immunomodulatory properties. It may also exert prophylactic and therapeutic effects on hematopoietic and cancer cells, reinforcing its potential as a multi-functional therapeutic agent.[122]

Taken together, these findings highlight the therapeutic relevance of *C. esculenta* and its active components in cancer prevention and treatment.

Toxicity Studies

Toxicological evaluations of *C. esculenta* extracts have been conducted to assess their safety profiles in both acute and sub-chronic settings. *C. esculenta* is widely consumed as a traditional carbohydrate-rich food.[27,90] Beyond its nutritional

value, this plant has also been reported to exhibit various pharmacological activities with potential therapeutic benefits. Therefore, toxicity studies are essential to ensure its safety for dietary and medicinal applications.

Toxicity evaluations of *C. esculenta* indicate that leaf doses up to 1000 mg/kg BW,[129] and tuber doses of 100–400 mg/kg BW are relatively safe in rats.[71] Higher doses, particularly in sub-chronic tests, can reduce body weight, affect liver and kidney organs, and alter hematological parameters and liver enzymes, indicating moderate toxic potential. Overall, *C. esculenta* is safe for consumption at moderate doses, but long-term high-dose administration should be cautiously approached. The following section provides a detailed account of the acute and sub-chronic toxicity assessments of the leaves and tubers of *C. esculenta*, including safe dosage ranges, effects on organ function, and alterations in hematological and biochemical parameters.

Acute toxicity tests reported by Oriyomi et al showed that a single-dose administration of the ethyl acetate fraction of *C. esculenta* leaf extract, collected from the Parks and Garden of Obafemi Awolowo University (OAU), Nigeria, at 10, 100, and 1000 mg/kg BW did not significantly change the signs of toxicity in test animals. However, animals that received higher doses of 1600, 2900, and 5000 mg/kg BW exhibited signs of toxicity. Assessments were performed every 4 hours for a total of 24 hours. Acute toxicity signs at a dose of ≥1600 mg/kg BW orally in rats indicated a no-observed-adverse-effect level (NOAEL) of ≤1000 mg/kg BW for the ethyl acetate fraction of *C. esculenta* leaf extract. However, the cumulative effect of this fraction did not result in mortality or tremors. Therefore, the fraction was considered biologically safe at an LD_{50} >5000 mg/kg BW.[41]

The sub-chronic toxicity test of the ethyl acetate fraction of *C. esculenta* leaf extract administered for 60 days showed a dose-dependent weight loss effect and a decrease in the viscera index (organ-to-body weight ratio) of the liver and kidneys, indicating possible organ toxicity at higher doses. A decrease in body weight and visceral index is a sensitive indicator of toxicity.[130] Additionally, there was an increase in the Atherogenic Risk Index (ARI) and Coronary Risk Index (CRI), as evidenced by changes in the lipid profile due to toxic expression. Hematological parameters showed an increase in red blood cells (RBC), white blood cells (WBC), lymphocytes, and mean corpuscular hemoglobin concentration (MCHC). Regarding liver enzymes, there was a decrease in total protein and albumin levels in the high-dose group. Furthermore, an increase in bilirubin, ALT, AST, urea, creatinine, and creatinine kinase levels was observed in the 1000 mg/kg BW dose group. These results suggest that the ethyl acetate fraction of *C. esculenta* leaf extract has moderate toxic potential.[38]

In another study, an acute toxicity test was conducted on fresh *C. esculenta* tubers purchased from a meat market in Abakaliki, Ebonyi, Nigeria. After an overnight fast, 2000 mg/kg of 50% aqueous ethanol extract of *C. esculenta* tuber was administered orally to a female rat, and physical or behavioral changes were observed for 30 minutes, then periodically every 4 hours for the next 24 hours, and daily thereafter for 14 days. After the first rat survived, four other female rats were recruited, fasted for 4 hours, administered the same dose of extract, and closely monitored for 14 days for signs of toxicity. The test showed no signs of toxicity or death in the animals; therefore, safe treatment doses for further testing were determined to be 100, 200, and 400 mg/kg BW.[36]

Metabolites and Their Mechanism of Action

C. esculenta is a plant known for its diverse pharmacological properties, attributed to its rich content of secondary metabolites such as saponins, flavonoids, alkaloids, tannins, terpenoids, and phenolic compounds.[14] These bioactive constituents exhibit a wide range of biological effects—including antibacterial,[50–52] anti-oxidant,[37,42] anti-inflammatory,[42,50,53,54] antihyperlipidemic,[71] and anticancer activities,[35,49,73]—through the modulation of various cellular targets and signaling pathways.

The antibacterial potential of *C. esculenta* is primarily mediated by compounds that disrupt the structural and functional integrity of bacterial cells. Saponins increase the permeability of the bacterial cell wall, leading to cell lysis.[56] Flavonoids interact with bacterial proteins and nucleic acids, causing denaturation and inhibition of metabolic processes, in addition to disrupting cell membrane synthesis.[131] Tannins exert antimicrobial action by inhibiting protein synthesis essential for cell wall formation, resulting in membrane contraction and cell death.[132] Alkaloids interfere with peptidoglycan synthesis in bacterial walls, weakening the structural support and causing cell death.[133] Terpenoids further contribute by damaging the bacterial outer membrane and altering permeability, which deprives bacteria of essential

nutrients and inhibits growth.[134] These mechanisms collectively highlight the multifaceted antibacterial actions of *C. esculenta* metabolites.

Many of these compounds—particularly flavonoids, phenolic acids, and tannins—are potent antioxidants. They neutralize free radicals and chelate pro-oxidant metal ions, thereby reducing oxidative stress, which is a key factor in the pathogenesis of many chronic diseases. The antioxidant activity of *C. esculenta* has been linked to its high polyphenol contents, including catechins, kaempferol, caffeic acid, rutin, quercitrin, ellagic acid, quercetin, and chlorogenic acid.[135] Studies on leaf extracts have shown strong radical scavenging capacity, attributed to high total phenolic and flavonoid content, as indicated by low IC_{50} values.[136] Moreover, LC-MS analysis of ethanol extracts from *C. esculenta* leaves has revealed the presence of eight polyphenols: quercetin, kaempferol, gallic acid, caffeic acid, luteolin-7-rutinoside, chlorogenic acid, vitexin, and rutin.[37]

The antioxidant properties of *C. esculenta* are mechanistically linked to its antihyperlipidemic effects. Oxidative stress plays a pivotal role in lipid peroxidation and the development of atherosclerosis. By reducing oxidative damage,

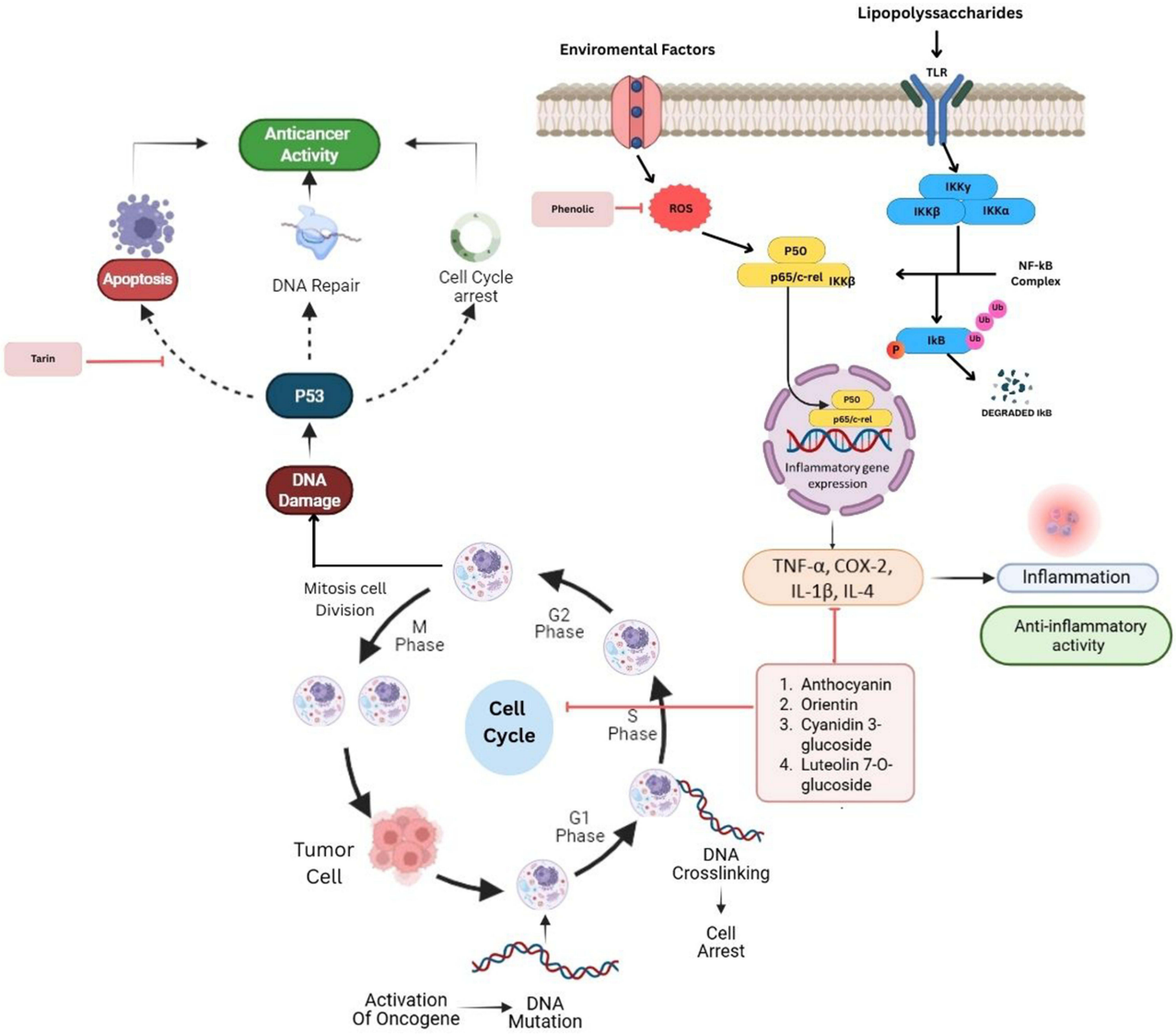

Figure 3 Mechanisms of anti-inflammatory and anticancer activities of bioactive metabolites in *Colocasia esculenta*, created using Biorender (https://www.biorender.com/) and combined in Canva (https://www.canva.com/).

Abbreviations: COX-2, cyclooxygenase-2; DNA, deoxyribonucleic acid; IkB, IkappaB; IKKβ, IkappaB kinase beta; IL-1β, interleukin-1β; IL-4, interleukin-4; M phase, mitosis phase, which refers to a phase when the cell divides its nucleus and its cytoplasm (cytokinesis) to form two distinct daughter cells; G2 phase, gap 2 phase, which refers to a phase when the cell continues to grow, synthesizes proteins, and prepares for the next M phase.

https://doi.org/10.2147/JEP.S550113

polyphenols in *C. esculenta* help lower total cholesterol, LDL, VLDL, and triglyceride levels, while simultaneously increasing HDL levels.[98,137] This lipid-modulating effect not only improves lipid metabolism but also contributes to the prevention of cardiovascular complications, particularly in conditions such as diabetes mellitus, where hyperlipidemia is a common metabolic disturbance.

These antioxidant and lipid-regulating mechanisms also intersect with the anti-inflammatory potential of plants. Oxidative stress and inflammation are tightly interlinked, with ROS capable of activating pro-inflammatory transcription factors such as NF-κB. *C. esculenta* flavonoids, anthocyanins (eg, cyanidin 3-glucoside), and other polyphenols have been shown to inhibit the activation of NF-κB and MAPK signaling pathways, thereby suppressing the expression of inflammatory mediators including TNF-α, IL-6, IL-1β, COX-2, and iNOS.[53,138,139] Compounds such as orientin and isoorientin further enhance this effect by modulating cytokine levels and reducing nitric oxide production. These mechanisms highlight how the anti-inflammatory activity of *C. esculenta* is closely related to its antioxidant function, forming a synergistic defense mechanism against chronic inflammation.[37,42,140]

In addition to mitigating inflammation, *C. esculenta* has shown promising anticancer activity by modulating apoptosis and immune function. Bioactive constituents such as tarin (a GNA-related lectin), flavonoids, and isoorientin activate the intrinsic mitochondrial apoptotic pathway, increasing the Bax/Bcl-2 ratio, promoting cytochrome c release, and triggering the activation of caspases-3 and −9.[141] This apoptotic signaling leads to the programmed death of cancer cells. Concurrently, the suppression of proliferative pathways such as PI3K/Akt and MAPK further reinforces the antiproliferative effects. Moreover, tarin enhances natural killer (NK) cell activity and stimulates the release of cytokines such as interferon (IFN)-γ, thereby augmenting antitumor immunity and contributing to the chemopreventive properties of plants.[47,123]

Taken together, the pharmacological activities of *C. esculenta* are interconnected at the molecular level. Its bioactive compounds exert antibacterial, antioxidant, anti-inflammatory, antihyperlipidemic, and anticancer effects through mechanisms involving the disruption of microbial integrity, neutralization of oxidative stress, modulation of inflammatory signaling, and induction of apoptosis. The mechanisms underlying the anti-inflammatory and anticancer activities of bioactive metabolites in *C. esculenta* are presented in Figure 3. These findings highlight *C. esculenta* as a promising candidate for the development of multi-targeted therapeutic agents for chronic diseases.

Conclusion

Our findings indicate that *C. esculenta* possesses a wide range of pharmacological properties under both in vitro and in vivo conditions, with antioxidant and anti-inflammatory activities being the most commonly observed. This suggests its potential against various diseases such as cancer, diabetes, coronary heart disease, and other diseases that are primarily caused by oxidative stress. These observations also support the safety of *C. esculenta*, as it has undergone acute and subchronic toxicity testing in animal models. Furthermore, anticancer observations using healthy human blood have demonstrated that *C. esculenta* has potential for clinical research in patients with cancer. *C. esculenta* contains a variety of bioactive molecules with significant potential as anti-inflammatory, antioxidant, metabolic-regulating, and anticancer agents, through the modulation of pro-inflammatory pathways, such as iNOS and COX-2. Based on toxicity studies, leaf doses up to 1000 mg/kg BW and tuber doses of 100–400 mg/kg BW in animals were considered relatively safe, indicating that moderate consumption can be considered safe. However, more in-depth molecular studies (in vitro, in vivo, and molecular biology) are needed to elucidate the specific protein-compound interactions and their pharmacodynamic effects.

Acknowledgments

The authors gratefully acknowledge the Rector of Universitas Padjadjaran, West Java, Indonesia, for supporting this publication's article processing charge (APC). This study was conducted as a component of the first author's dissertation at the Doctoral Program in Pharmacy, Faculty of Pharmacy, Universitas Padjadjaran, West Java, Indonesia. The first author also sincerely thanks the Indonesian Education Scholarship (Beasiswa Pendidikan Indonesia), the Center for Higher Education Funding and Assessment, the Ministry of Higher Education, Science, and Technology of Republic Indonesia, and the Indonesia Endowment Fund for Education (LPDP) for supporting the doctoral studies.

Disclosure

The authors declare no conflicts of interest related to this work.

References

1. World Health Organization. *WHO Monographs on Selected Medicinal Plants*. Vol. 1. Geneva, Switzerland: World Health Organization; 1999.
2. Otekunrin OA, Sawicka B, Adeyonu AG, Otekunrin OA, Rachoń L. Cocoyam [colocasia esculenta (L.) Schott]: exploring the production, health and trade potentials in Sub-Saharan Africa. *Sustainability*. 2021;13(8):4483. doi:10.3390/su13084483
3. Grimaldi IM, Muthukumaran S, Tozzi G, et al. Literary evidence for taro in the ancient mediterranean: a chronology of names and uses in a multilingual world. *PLoS One*. 2018;13(6):e0198333. doi:10.1371/journal.pone.0198333
4. Sharma S, Jan R, Kaur R, Riar CS. Taro (Colocasia esculenta). In: Nayik GA, Gull A editors. *Antioxidants in Vegetables and Nuts: Properties and Health Benefits*. Springer; 2020:1–14. doi:10.1007/978-981-15-7470-2_18
5. Oktavianingsih L, Suharyanto E, Daryono BS, Purnomo, Purnomo P. Traditional usages of taro (Colocasia spp.) by ethnic communities in Borneo. *Biosaintifika*. 2017;9(2):248–256. doi:10.15294/biosaintifika.v9i2.9956
6. World Flora Online. Colocasia esculenta (Schott L). 2025. Available from: http://www.worldfloraonline.org/taxon/wfo-0000917419. Accessed September 4, 2025.
7. Rojas-Sandoval J, Acevedo-Rodríguez P. Colocasia esculenta (taro). *CABI Compendium*. 2022. doi:10.1079/cabicompendium.17221
8. Ahmed I, Lockhart PJ, Agoo EMG, et al. Evolutionary origins of taro (Colocasia esculenta) in Southeast Asia. *Ecol Evol*. 2020;10(23):13530–13543. doi:10.1002/ece3.6958
9. Borelli T, Keim A, Sujarwo W, et al. Invisible treasures: assessing Indonesia's unique agrobiodiversity for food and nutrition security. *Sustainability*. 2024;16(22):9824. doi:10.3390/su16229824
10. Paudel R, Bartlett B, Zamora CM, et al. Breeding and selection of taro (Colocasia esculenta) for improved disease-resistance in Hawaii. *Plant Pathol*. 2022;71(6):1472–1485. doi:10.1002/ppp3.10335
11. Saxby S, Lee C, Li Y. Nutritional, physicochemical, and functional properties of five varieties of taro (Colocasia esculenta). *Curr Dev Nutr*. 2021;5(Suppl 2):607. doi:10.1093/cdn/nzab044_038
12. Brandão NA, Tagliapietra BL, Clerici MTPS. Taro [*Colocasia esculenta* (L.) Schott]: a critical review of its nutritional value and potential for food application. *Food Sci Technol*. 2023;43. doi:10.5327/fst.00118
13. Rashmi DR, Raghu N, Gopenath TS, et al. Taro (*Colocasia esculenta*): an overview. *J Med Plants Stud*. 2018;6(4):156–161.
14. Samadder M, Rahman S, Huda KT, Hossain MA, Patwary MA, Yasin M. Antioxidant and antimicrobial prospects of Colocasia esculenta stolon: a phytochemical perspective. *Discover Food*. 2025;5(1). doi:10.1007/s44187-025-00317-6
15. El-Mesallamy AM, El-Tawil NA, Ibrahim SA, Hussein SAM. Phenolic profile: antimicrobial activity and antioxidant capacity of *Colocasia Esculenta* (L.) Schott. *Egypt J Chem*. 2021;64(4):2165–2172. doi:10.21608/EJCHEM.2021.56495.3213
16. Ferdaus MJ, Chukwu-Munsen E, Foguel A, da Silva RC. Taro roots: an underexploited root crop. *Nutrients*. 2023;15(15):3337. doi:10.3390/nu15153337
17. Martín MÁ, Ramos S. Dietary flavonoids and insulin signaling in diabetes and obesity. *Cells*. 2021;10(6):1474. doi:10.3390/cells10061474
18. Chakraborty P, Abraham J, Deb P, Chakraborty S, Chatterjee B. Cytotoxicity and antimicrobial activity of *Colocasia esculenta*. *J Chem Pharm Res*. 2015;7(12):627–635.
19. Mitharwal S, Kumar A, Chauhan K, Taneja NK. Nutritional, phytochemical composition and potential health benefits of taro (*Colocasia esculenta* L.) leaves: a review. *Food Chem*. 2022;383(February):132406. doi:10.1016/j.foodchem.2022.132406
20. Okechukwu KE, Sampson Ogah U. Phytochemical, vitamins and toxic level of processed cocoyam (Colocasia esculenta [L.] Schott) inflorescence. *MOJ Food Process Technol*. 2023;11(2):116–128. doi:10.15406/mojfpt.2023.11.00289
21. Lad SS, Kolhe SU, Devade OA, Patil CN, Nalawade RD, Rode MR. A review on medicinal properties of *Colocasia esculenta* Linn. *Res J Pharmacol Pharmacodyn*. 2023;15(3):144–148. doi:10.52711/2321-5836.2023.00026
22. Prajapati R, Kalariya M, Umbarkar R, Parmar S, Sheth N. *Colocasia esculenta*: a potent indigenous plant. *Int J Nutr Pharmacol Neurol Dis*. 2011;1(2):90–96. doi:10.4103/2231-0738.84188
23. Krishnapriya TV, Suganthi A. Biochemical and phytochemical analysis of *Colocasia esculenta* (L.) Schott tubers. *Int J Res Pharm Pharm Sci*. 2017;2(3):21–25.
24. Islam ATMR, Hasan M, Islam T, Rahman A, Mitra S, Das SK. Ethnobotany of medicinal plants used by rakhine indigenous communities in Patuakhali and Barguna District of Southern Bangladesh. *J Evid Based Integr Med*. 2021;25. doi:10.1177/2515690X20971586
25. Yu JG, Zhang Y, Zhong X, et al. Itches—stimulating compounds from *Colocasia esculenta* (taro): bioactive-guided screening and LC–MS/MS identification. *Bioorg Med Chem Lett*. 2015;25(20):4382–4386. doi:10.1016/j.bmcl.2015.09.023
26. Matthews PJ, Nguyen VD, Tandang D, Agoo EM, Madulid DA. Taxonomy and Ethnobotany of *Colocasia esculenta* and *C. formosana* (Araceae): implications for the evolution, natural range, and domestication of taro. *Aroideana*. 2015;38E(1):153–176.
27. Lebot V. Tropical root and tuber crops: cassava, sweet potato, yams, aroids. 2nd Edition. 2008.
28. Hay A. Aroids of Papua New Guinea. 1990;120.
29. Kuruvilla KM, Singh A. Karyotypic and electrophoretic studies on taro and its origin. *Euphytica*. 1981;30(2):405–413. doi:10.1007/BF00034004
30. Mace ES, Godwin ID. Development and characterization of polymorphic microsatellite markers in taro (Colocasia esculenta). *Genome*. 2002;45(5):823–832. doi:10.1139/g02-045
31. Sudhakar P, Thenmozhi V, Srivignesh S, Dhanalakshmi M. Colocasia esculenta (L.) Schott: pharmacognostic and pharmacological review. *J Pharmacognosy Phytochem*. 2020;9(4):1382–1386. doi:10.22271/phyto.2020.v9.i4s.11937
32. Zubair MW, Imran A, Islam F, et al. Functional profile and encapsulating properties of Colocasia esculenta (Taro). *Food Sci Nutr*. 2023;11(6):2440–2449. doi:10.1002/fsn3.3357
33. Temesgen M. Nutritional potential, health and food security benefits of taro *Colocasia esculenta* (L.): a review. *Food Science and Quality Management*. 2015;36:23–31.

34. Ogukwe CE, Amaechi PC, Enenebeaku CK. Studies on the flowers and stems of two cocoyam varieties: xanthosoma sagittifolium and Colocasia esculenta. *Nat Prod Chem Res*. 2017;5(3):263. doi:10.4172/2329-6836.1000263
35. Esposito T, Pisanti S, Mauro L, Mencherini T, Martinelli R, Aquino RP. Activity of *Colocasia esculenta* (Taro) corms against gastric adenocarcinoma cells: chemical study and molecular characterization. *Int J Mol Sci*. 2024;25(1). doi:10.3390/ijms25010252
36. Eleazu K, Maduabuchi Aja P, Eleazu CO. Cocoyam (*Colocasia esculenta*) modulates some parameters of testosterone propionate-induced rat model of benign prostatic hyperplasia. *Drug Chem Toxicol*. 2022;45(5):1923–1933. doi:10.1080/01480545.2021.1892956
37. Varghese VJ, Nair ARK, Joseph E. Comparative antioxidant and phytochemical evaluation of selected varieties of *C. esculenta* (L.) Schott leaves. *Int J Pharmaceutical Sci Drug Res*. 2024;16(3):370–377. doi:10.25004/ijpsdr.2024.160308
38. Mohammad M, Hossain MR, Hasan MM, et al. A novel insight into the anti-diabetic and diuretic potentials of the *Colocasia esculenta* L. (Taro) vegetable flower extract accentuating its ethnobotanical importance. *Pharmacol Res Nat Prod*. 2025;6. 100177. doi:10.1016/j.prenap.2025.100177
39. Khazaal HT, Khazaal MT, Abdel-Razek AS, et al. Antimicrobial, antiproliferative activities and molecular docking of metabolites from alternaria alternata. *AMB Express*. 2023;13(1):1–19. doi:10.1186/s13568-023-01568-1
40. Khazaal HT, El-Sayed EK, Mansour YE, et al. Neuroprotective activity of Colocasia esculenta (L.) Schott leaves against monosodium glutamate-induced excitotoxicity in rats: phytochemical and molecular docking study. *Nat Prod Res*. 2025;.1–40. doi:10.1080/14786419.2024.2340061
41. Oriyomi VO, Fagbohun OF, Akinola FT, Adekola MB, Oyedeji TT. Assessment of *Colocasia esculenta* leaf extract as a natural alternative for Sitophilus zeamais control: toxicological, biochemical, and mechanistic insights. *Pestic Biochem Physiol*. 2023;195:105545. doi:10.1016/j.pestbp.2023.105545
42. Shrivastava AK, Keshari M, Neupane M, et al. Evaluation of antioxidant and anti-inflammatory activities, and metabolite profiling of selected medicinal plants of Nepal. *J Trop Med*. 2023;2023:1–15. doi:10.1155/2023/6641018
43. Eleazu CO. Characterization of the natural products in cocoyam (*Colocasia esculenta*) using GC–MS. *Pharm Biol*. 2016;54(12):2880–2885. doi:10.1080/13880209.2016.1190383
44. Rajashekar Y, Tonsing N, Shantibala T, Manjunath JR. 2, 3-Dimethylmaleic anhydride (3, 4-Dimethyl-2, 5-furandione): a plant derived insecticidal molecule from Colocasia esculenta var. esculenta (L.) Schott. *Sci Rep*. 2016;6(1):1–7. doi:10.1038/srep20546
45. Gupta K, Kumar A, Tomer V, Kumar V, Saini M. Potential of Colocasia leaves in human nutrition: review on nutritional and phytochemical properties. *J Food Biochem*. 2019;43(7):e12878. doi:10.1111/jfbc.12878
46. Talang H, Mawlong GT, Kjam L, et al. Assessment of nutritional quality of taro (Colocasia esculenta L. Schott.) genotypes of the Eastern Himalaya, India. *Front Nutr*. 2025;12:1567829. doi:10.3389/fnut.2025.1567829
47. Ventura S, l OV, White CW, Xie JH, Haynes JM, Exintaris B. Novel drug targets for the pharmacotherapy of benign prostatic hyperplasia (BPH). *Br J Pharmacol*. 2011;163(5):891–907. doi:10.1111/j.1476-5381.2011.01332.x
48. Tusubira D, Aja PM, Munezero J, et al. Safety profile of colocasia esculenta tuber extracts in benign prostate hyperplasia. *BMC Complement Med Ther*. 2023;23(1):1–13. doi:10.1186/s12906-023-04018-4
49. Anna CNTFC, Vericimo MA, Dashevskiy A, Pereira PR, Paschoalin VMF. Liposomal taro lectin nanocapsules control human glioblastoma and mammary adenocarcinoma cell proliferation. *Molecules*. 2019;24(3). doi:10.3390/molecules24030471
50. Moon SH, Ji SH, Son JL, et al. Antibacterial, anti-inflammatory, and anti-osteoclastogenic activities of *Colocasia antiquorum var. Esculenta*: potential applications in preventing and treating periodontal diseases. *Dent Mater J*. 2020;39(6):1096–1102. doi:10.4012/dmj.2020-157
51. Moon SH, Shin SJ, Tae HJ, Oh SH, Bae JM. Effects of *Colocasia antiquorum var. Esculenta* extract in vitro and in vivo against periodontal disease. *Medicina*. 2021;57(10). doi:10.3390/medicina57101054
52. Wardhani RAK, Asri LATW, Rachmawati H, Khairurrijal K, Purwasasmita BS. Physical–chemical crosslinked electrospun colocasia esculenta tuber protein–chitosan–poly (Ethylene oxide) nanofibers with antibacterial activity and cytocompatibility. *Int J Nanomed*. 2020;15:6433–6449. doi:10.2147/IJN.S261483
53. Baro MR, Das M, Kalita A, Das B, Sarma K. Exploring the anti-inflammatory potential of *Colocasia esculenta* root extract in in-vitro and in-vivo models of inflammation. *J Ethnopharmacol*. 2023;303(September 2022):116021. doi:10.1016/j.jep.2022.116021
54. Anwar M, Mros S, McConnell M, Bekhit AEDA. Effects of taro (*Colocasia esculenta*) water-soluble non-starch polysaccharide, lactobacillus acidophilus, bifidobacterium breve, bifidobacterium infantis, and their synbiotic mixtures on pro-inflammatory cytokine interleukin-8 production. *Nutrients*. 2022;14(10):2128. doi:10.3390/nu14102128
55. Kundu N, Campbell P, Hampton B, et al. Antimetastatic activity isolated from Colocasia esculenta (taro). *Anticancer Drugs*. 2012;23(2):200–211. doi:10.1097/CAD.0b013e32834b85e8
56. Arabski M, Węgierek-Ciuk A, Czerwonka G, Lankoff A, Kaca W. Effects of saponins against clinical E. coli strains and eukaryotic cell line. *J Biomed Biotechnol*. 2012;2012:1–6. doi:10.1155/2012/286216
57. Agyare C, Boakye YD. Antimicrobial and anti-inflammatory properties of anchomanes difformis (Bl.) Engl. and Colocasia esculenta (L.) Schott. *Biochem Pharmacol*. 2015;05(01). doi:10.4172/2167-0501.1000201
58. Shields AM, Klavinskis LS, Antoniou M, et al. Systemic gene transfer of binding immunoglobulin protein (BiP) prevents disease progression in murine collagen-induced arthritis. *Clin Exp Immunol*. 2015;179(2):210–219. doi:10.1111/cei.12456
59. Gupta K, Kumar A, Tomer V, Kumar V, Saini M. Potential of Colocasia leaves in human nutrition: review on nutritional and phytochemical properties. *J Food Biochem*. 2019;43(7):1–16. doi:10.1111/jfbc.12878
60. Jiang Y, Yu L, Wang MH. N-trans-feruloyltyramine inhibits LPS-induced NO and PGE2 production in RAW 264.7 macrophages: involvement of AP-1 and MAP kinase signalling pathways. *Chem Biol Interact*. 2015;235:56–62. doi:10.1016/j.cbi.2015.03.029
61. Fujiwara T, Kanazawa S, Ichibori R, et al. L-Arginine stimulates fibroblast proliferation through the GPRC6A-ERK1/2 and PI3K/Akt pathway. *PLoS One*. 2014;9(3):e92168. doi:10.1371/journal.pone.0092168
62. Friess W. Collagen–biomaterial for drug delivery. *Eur J Pharm Biopharm*. 1998;45(2):113–136. doi:10.1016/S0939-6411(98)00017-452
63. Guo S, DiPietro LA. Factors affecting wound healing. *J Dent Res*. 2010;89(3):219–229. doi:10.1177/0022034509359125
64. Talang H, Devi HM, Laskar MA, et al. Assessment of nutritional quality of taro (*Colocasia esculenta* L. Schott.) genotypes of the Eastern Himalaya, India. *Front Nutr*. 2025;12:1567829. doi:10.3389/fnut.2025.1567829

65. Mba CJ, Agu HO. Developments on the bioactive compounds and food uses of the tubers: colocasia esculenta (L.) Schott (Taro) and Xanthosoma sagittifolium (L.) Schott (Tannia). *Asian Food Sci J*. 2021;20(11):101–112. doi:10.9734/afsj/2021/v20i1130380
66. Rabiu I, Yusha'u M, Abdullahi JI, Muhammed A. Phytochemical analysis, thin layer chromatography and gas chromatography–mass spectroscopy profile of Colocasia esculenta and manihot esculanta extracts and their potential for drug discovery. *Drug Discovery*. 2024;18(41): e10dd1975. doi:10.54905/disssi.v18i41.e10dd1975
67. Kumar R, Saha P, Kumar Y, et al. A review on diabetes mellitus: type 1 & type 2. *World J Pharm Pharm Sci*. 2020;9(10):838–850. doi:10.20959/wjpps202010-17336
68. Proença C, Ribeiro D, Freitas M, Fernandes E. Flavonoids as potential agents in the management of type 2 diabetes through the modulation of α-amylase and α-glucosidase activity: a review. *Crit Rev Food Sci Nutr*. 2022;62(12):3137–3207. doi:10.1080/10408398.2020.1862755
69. Zhu J, Chun C, Bin Z, Huang Q. The inhibitory effects of flavonoids on α-amylase and α-glucosidase. *Crit Rev Food Sci Nutr*. 2020;60(4):695–708. doi:10.1080/10408398.2018.1548428
70. Kumawat NS, Chaudhari SP, Wani NS, Deshmukh TA, Patil VR. Antidiabetic activity of ethanol extract of *Colocasia esculenta* leaves in alloxan-induced diabetic rats. *Int J Pharmtech Res*. 2010;2(2):1246–1249.
71. Eleazu CO, Eleazu KC, Iroaganachi MA. Effect of cocoyam (*Colocasia esculenta*), unripe plantain (*Musa paradisiaca*) or their combination on glycated hemoglobin, lipogenic enzymes, and lipid metabolism of streptozotocin-induced diabetic rats. *Pharm Biol*. 2016;54(1):91–97. doi:10.3109/13880209.2015.1016181
72. Tusubira D, Munezero J, Agu PC, et al. In-vivo and in-silico studies revealed the molecular mechanisms of Colocasia esculenta phenolics as novel chemotherapy against benign prostatic hyperplasia via inhibition of 5α-reductase and α1-adrenoceptor. *Silico Pharmacol*. 2023;11(1):1–15. doi:10.1007/s40203-023-00141-9
73. Kundu N, Ma X, Hoag S, et al. An extract of Taro (Colocasia esculenta) mediates potent inhibitory actions on metastatic and cancer stem cells by tumor cell-autonomous and immune-dependent mechanisms. *Breast Cancer*. 2021:15. doi:10.1177/11782234211034937
74. Obsa Terfa T, Abera Kebede F, Kitessa Beyene M, Tesfaye Abebe T, Basazn Mekuria A, Seid Yesuf J. Evaluation of in vivo antidiarrheal activities of 80% methanol extract and solvent fractions of peels of Colocasia esculenta (Araceae). *Evid Based Complement Alternat Med*. 2024;2024(1). doi:10.1155/2024/2728282
75. Azubuike NC, Onwukwe OS, Onyemelukwe AO, et al. Impact of Colocasia esculenta extract and fractions on high-fat diet-induced changes in body weight, adipose tissue and liver of rats. *Pak J Pharm Sci*. 2018;31(5):2143–2148.
76. Shin SJ, Moon SH, Kim HJ, Oh SH, Bae JM. Oral microbiome using *Colocasia antiquorum* var. *esculenta* extract varnish in a mouse model with oral gavage of *P. gingivalis* ATCC 53978. *Medicina (Kaunas)*. 2022;58(4):506. doi:10.3390/medicina58040506
77. Vela-Gutiérrez G, Velázquez López AA, Tacias Pascacio VG, Vidal López DG, León García E, De La Cruz Medina J. Effect of heat treatment on oxalate and hydrocyanic acid levels of malanga corms of two cultivars (Xanthosoma sagittifolium and Colocasia esculenta) in a murine model. *J Food Sci Technol*. 2022;59(1):220–227. doi:10.1007/s13197-021-05004-9
78. Kalariya M, Prajapati R, Parmar SK, Sheth N. Effect of hydroalcoholic extract of leaves of Colocasia esculenta on marble-burying behavior in mice: implications for obsessive-compulsive disorder. *Pharm Biol*. 2015;53(8):1239–1242. doi:10.3109/13880209.2015.1014923
79. Omotoso A, Maduabuchi Ezealisiji K, Abayomi OE, Kenneth E, MK I. Chemometric profiling of methanolic leaf extract of Cnidoscolus aconitifolius (Euphorbiaceae) using UV-VIS, FTIR and GC-MS techniques. *Peak J Med Plant Res*. 2014;2(1):6–12.
80. Pereira PR, Silva JT, Verícimo MA, Paschoalin VMF, Teixeira GAPB. Crude extract from taro (Colocasia esculenta) as a natural source of bioactive proteins able to stimulate haematopoietic cells in two murine models. *J Funct Foods*. 2015;18:333–343. doi:10.1016/j.jff.2015.07.014
81. Brown AC, Reitzenstein JE, Liu J, Jadus MR. The anti-cancer effects of poi (Colocasia esculenta) on colonic adenocarcinoma cells in vitro. *Phytother Res*. 2005;19(9):767–771. doi:10.1002/ptr.1712
82. Russo M, Coppola V, Giannetti E, Buonavolontà R, Piscitelli A, Staiano A. Oral administration of tannins and flavonoids in children with acute diarrhea: a pilot, randomized, control-case study. *Ital J Pediatr*. 2018;44(1):4–9. doi:10.1186/s13052-018-0497-6
83. Bonelli F, Turini L, Sarri G, Serra A, Buccioni A, Mele M. Oral administration of chestnut tannins to reduce the duration of neonatal calf diarrhea. *BMC Vet Res*. 2018;14(1):4–9. doi:10.1186/s12917-018-1549-2
84. Kang DW, Choi SC, Kang JE, Park JS, Lee IA. The anti-inflammatory effect of Colocasia esculenta water extract on mouse ear edema models induced by TPA. *J People Plants Environ*. 2021;24(1):53–62. doi:10.11628/ksppe.2021.24.1.53
85. Han LK, Zheng YN, Yoshikawa M, Okuda H, Kimura Y. Anti-obesity effects of chikusetsusaponins isolated from Panax japonicus rhizomes. *BMC Complement Altern Med*. 2005;5(1):1–10. doi:10.1186/1472-6882-5-9
86. Han LK, Takaku T, Li J, Kimura Y, Okuda H. Anti-obesity action of oolong tea. *Int J Obes*. 1999;23(1):98–105. doi:10.1038/sj.ijo.0800766
87. Portillo MP, Simón E, García-Calonge MA, Del Barrio AS. Effect of high-fat diet on lypolisis in isolated adipocytes from visceral and subcutaneous WAT. *Eur J Nutr*. 1999;38(4):177–182. doi:10.1007/s003940050059
88. Yun JW. Possible anti-obesity therapeutics from nature - A review. *Phytochemistry*. 2010;71(14–15):1625–1641. doi:10.1016/j.phytochem.2010.07.011
89. Browning JD, Horton JD, Browning JD, Horton JD. Molecular mediators of hepatic steatosis and liver injury Find the latest version: molecular mediators of hepatic steatosis and liver injury. *J Clin Invest*. 2004;114(2):147–152. doi:10.1172/JCI200422422.The
90. Huang CC, Chen WC, Wang CCR. Comparison of Taiwan paddy- and upland-cultivated taro (Colocasia esculenta L.) cultivars for nutritive values. *Food Chem*. 2007;102(1):250–256. doi:10.1016/j.foodchem.2006.04.044
91. Yadav UCS, Moorthy K, Baquer NZ. Effects of sodium-orthovanadate and Trigonella foenum-graecum seeds on hepatic and renal lipogenic enzymes and lipid profile during alloxan diabetes. *J Biosci*. 2004;29(1):81–91. doi:10.1007/BF02702565
92. Cosson E, Chiheb S, Cussac-Pillegand C, et al. Haemoglobin glycation may partly explain the discordance between HbA1c measurement and oral glucose tolerance test to diagnose dysglycaemia in overweight/obese subjects. *Diabetes Metab*. 2013;39(2):118–125. doi:10.1016/j.diabet.2012.08.013
93. Randle PJ, Priestman DA, Mistry SC, Halsall A. Glucose fatty acid interactions and the regulation of glucose disposal. *J Cell Biochem*. 1994;55 (S1994A):1–11. doi:10.1002/jcb.240550002
94. Baek EJ, Kim S. Current understanding of pressure natriuresis. *Electrolyte Blood Pressure*. 2021;19(2):38–45. doi:10.5049/EBP.2021.19.2.38
95. Ellison DH, Felker GM. Diuretic Treatment in Heart Failure. *N Engl J Med*. 2017;377(20):1964–1975. doi:10.1056/nejmra1703100

96. Palmer BF, Clegg DJ. Physiology and pathophysiology of potassium homeostasis. *Adv Physiol Educ*. 2016;40(4):480–490. doi:10.1152/advan.00121.2016
97. Oyedepo TA, Palai S. Herbal remedies, toxicity, and regulations. In: *Preparation of Phytopharmaceuticals for the Management of Disorders: the Development of Nutraceuticals and Traditional Medicine*. 2021:89–127. doi:10.1016/B978-0-12-820284-5.00014-9
98. Iqbal I, Wilairatana P, Saqib F, et al. Plant polyphenols and their potential benefits on cardiovascular health: a review. *Molecules*. 2023;28(17):6403. doi:10.3390/molecules28176403
99. Supuran CT, Temperini C, Cecchi A, et al. Carbonic anhydrase inhibitors. sulfonamide diuretics revisited—old leads for new applications? *Org Biomol Chem*. 2008;6(14):2499–2506. doi:10.1039/B800767E
100. Nelson RH. Hyperlipidemia as a risk factor for cardiovascular disease. *Prim Care*. 2013;40(1):195–211. doi:10.1016/j.pop.2012.11.003
101. Merzouk H, Madani S, Sari DC, Prost J, Bouchenak M, Belleville J. Time course of changes in serum glucose, insulin, lipids and tissue lipase activities in macrosomic offspring of rats with streptozotocin-induced diabetes. *Clin Sci*. 2000;98(1):21–30. doi:10.1042/cs0980021
102. Mustapha IZ, Debrey S, Oladubu M, Ugarte R. Markers of systemic bacterial exposure in periodontal disease and cardiovascular disease risk: a systematic review and meta-analysis. *J Periodontol*. 2007;78(12):2289–2302. doi:10.1902/jop.2007.070140
103. Sim S, Kim H, Moon J, et al. Periodontitis and the risk for non-fatal stroke in Korean Adults. *J Periodontol*. 2008;79(9):1652–1658. doi:10.1902/jop.2008.080015
104. Yang Y, Liu S, Wang Y, et al. Changes of saliva microbiota in the onset and after the treatment of. *Aging*. 2020;12(13):13090–13114. doi:10.18632/aging.103399
105. Willis JR, Gabaldón T. The human oral microbiome in health and disease: from sequences to ecosystems. *Microorganisms*. 2020;8(2):1–28. doi:10.3390/microorganisms8020308
106. D'Aiuto F, Parkar M, Brett PM, Ready D, Tonetti MS. Gene polymorphisms in pro-inflammatory cytokines are associated with systemic inflammation in patients with severe periodontal infections. *Cytokine*. 2004;28(1):29–34. doi:10.1016/j.cyto.2004.06.005
107. Prajapati R, Kalariya M, Umbarkar R, Parmar S, Sheth N. Colocasia esculenta: a potent indigenous plant. *Int J Nutr Pharmacol Neurol Dis*. 2011;1(2):90. doi:10.4103/2231-0738.84188
108. Park HR, Lee HS, Cho SY, Kim YS, Shin KS. Anti-metastatic effect of polysaccharide isolated from Colocasia esculenta is exerted through immunostimulation. *Int J Mol Med*. 2013;31(2):361–368. doi:10.3892/ijmm.2012.1224
109. Vinegar R, Schreiber W, Hugo R. Biphasic development of carrageenin edema in rats. *J Pharmacol Exp Ther*. 1969;166(1):96–103. doi:10.1016/S0022-3565(25)28209-X
110. Crunkhorn P, Meacock SCR. Mediators of the inflammation induced in the rat paw by carrageenin. *Br J Pharmacol*. 1971;42(3):392–402. doi:10.1111/j.1476-5381.1971.tb07124.x
111. Akhtar MS, Israr B, Bhatty N, Ali A. Effect of cooking on soluble and insoluble oxalate contents in selected Pakistani vegetables and beans. *Int J Food Prop*. 2011;14(1):241–249. doi:10.1080/10942910903326056
112. Pérez EE, Gutiérrez ME, De Delahaye EP, Tovar J, Lares M. Production and characterization of Xanthosoma sagittifolium and Colocasia esculenta flours. *J Food Sci*. 2007;72(6). doi:10.1111/j.1750-3841.2007.00420.x
113. Boakye AA, Wireko-Manu FD, Oduro I, Ellis WO, Gudjónsdóttir M, Chronakis IS. Utilizing cocoyam (Xanthosoma sagittifolium) for food and nutrition security: a review. *Food Sci Nutr*. 2018;6(4):703–713. doi:10.1002/fsn3.602
114. Rasmussen SA, Eisen JL. The epidemiology and clinical features of obsessive–compulsive disorder. *Psychiatr Clin North Am*. 1992;15(4):743–758. doi:10.1016/S0193-953X(18)30205-3
115. Hartmann A, Hunot S, Michel PP, et al. Caspase-3: a vulnerability factor and final effector in apoptotic death of dopaminergic neurons in Parkinson's disease. *Proc Natl Acad Sci U S A*. 2000;97(6):2875–2880. doi:10.1073/pnas.040556597
116. Maren TH. Use of inhibitors in physiological studies of carbonic anhydrase. *Am J Physiol Renal Physiol*. 1977;232(4):F291–F297. doi:10.1152/ajprenal.1977.232.4.F291
117. Millan MJ, Dekeyne A, Papp M, et al. S33005, a novel ligand at both serotonin and norepinephrine transporters: II. behavioral profile in comparison with venlafaxine, reboxetine, citalopram, and clomipramine. *J Pharmacol Exp Ther*. 2001;298(2):581–591. doi:10.1016/S0022-3565(24)29416-7
118. Njung'e K, Handley SL. Effects of 5-HT uptake inhibitors, agonists and antagonists on the burying of harmless objects by mice; a putative test for anxiolytic agents. *Br J Pharmacol*. 1991;104(1):105–112. doi:10.1111/j.1476-5381.1991.tb12392.x
119. Njung'e K, Handley SL. Evaluation of marble-burying behavior as a model of anxiety. *Pharmacol Biochem Behav*. 1991;38(1):63–67. doi:10.1016/0091-3057(91)90590-X
120. Gyertyán I. Analysis of the marble burying response: marbles serve to measure digging ratherthan evoke burying. *Behav Pharmacol*. 1995;6(1):24–31.
121. Librowski T, Czarnecki R, Mendyk A, Jastrzebska M. Influence of new monoterpene homologues of GABA on the central nervous system-activity in mice. *Pol J Pharmacol*. 2000;52(4):317–321.
122. Wu L, Wang Y, Wang X, et al. Evaluation of Colocasia esculenta Schott in anti-cancerous proper ties with proximity extension assays. *Food Nutr Res*. 2021;65:1–8. doi:10.29219/fnr.v65.7549
123. Pereira PR, Corrêa ACNTF, Vericimo MA, Paschoalin VMF. Tarin, a potential immunomodulator and COX-inhibitor lectin found in taro (*Colocasia esculenta*). *Compr Rev Food Sci Food Saf*. 2018;17(4):878–891. doi:10.1111/1541-4337.12358
124. Terada N, Kulkarni P, Getzenberg RH. Cyr61 is a potential prognostic marker for prostate cancer. *Asian J Androl*. 2012;14(3):405–408. doi:10.1038/aja.2011.149
125. Yang R, Chen Y, Chen D. Biological unctions and role of CCN1/Cyr61 in embryogenesis and tumorigenesis in the female reproductive system (Review). *Mol Med Rep*. 2018;17(1):3–10. doi:10.3892/mmr.2017.7880
126. Menéndez JA, Mehmi I, Griggs DW, Lupu R. The angiogenic factor CYR61 in breast cancer: molecular pathology and therapeutic perspectives. *Endocr Relat Cancer*. 2003;10(2):141–152. doi:10.1677/erc.0.0100141
127. Inokuchi J, Lau A, Tyson DR, Ornstein DK. Loss of annexin A1 disrupts normal prostate glandular structure by inducing autocrine IL-6 signaling. *Carcinogenesis*. 2009;30(7):1082–1088. doi:10.1093/carcin/bgp078
128. Lazarova DL, Bordonaro M. Vimentin, colon cancer progression and resistance to butyrate and other HDACis. *J Cell Mol Med*. 2016;20(6):989–993. doi:10.1111/jcmm.12850

129. Akinmoladun FO, Olaleye TM, Adeyemi OO, Nwachukwu DC, Onwukwe OS, Onyemelukw AO. Subacute toxicity profile of the leaves of Colocasia esculenta [L. Schott] in albino rats. *Res J Med Plant*. 2016;10(5):340–348. doi:10.3923/rjmp.2016.340.348
130. Mbaka GO, Obgonnia SO, Awoyemi FO. Acute and sub-acute toxicity studies of ethanol seed extract of *Raphia hookeri* on Swiss albino rats. *Br J Pharm Res*. 2014;4:1196–1208.
131. Xie Y, Yang W, Tang F, Chen X, Ren L. Antibacterial activities of flavonoids: structure-activity relationship and mechanism. *Curr Med Chem*. 2014;22(1):132–149. doi:10.2174/0929867321666140916113443
132. Farha AK, Yang QQ, Kim G, et al. Tannins as an alternative to antibiotics. *Food Biosci*. 2020;38:100751. doi:10.1016/J.FBIO.2020.100751100751
133. Cushnie TPT, Cushnie B, Lamb AJ. Alkaloids: an overview of their antibacterial, antibiotic-enhancing and antivirulence activities. *Int J Antimicrob Agents*. 2014;44(5):377–386. doi:10.1016/j.ijantimicag.2014.06.001
134. Evans SM, Cowan MM. Plant products as antimicrobial agents. *Cosmetic Drug Microbiol*. 2016;12(4):205–231. doi:10.3109/9781420019919-17
135. Adefegha SA. Impact of pasting on starch composition, estimated glycemic index, phenolic constituents, antioxidant activities and antidiabetic properties of flour produced from cocoyam (Colocasia esculenta) corm. *J Food Biochem*. 2018;42(4):1–11. doi:10.1111/jfbc.12514
136. Nwozo OS, Effiong EM, Aja PM, Awuchi CG. Antioxidant, phytochemical, and therapeutic properties of medicinal plants: a review. *Int J Food Prop*. 2023;26(1):359–388. doi:10.1080/10942912.2022.2157425
137. Nugroho GA, Desmiaty Y, Sumiyati Y, Suherman SL, Lim H. Phenolic content and antioxidant activity of *Colocasia esculenta* in commercial herbal products. *Sci Phytochem*. 2025;4(1):33–39. doi:10.58920/sciphy0401288
138. Duarte LJ, Chaves VC, Nascimento MVPS, et al. Molecular mechanism of action of pelargonidin-3-O-glucoside, the main anthocyanin responsible for the anti-inflammatory effect of strawberry fruits. *Food Chem*. 2018;247:56–65. doi:10.1016/j.foodchem.2017.12.015
139. Sun Y, Li L. Cyanidin-3-glucoside inhibits inflammatory activities in human fibroblast-like synoviocytes and in mice with collagen-induced arthritis. *Clin Exp Pharmacol Physiol*. 2018;45(10):1038–1045. doi:10.1111/1440-1681.12970
140. Li Y, Zhao Y, Tan X, et al. Isoorientin inhibits inflammation in macrophages and endotoxemia mice by regulating glycogen synthase kinase 3β. *Mediators Inflamm*. 2020;2020:8704146. doi:10.1155/2020/87041461-10
141. Jiang X, Wang X. Cytochrome C Mediated Apoptosis. *Annu Rev Biochem*. 2004;73(1):87–106. doi:10.1146/annurev.biochem.73.011303.073706