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A Comprehensive Review of Botanical Characterization, Phytochemistry, Pharmacological Effects and Quality Control of Ipomoea Eriocarpa

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ABSTRACT

Ipomoea eriocarpa, known as Tiny Morning Glory, is a popular herb used in treating fever, ulcers, leprosy, rheumatism, migraines, epilepsy, cattle wounds, and menstrual distress. This narrative review examines the scientific evidence about the traditional utilization of Ipomoea eriocarpa, focusing on its botanical attributes, cultivation, geographical distribution, phytochemical composition, pharmacological impacts, ethnomedical uses, toxicity, and quality assurance measures. The study utilized data from various online scientific databases throughout the past decade. Scopus, Web of Science, PubMed, CNKI, Google Scholar, Elsevier, Wiley, ACS publications, SpringerLink, and Dr. C. P. Khare's, "Indian Medicinal Plants" following PRISMA guidelines. ChemBio Draw Ultra Version 16.0 and BioRender were used to draw phytochemical structures and figures. Ipomoea eriocarpa contains various phytoconstituents, including phenols, terpenoids, alkaloids, proteins, carbohydrates, and phytosterols. To date, 17 chemical ingredients have been isolated from Ipomoea eriocarpa. Preclinical research has also revealed that Ipomoea eriocarpa has a variety of other uses, such as antibacterial, antiarthritic, antidiabetic, antisecretory, antinociceptive, antipyretic, anthelmintic, and antiurolithiatic action. No signs of toxicity were reported at petroleum ether extract concentrations of 100, 200, and 400 mg/kg oral. This investigation suggests that Ipomoea eriocarpa could be a significant source of future herbal medications. However, research investigating more findings of phytoconstituents is still limited, and more research can be emphasized based on the molecular and cellular levels. Further research is needed to understand the scientific connection between traditional medicinal applications and the pharmacological effects of Ipomoea eriocarpa, its bioactive components' mechanism of action, and potential toxicity.

KEYWORDS : Ipomoea, Ipomoea eriocarpa, Convolvulaceae, Medicinal plant, Ethnomedical uses, Toxicology

1. INTRODUCTION

Medicinal plants have significant importance for the health care of local communities as a source of medicine. Since immemorial, plants have played an important part in the human health care system. 422,000 have been documented globally, of which over 50,000 are used medicinally by a large number of people living in rural areas[1]. Approximately 80% of people worldwide utilize herbal remedies for basic healthcare, with emerging nations using them the most[2]. Due to the high cost and side effects of allopathic drugs, over 4.5 million rural people use medicinal plants for healthcare. The family Convolvulaceae comes from Latin "Convolvere"—"To wind" [3, 4]. Common names for it include bindweed and the morning glory family. They include around 1600–1700 species spread throughout 50–60 genera [5][6].

With over 500 species, Ipomoea is the biggest genus in the Convolvulaceae family [7] [8]. The majority of it consists of tiny trees, bushes, trailers, twiner, climbing veins, and herbs [9]. One unique diagnostic characteristic of Ipomoea is the presence of yellowish sap. This genus of plants is utilized for medical, ceremonial, decorative, agricultural, and environmental indicator uses [10]. Ipomoea eriocarpa R. Br. (tiny morning glory), an annual herb that is aggressive and invasive in farming settings, belongs to the Convolvulaceae family. Strongly climbing, it can withstand droughts and sudden cold spells and thrives in well-drained, rich, alluvial, and sandy-loamy soils [11] [12]. In the San Joaquin Valley, California, Ipomoea species may be abundant and a major agricultural weed. Agriculture requires management from emergence to harvest. Remove seedlings early because their twined stems make them difficult to manage without harming the crop. Ipomoea is found in the tropics and temperate regions [13]. Ipomoea eriocarpa is found in tropical Asia, northern Australia, Madagascar, South Africa, and Egypt, among other places in tropical Africa [14, 15].

Ipomoea eriocarpa leaves are used as a vegetable that has been cooked in soups, or combined with other foods in Africa and India. In Uganda, women consume a root decoction to ease the discomfort associated with menstruation [16–18]. Its oil extract is applied topically to treat fever, ulcers, leprosy, headache, and rheumatism in India [19]. The oil extract is utilized in veterinary medicine to treat cow wounds [20]. Healthy seeds provide protein and carbs. Long, intertwined stalks rise on mature plants. Petiolate, broad, heart-shaped leaves [21]. The bisexual, funnel-shaped, pinkish flowers are up to 1 cm long and darkened in the center. The 6-mm fruits are globose to ovoid capsules. Ovoid, black seeds germinate at least 4 inches below the surface, deeper than many annual plants [22, 23]. Compared to field bindweed, cotyledons, or seed leaves, have a deeper notch and a butterfly-like structure (Figure 1). The taxonomical classification and vernacular names of I. eriocarpa have been represented in (Table 1) & (Table 2)

According to a phytochemical study, the plant's main constituents include phenols, flavonoids, phytosterols, and alkaloids [24] [25]. Through carefully trawling through Indian Medicinal Plants, including various research articles, as well as the ethnopharmacology information of I. eriocarpa in India and other countries, it was found that I. eriocarpa has diverse traditional medicine effects, including headache, rheumatism, leprosy, epilepsy, ulcers, and fever. Currently, 17 compounds, including terpenoids, fatty acids, carotenoids, terpene alcohol, esters, phytosterols, etc., have been characterized from I. eriocarpa by GC-MS [26]. As a result, phenolic components have been demonstrated to be active chemicals with a diverse spectrum of pharmacological actions. Scientific investigation of I. eriocarpa recently demonstrated cerebroprotective [27], antioxidant [28], antisecretory [29], antinociceptive [30], antipyretic [31], anthelmintic, insecticidal activity [26] , antimicrobial [32], antiarthritic, antidiabetic and antiurolithiatic activity [25] [33]. Ipomoea eriocarpa leaves have antimicrobial activity against Staphylococcus aureus, Pseudomonas aeruginosa, Bacillus subtilis, Escherichia coli, Aspergillus oryzae, and Aspergillus niger [32]. Further research is needed to address limitations in active component and non-medicinal portions. This study identifies knowledge gaps about I. eriocarpa's pharmacological and biological mechanisms of therapeutic efficacy. It also aims to provide a scientific foundation for developing new natural medicine-based therapeutics and applications. No comprehensive I. eriocarpa review articles were found during the literature review. To understand the plant's contribution, this article will discuss traditional uses, chemical constituents, pharmacological effects, therapeutic uses, foods, and I. eriocarpa quality control. We want to use this assessment as a reference for future development.

Table 1. The Taxonomical classification of Ipomoea eriocarpa

Kingdom	**Plantae**
Phylum	Tracheophyta
Class	Magnoliopsida
Order	Solanales
Family	Convolvulaceae
Genus	Ipomoea
Species	Ipomoea eriocarpa (R.Br.)

Table 2. Vernacular Names of Ipomoea eriocarpa

Languages	**Vernacular names**
Hindi	Buta, Bhanwar
Telugu	Puritittige
Kannada	Mullu balli
Sanskrit	Nakhari
English	Tiny Morning Glory, Woolly Fruited Morning Glory
Punjabi	Bhanwar
Bengali	Ghorakalami
Gujarati	Odi kudaradi
Malayalam	Pulichevidu
Marathi	Maal ghanti, Raanbhovari
Oriya	Paninoi
Kachchhi	Adabau neri ji val
Assamese	Khud kalmou

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Figure 1. Macroscopic view of the aerial part of Ipomoea eriocarpa.

2. MATERIAL AND METHODS

For this review, an extensive search on various academic databases including Google Scholar, PubMed, Scopus, and Web of Science, covering the studies from December 2010 to September 2023 (Figure 2). Ipomoea, Ipomoea eriocarpa, Convolvulaceae, Medicinal plant, Ethnomedical uses, Toxicology, alkaloids, polyphenols, and triterpenoids were our main keywords. To refine the search, Boolean operators like AND and OR were used, such as Ipomoea genus OR Ipomoea eriocarpa, alkaloids AND phenolic compounds in Ipomoea eriocarpa, etc. The search only included English-language studies. Original research papers, systematic reviews, observational studies, and RCTs were included. Non-English, studies, case reports, conferences, and abstracts were excluded. "eFLORAofINDIA" (www.efloraofindia.com), "The World Flora Online" (https://www.worldfloraonline.org/search?query=Ipomoea+eriocarpa), "Tropicos" (https://www.tropicos.org/name/Search?name=Ipomoea%20eriocarpa) were contacted for the approved names of plants to guarantee the accuracy of the plant names, while ChemBio Draw Ultra Version 16.0 software was employed in drawing the phytochemical compounds.

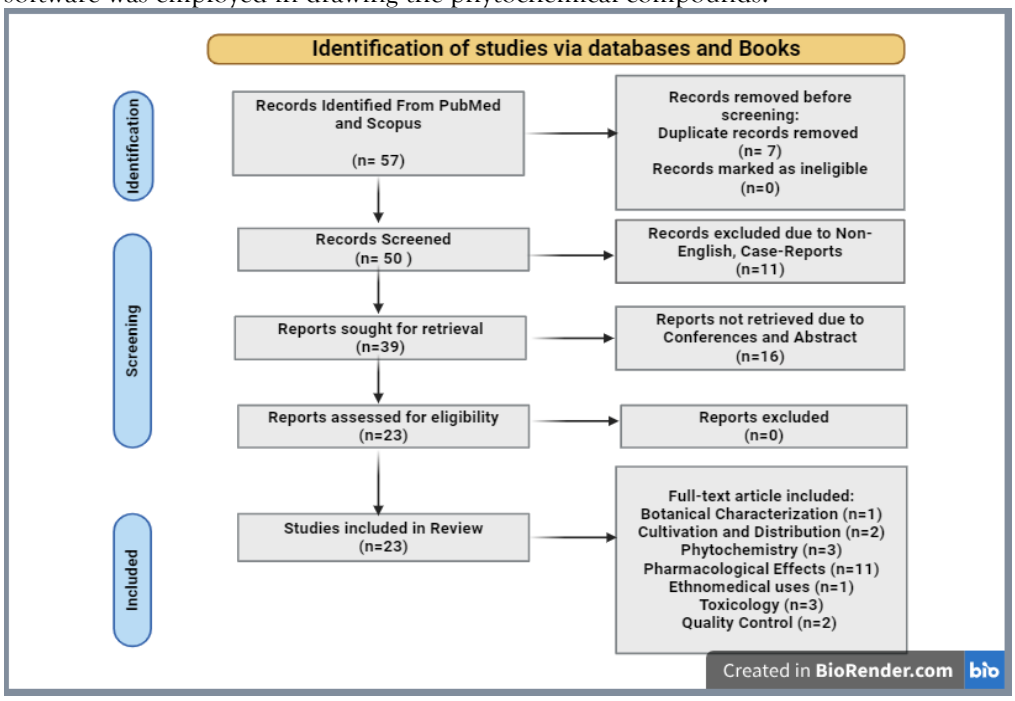


Figure 2. Flowchart of Literature Findings

3. BOTANICAL CHARACTERIZATION

The annual Ipomoea eriocarpa R. Br. invades and crops aggressively. It climbs in well-drained, wet, fertile alluvial and sandy loam soils and can withstand drought and sudden cold spells. Upper green of simple, alternating, exstipulate, petiolate leaves is lighter than lower. Lamina is cordate, symmetric, acuminate,

and full-edged. It is 0.7-5.6 cm wide and 4-11 cm long. Fur covers both sides. The pale green, cylindrical petiole is 3.6-6.7 cm long and 0.3-0.7 cm wide. Mildly bitter leaf is odorless. The cylindrical, herbaceous, twining, prostrate stem is greenish brown when fresh and grayish brown when dried. One branch pod and pubescence. Long internodes, short golden fracture. Odorless, bitter taste. The seed is 0.2-0.4 cm tall and 0.5-0.7 cm wide. Although small, it is dark black when fresh and grey when dry. Three-sided, convex dorsal, centre depression, flat ventral. Central ventral depression has micropyle and hilum. A raised ridge from seed bottom to tip is the raphe. Taste, smell, and hardness are absent from the seed. Large spiral-curled embryo. L.C. and T.C. show tiny endosperm moving between embryo folds. Superior ovaries produce fruit from simple, dry, dehiscent septifragal capsules. This short-pediced green plant turns brown. It is 0.5-0.9 cm tall and 0.6-1 cm wide. The remaining style is sub-globular with a spherical base and pointy tip. The fruit has four dark brown seeds and five persistent sepals. Warty, hairy, tasteless, odorless pericarp has short cracks. Fruit has two locules transversely. Each locule has 2 seeds. Fruit has two longitudinal locules. Every locule has one seed, and basal placentation [24]. Ipomoea eriocarpa R.Br. leaf, stem, seed, and fruit microscopical measurements (in microns) (Table 3).

Table 3. Microscopical measurements of the Leaf (Lamina), stem, Seeds, Fruits of Ipomoea eriocarpa R.Br. (In microns). [24]

Parts	Items	Length	Width	Diameter	Height
LEAF (Lamina)	Upper epidermis	31.8-68.1	13.6-50	15.4-23	11.5-23
	Lower epidermis	23.3 -41.6	10-28.3	7.7-23.1	7.6-23
	Stomata	18.1-27.3		4.5-13.6	
	Palisade cells	20.8-62.5	12.5-20.8		
	Parenchyma			23-53.8	
	Collenchyma			7.7-26.9	
	Starch			2.6-3.8	
	Xylem vessels			26.9-38.5	
	Glandular hair	13.3-23.3	13.3-30		
	Non- glandular hair	250-375	15.6-37.5		
	Medullary rays	91.7-116.7	16.7-33.3		
STEM	Epidermal cells	32.1-64.3	10.7-21.4	3.5-25	17.8-25
	Stomata	14.3-21.4		10.7-17.8	
	Parenchyma			21.4-39.3	
	Collenchyma			7.1-23.1	
	Starch			2.1-6.3	
	Xylem vessels			27.7-44.4	
	Pericyclic fibers	428.5-571		7.1-14.2	
	Non- glandular hair	111-138.9	5.5-16.7		
	Medullary rays	17.9-39.3	10.7-21.4		
	Wood parenchyma	30.9-45.2	7.1-11.9		
	Wood fiber	789.4-999			
	Tracheids	60-90	2-8		
SEED	Epidermis of testa	28.5-42.8	14.3-26.2	44.7-50	23.7-28.9
	Hypodermis	7.9-15.8	2.6-8		
	Palisade like cells	15.8-26.3	2.6-7.8		
FRUITS	Epicarp	44.4-55.5	5.6-33.3	20.5-27.3	6.8-25
	Parenchyma				20.5-31.8
	Sclerides	50-75	14.3-21.4	36.4-50	11.4-13.6
	Resin Cavity				77.3-81.8
	Fiber	300-400			5.5-16.7
	Endocarp	14.3-30.9	7.1-11.9	4.5-9.1	11.4-15.9
	Non glandular hair	193.3-213	6.7-20		

4. CULTIVATION AND DISTRIBUTION

I. eriocarpa germinates in spring, summer, and fall in most subtropics. Temperature, salinity, drought, pH, and planting depth affect I. eriocarpa germination and seedling emergence. It can handle hot summers, warm to chilly winters, moderate precipitation, well-drained, somewhat acidic soil, and other subtropical and semi-arid climate traits. This weed grows differently in different environments. I. eriocarpa can survive and germinate in a wide pH range, suggesting it can grow in different soils. Up to 2 cm of sowing depth increased seed emergence and germination, but burial decreased them after 10 cm [11].

It grows in grasslands, open spaces, floodplains, dry deciduous woods, scrub jungles, and thickets. It inhabits tropical Asia, Northern Australia, Myanmar, Nepal, New Guinea, Pakistan, Philippines, Sri Lanka, Thailand, Uganda, and Vietnam. Tropical Africa, including Madagascar, South Africa, and Egypt, has it [14]. In India, it is available in Andhra Pradesh, Assam, Bihar, Meghalaya; Kerala, Jharkhand, and Karnataka (Figure 3). Many more places are yet to discover the presence of I. eriocarpa.

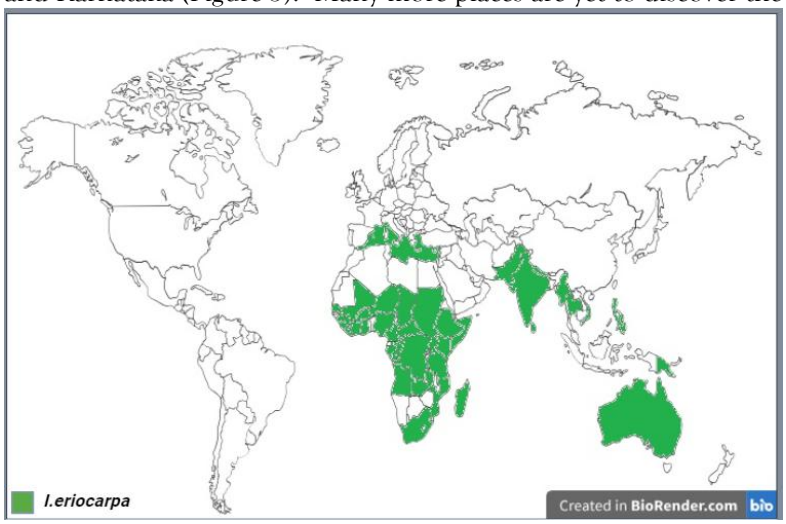


Figure 3. Geographical Distribution of I. eriocarpa.

5. MEDICINAL PARTS

Indian Medicinal Plants by C.P. Khare listed I. eriocarpa's property, efficacy, and drug name, but not its medicinal value. The literature survey showed that I. eriocarpa research has focused on leaves, bark, inflorescence, or the whole plant. The therapeutic uses of I. eriocarpa seeds, stems, roots, and fruits have not been studied, so more research is needed.

6. PHYTOCHEMISTRY

Phytochemicals are secondary metabolites of plants, encompassing phenolic substances including tannins, flavonoids, saponins, and glycosides [34–37]. The results of the phytochemical study showed that the water, chloroform, and petroleum ether extracts possessed alkaloids, phenols, and phytosterols; the chloroform extract also contained terpenoids and saponins[32]. Total phenol concentrations in ethanol, water, and chloroform extracts were 13.55–55.81 mg GAE/g. The ethanol extract had the highest phenol content (55.81 ± 1.6 mg GAE/g). The extracts of water (13.55 ± 0.56 mg GAE/g) and chloroform (13.83 ± 1.8 mg GAE/g) contained significantly less phenol. Flavonoids ranged from 161.19 to 292.34 mg QCE/g. The ethanol extract had the highest flavonoid concentration (292.34 ± 3.1 mg QCE/g), while the water and chloroform extracts had lower concentrations (161.19 ± 2.8 and 207.14 ± 0.46 mg QCE/g, respectively). The total terpenoid content was 17.47–30.2 mg linalool/g. The ethanol extract had the highest terpenoids concentration (30.2 ± 2.1 mg linalool/g), while the water and chloroform extracts had 17.47 ± 2.3 and 21.26 ± 0.86 mg, respectively. Sterol concentrations were 94.14–196.73 mg cholesterol/g. For cholesterol/g, the water extract had the highest sterol concentration (196.73 ± 3.8 mg), while the ethanol and chloroform extracts had the lowest (138.79 ± 1.2 and 94.14 ± 1.4 mg, respectively) [33].

GC-MS analysis of petroleum ether extract revealed eleven phytoconstituents, while ethanol extract revealed nine, three of which were found in both extracts. Hentriacontane, Z,Z-6,28-heptatriactontadien-2-one, is in petroleum ether extract. Hexadecanoic acid, 3,7,11,15-tetramethyl-2-hexadecen-1-ol Methyl-8,11,14-heptadecatrienoate, Hexacosanol acetate, (3-Beta)-2,6,10,15,19,23-hexamethyl-2,6,10,14,18,22-

tetracosahexaene -ergost-5-en-3-ol, γ-sitosterol, methyl-2-hydroxy-eicosanoate 2R-acetoxymethyl-1,3,3-trimethyl-4t-(3-methyl-2-buten-1-yl)-1t-cyclohexanol (Table 4) (Figure 4)

Ethanol extract contains Hentriacontane, Z,Z-6,28-heptatriactontadien-2-one, 3,7,11,15-tetramethyl-2-hexadecen-1-ol, Ethyl-14-methyl-hexadecanoate, Ethyl-9,12,15-octadecatrienoate, 1,1-hexadecanediol, Stigmasterol, β-sitosterol, (-)-isolongifolol, trimethylsilyl ether (Table 5) (Figure 5). The above phytoconstituents include 17 compounds: terpenoids, fatty acids, carotenoids, terpene alcohol, esters, phytosterols, etc. Most phenolic compounds are active and have many pharmacological effects [26, 38–40].

Table 4. Phytoconstituents isolated from petroleum ether extract of I. eriocarpa.

S.No.	Constituents	Molecular Formula	Molecular Weight	Category of Phytoconstituents	Biological Activity	Figure 4
1	Hentriacontane	$C_{31}H_{64}$	436	Esterified fatty acids	Anti-inflammatory Effects	A
2	Z,Z-6,28-heptatriactontadien-2-one	$C_{37}H_{70}O$	530	Terpenoids (Phytosteroid)	Anti-inflammatory, Antioxidant, and Cytotoxic properties	B
3	N-hexadecanoic acid	$C_{16}H_{32}O_2$	256	Saturated Fatty Acids	Cell culture studies and Lipid metabolism	C
4	3,7,11,15-tetramethyl-2-hexadecen-1-ol	$C_{20}H_{40}O$	296	Terpenoid Alcohol	Antioxidant, Anti-inflammatory, and antimicrobial properties	D
5	Methyl-8,11,14-heptadecatrienoate	$C_{18}H_{30}O_2$	278	Unsaturated Fatty Acid Ester	Anti-inflammatory and Antioxidant properties	E
6	Hexacosanol acetate	$C_{28}H_{56}O_2$	424	Fatty acid	Anti-inflammatory and Antioxidant properties	F
7	(All-E)-2,6,10,15,19,23-hexamethyl-2,6,10,14,18,22-tetracosahexaene	$C_{30}H_{50}$	410	Carotenoids	Vision, Antioxidant defense, and overall health.	G
8	(3-Beta)-ergost-5-en-3-ol	$C_{28}H_{48}O$	400	Steroids	Membrane structure and function in cells.	H
9	Methyl-2-hydroxy-eicosanoate	$C_{21}H_{42}O_3$	342	Fatty acid	Skin health, Wound Healing, or Lipid Metabolism	I
10	γ-sitosterol	$C_{29}H_{50}O$	414	Phytosterol	Heart-healthy diet to help manage cholesterol levels.	J
11	2R-acetoxymethyl-1,3,3-trimethyl-4t-(3-methyl-2-buten-1-yl)-1t-cyclohexanol	$C_{17}H_{30}O_3$	282	Terpenoid Alcohol Ester	Antioxidant, Antimicrobial, and Anti-inflammatory properties.	K

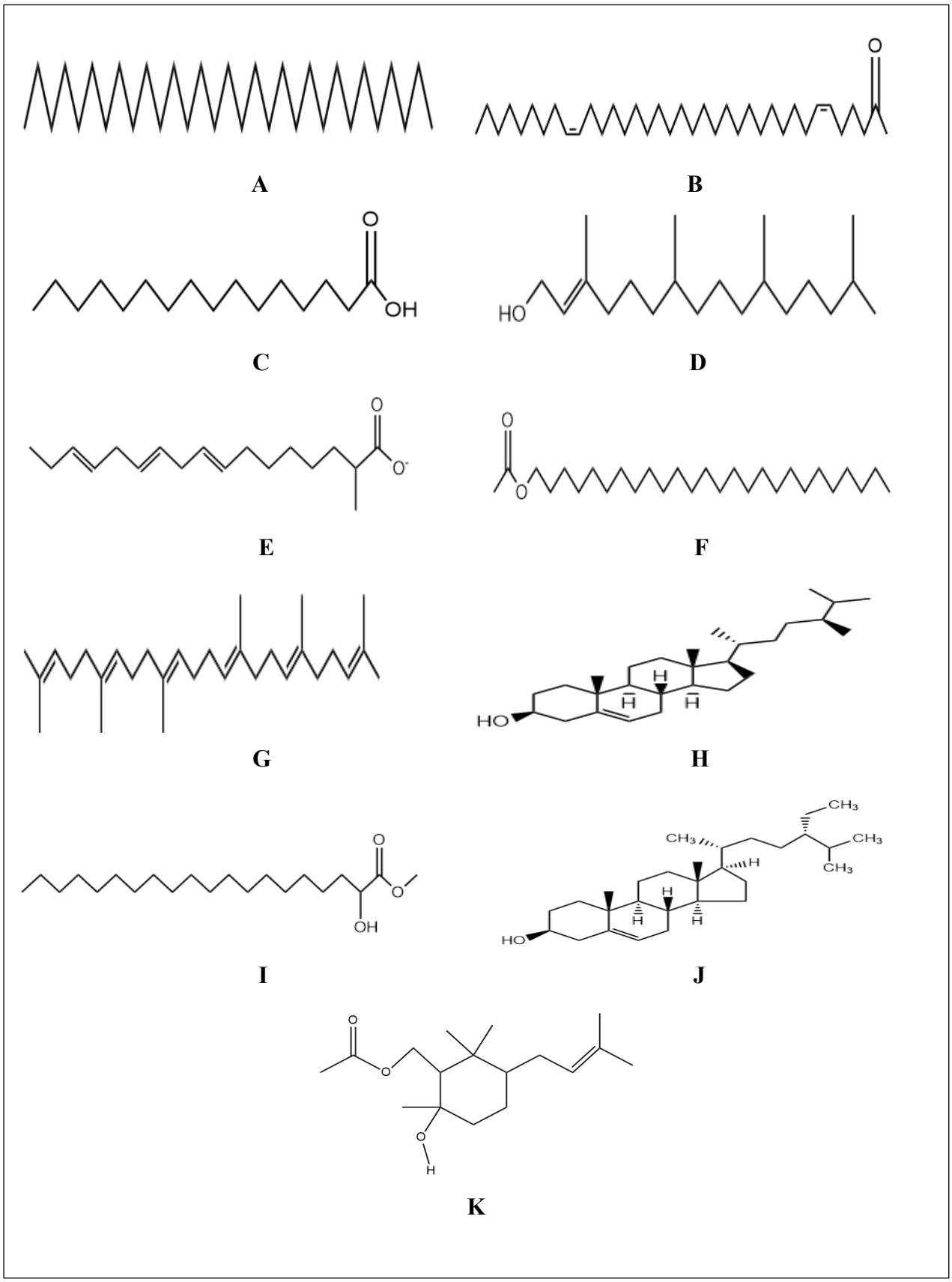
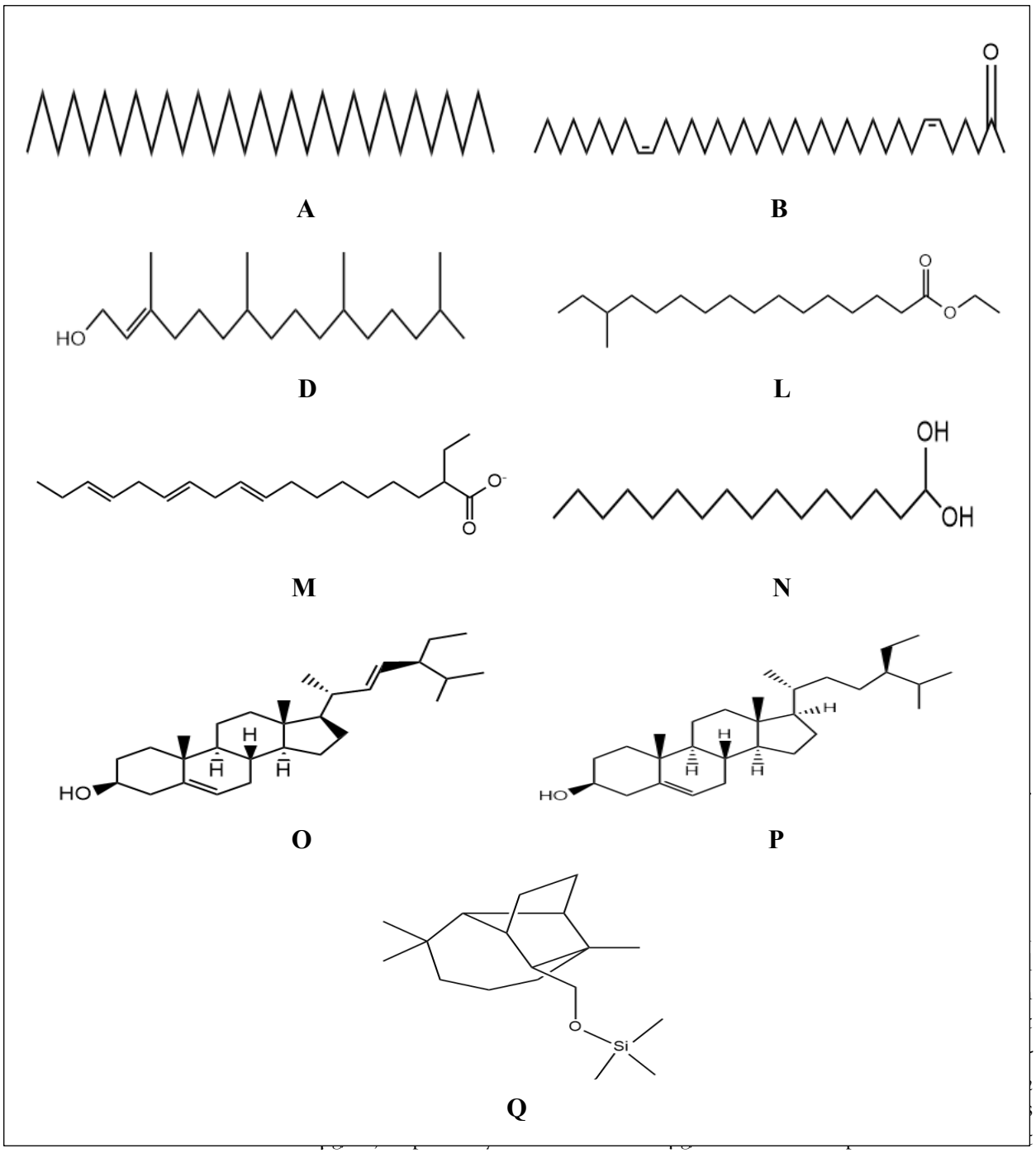


Figure 4. Chemical structures of the phytoconstituents isolated from the Petroleum ether extract of I. eriocarpa.

Table 5. Phytoconstituents isolated from ethanolic extract of I. eriocarpa.

S.No.	Constituents	Molecular Formula	Molecular Weight	Category of Phytoconstituents	Biological Activity	Figure 5

1	Hentriacontane	$C_{31}H_{64}$	436	Esterified fatty acids	Anti-inflammatory Effects	**A**
2	Z,Z-6,28-heptatriactontadien-2-one	$C_{37}H_{70}O$	530	Terpenoids (Phytosteroid)	Anti-inflammatory, Antioxidant, and Cytotoxic properties	**B**
3	3,7,11,15-tetramethyl-2-hexadecen-1-ol	$C_{20}H_{40}O$	296	Terpenoid Alcohol	Antioxidant, Anti-inflammatory, and Antimicrobial properties	**D**
4	Ethyl-14-methyl-hexadecanoate	$C_{19}H_{38}O_2$	298	Fatty Acid	Antioxidant, Anti-inflammatory, and Antimicrobial properties	**L**
5	Ethyl-9,12,15-octadecatrienoate	$C_{20}H_{34}O_2$	306	Fatty Acid	Anti-fungal activity	**M**
6	1,1-hexadecanediol	$C_{16}H_{34}O_2$	258	Fatty Acid	Antimicrobial, Antifungal, and Antioxidant agent.	**N**
7	Stigmasterol	$C_{29}H_{48}O$	412	Phytosterol	Cholesterol-lowering effects, Anti-inflammatory properties, Antioxidant activity	**O**
8	β-sitosterol	$C_{29}H_{50}O$	414	Phytosterol	Cholesterol-lowering effects, Anti-inflammatory properties, Antioxidant activity	**P**
9	(-)-isolongifolol, trimethylsilyl ether	$C_{18}H_{34}OSi$	294	Terpene Alcohol (Squiterpene Alcohol)	Antimicrobial, Antifungal, or Antioxidant agent	**Q**



(specimen voucher no.- BSI/SRC/5/23/2017/Tech/2172), n-hexadecanoic acid increased DPPH scavenging activity by 30.19-89.13%, according to various studies. Comparing the concentration to standard ascorbic acid (59.81-100% at 100-500 µg/ml), increasing concentration also increases activity. N-hexadecanoic acid showed the highest ABTS scavenging activity at 100-500 µg/ml, with 42.18-83.86%, while normal ascorbic acid showed 55.07-100%. Dose-dependent reduction power of n-hexadecanoic acid is 0.02–0.16% at 100-500 µg/ml, while ascorbic acid is 0.11–0.24% at the same dosage. The nitric oxide radical scavenging activity of n-hexadecanoic acid increased with concentration, reaching 18.65-73.17% at 100-500 µg/ml, while ascorbic acid showed 55.97-100% at the same concentration [43, 44]. n-hexadecanoic acid exhibited 17.18-81.21% superoxide radical scavenging activity at 100-500 µg/ml, while ascorbic acid showed 48.09-100% [45, 46]. At 100-500 µg/ml, n-hexadecanoic acid exhibited 13.17-52.01% hydroxyl anion scavenging activity, while ascorbic acid showed 32.17-86.92% [42, 46, 47]. Ethanol extract's higher phenol and flavonoid content may explain its antioxidant properties. In addition to investigating new chemicals that underlie pharmacological effects, mechanistic studies are needed to create modern pharmacological actions and conventional uses.

7.2. Anti-inflammatory activity

The experimental model showed significant anti-edemic effects and inhibition when aqueous extract encapsulating AgNPs was given intraperitoneally (1 ml/kg) [48, 49]. Diclofenac (17.76 ± 0.32) and the aqueous extract (15.32 ± 1.0) were less effective than extract-encapsulated AgNPs in suppressing paw edema in carrageenan-induced paws (21.31 ± 1.34) [50]. Thus, extract-encapsulated AgNPs may have inhibited COX enzyme activity to reduce pro-inflammatory mediator release (prostaglandin) [51, 52]. Carrageenan-induced inflammation is inhibited by the extract [53]. More in-vivo experiments and methods are needed to confirm its conventional role. To determine I. eriocarpa's mechanism of action, enzyme specifications and inflammatory mediators can be examined.

7.3. Hepatoprotective activity

One use of I. eriocarpa is liver disease treatment. The two most common chronic liver diseases worldwide are "alcoholic liver disease" (ALD) and "nonalcoholic fatty liver disease". The ethanolic extract of I. eriocarpa was tested for its effect on CCl_4-induced hepatotoxicity in albino Wistar rats by measuring AST, ALT, ALP, total bilirubin, and total protein [54, 55]. Lipid peroxidation occurs in aerobic liver parenchymal cells when CCl_3 reactive oxygen species attach to proteins and lipids. Metabolic enzyme inactivation increases marker enzymes (AST, ALT, ALP, bilirubin) and decreases protein synthesis, causing lipid peroxidation and Ca^{2+} homeostasis disruption. Hepatic cell AST, ALT, ALP, and bilirubin decreased with membrane failure, but serum levels increased. Blood AST levels drop significantly in I. eriocarpa extract-treated groups (100mg/kg and 200mg/kg p.o) [56]. Plant extracts yielded the best results (352.9 ± 4.99) at the highest dose. Plant extract showed the highest activity in lowering blood ALT levels (229.6 ± 5.0) at the highest dose compared to the low dose [57]. This study found that most liver-protective compounds in I. eriocarpa are phenolic or flavonoid, but more must be found.

7.4. Effects on diabetes mellitus

Reports show that diabetes mellitus is rising rapidly and often causes metabolic disease. The α-amylase enzyme hydrolyzes complex starch molecules into glucose units, regulating blood glucose levels [58]. Both petroleum ether extract and conventional acarbose showed significant efficacy in treating DM at 200 µg/ml, with an approximate 75% improvement. The water extract produced less inhibition of the α-amylase enzyme, possibly due to the presence of terpenoids [59]. Thus, mechanistic research is needed to develop modern pharmacological effects and traditional applications in addition to studying new chemicals that underlie them.

7.5. Cerebroprotective effect

I. eriocarpa was found to be cerebroprotective in the literature. Hippocampal neurons are susceptible to ischemia and reperfusion. After Alzheimer's disease-related dementia, vascular dementia is the fastest-growing. An obstructed or impaired vascular system reduces cerebral blood flow, causing memory and cognitive decline [60]. Over 10 minutes, rats with bilateral carotid artery occlusion (BCAO) had fewer pyramidal nerve cells in the CA1 region of the hippocampus [61]. Visible neuron absence took 96 hours and caused cerebral hypoperfusion, which caused white matter lesions, cognitive and memory dysfunction, and hippocampus neuron damage [62, 63]. This study found that albino Wistar rats receiving 200 mg/kg and 400 mg/kg ethanolic extract p.o. had significantly increased locomotor activity. At 200 and 400 mg/kg p.o., EEIE (ethanol extract of I. eriocarpa leaves) significantly reduced ischemia and reperfusion-induced short-term mental recall and motor impairment [64, 65]. It has also significantly reduced ischemia-reperfusion-induced cerebral infarction dimensions [66]. While I. eriocarpa is widely used, brain diseases can be better understood [60, 67]. To demonstrate I. eriocarpa's traditional cerebroprotection, brain molecular and cellular mechanisms can be established.

7.6. Antiurolithiatic activity

I. eriocarpa could treat urolithiasis. Severe kidney tubular injury increases calcium excretion, phosphorus loss, and oxalate stress. A comparison with the control group showed that phosphorus [68] levels were significantly higher in the stone-induced group in male Wistar rats. After administering the ethanolic extract (200 mg/kg p.o.), the test groups' calcium and phosphorus levels returned to almost normal, proving that it prevented hyperphosphaturia and elevated calcium [69] levels. Due to supersaturation and acidic metabolism, magnesium [70] levels were considerably lower in the stone-induced group contrasted to the control group. Since magnesium reduces supersaturation, it may block CaOx stones [25, 71, 72]. Other mechanisms can be established by using different extracts and comparing potency.

7.7. Anti-Arthritic activity

Three I. eriocarpa extracts—water, chloroform, and petroleum ether—were tested for egg albumin denaturation[73]. Research indicates that I. eriocarpa extracts reduce protein denaturation dose-

dependently at 50-200 µg/ml concentrations. A maximum impact of 91% was observed at 200 µg/ml diclofenac sodium concentration. At 200 µg/ml, the water and chloroform extracts showed the highest efficacy, with an estimated 80% impact [59]. Screening model studies for I. eriocarpa arthritis are still to be discovered.

7.8. Anti-bacterial activity

Since bacteria are becoming resistant to many commercial antibiotics, research into novel natural antibacterial agents has begun, with I. eriocarpa showing bactericidal activity. At 50 µg/ml, n-hexadecanoic acid from I. eriocarpa inhibited Staphylococcus aureus, Bacillus subtilis, E. coli, and Klebsiella pneumoniae with zones of 7.96, 10.96, 11.10, and 11.93 mm. Minimum inhibitory concentration[74] of n-hexadecanoic acid towards Staphylococcus aureus, Bacillus subtilis, Escherichia coli, and Klebsiella pneumoniae were 6.87 ± 0.08, 3.94 ± 0.63, 4.72 ± 0.24, and 2.65 ± 0.30 50 µg/ml, respectively [75]. Additional antibacterial activity examination was performed utilizing the agar well diffusion method [76] on four bacterial varieties: Escherichia coli, Staphylococcus aureus, Bacillus subtilis, and Pseudomonas aeruginosa [77]. Azithromycin, Ampicillin, and Amikacin were positive controls. Azithromycin showed the highest activity against Escherichia coli (14.2 ± 1.0 mm), while Ampicillin had the lowest (7.6 ± 2.12 mm). I. eriocarpa has antibacterial properties from 9.6 ± 1.2 mm to 6 ± 0.8 mm. Bark extract is most effective against Escherichia coli, while inflorescence extract is least effective against B. subtilis. Activity in I. eriocarpa leaves ranged from 0±0 to 9.2 ± 0.8 mm [78, 79]. The ethanol extraction of leaves inhibited Staphylococcus aureus with a maximal zone of 9.2 ± 0.8 mm. [42]. However, no studies have examined food or illness-associated bacteria or the mechanisms behind current bacteriostatic effects. Establish more structure-activity links and investigate new compounds.

7.9. Insecticidal activity

I. eriocarpa showed insecticidal activity on termites (Coptotermes formosanus) [80, 81]. The insect mortality duration of petroleum ether and ethanolic I. eriocarpa extracts was compared to chlorpyrifos. After 12 hours, the control group had no deaths. Tests used standard chlorpyrifos to assess extract insecticidal properties. Each extract eradicated more insects than the drug [26]. However, insecticidal research is still early, and mechanistic studies are needed to determine how valuable it is.

7.10. Anthelmintic activity

An investigation was carried out to find out how effective anthelmintics were against earthworms (Eudrilus eugeniae) [82]. Petroleum ether and ethanolic I. eriocarpa extracts were compared to mebendazole for earthworm paralysis and mortality. Submerging earthworms in heated water stimulated locomotion when viable, determining mortality time. Both extracts are potent anthelmintics [26]. Since more studies can be performed against more species of earthworms, more mechanisms can be established to note the potency of I. eriocarpa.

7.11. Antinociceptive activity

I. eriocarpa has long been analgesic. In male albino mice, oral administration of I. eriocarpa petroleum ether extract at 100, 200, and 400 mg/kg suppressed acetic acid-induced writhing. Extracts can work by inhibiting phospholipase A2 or COX-1 and/or COX-2. The reliable formalin assay detects nociception and is sensitive to many analgesics. The formalin test involves substance P and bradykinin in the first stage and histamine, serotonin, prostaglandins, nitric oxide, and bradykinin in the second. The impact of I. eriocarpa on the late phase of the formalin test [55, 83] indicates that its activity may be attributed to its peripheral action or anti-inflammatory properties [84], in contrast to the activity of indomethacin[30]. Additional research is required to completely clarify the mechanism by which the analgesic activity of I .eriocarpa operates.

8. ETHNOMEDICAL USES

I. eriocarpa is a well-known herb used to cure fever, ulcers, leprosy, rheumatism, headaches, and epilepsy, according to the Indian Medicinal Plant [85]. It is eaten as a cooked vegetable, in soups, or with other foods in India, according to ancient literature and custom. Ugandan women
drink a root decoction to relieve menstrual pain. Veterinarians use oil extract to treat cattle wounds.

9. TOXICOLOGY

Many ailments have been treated with medicinal plants. They also helped develop modern drugs and conduct pharmacological studies [86]. Secondary metabolic pathways produce many of medicinal plants' bioactive compounds, which treat and prevent disease with few side effects [87, 88].

Rats were unaffected by oral I. eriocarpa petroleum ether extract up to 2000 mg /kg, p.o. This study found no toxicity or mortality at 2000 mg/kg b.w. The six-week chronic toxicity assessment showed no effect from 100, 200, or 400 mg/kg on rats' weight or behaviour. After six weeks of therapy, the treated and control groups had similar hematological characteristics, suggesting that neither the extract's toxicity nor red cell formation interference affected circulating red blood cells. Both leucopoiesis and hematopoiesis were unaffected. Most hepatology and renal parameters were unaffected by 100, 200, and 400 mg/kg petroleum ether extract [89]. The acute toxicity of I. eriocarpa leaf ethanol extract was assessed using the Acute Toxic Class Method (OECD guideline 423). Even at 2500 mg/kg, I. eriocarpa extract was not fatal to rats [66]. Thus, 200 mg/kg and 400 mg/kg were the doses used for the investigation [90]. Neither petroleum ether nor ethanolic extract of I. eriocarpa produced any side effects, adverse effects or fatality when administered to rats.

The daily magnesium intake in I. eriocarpa was 2 mg for infants and adults, despite the recommended 300–600 mg for newborns under six years old and 280–350 mg for adults. The RDAs for calcium are 800–1200 mg for adults and 600–800 mg for babies under six [91]. I. eriocarpa consumed 2.64 ppm of calcium, below the daily recommendation [92, 93]. Potassium RDA is 1600 mg for children under six and 3500 mg for adults. This study found that 100 g of I. eriocarpa provides 58 to 669 mg of potassium per day for children and adults [94]. Adults and children acquire 1-2 mg of iron from 100 g of fresh I. eriocarpa daily. Children and adults should consume 0.5 mg of zinc from wild edible plants, while babies under three and adults should consume 10 mg [95]. Thus, consuming additional foods may help meet the RDA for minerals like magnesium, calcium, potassium, iron, and zinc, which are needed for many bodily functions. I. eriocarpa has low mineral and heavy metal levels, which explains its low toxicity (Table 6).

Table 6. Micro-nutrient concentration of mineral nutrients mg/g present in Ipomoea eriocarpa for Mg, Ca, K, Fe, and Zn. [96]

Heavy Metals	Dry Weight (mg/g)	Fresh Weight (mg/g)	Daily Intake (mg/g)	Percentage Recommended Daily Allowance (%RDA) (mg/day)
Magnesium	0.101	0.02	2.02	0.72
Calcium	5.24	1.05	104.75	17.46
Potassium	15.60	3.11	310.92	19.43
Iron	0.05	0.01	0.95	9.50
Zinc	0.01	0.001	0.12	1.23

10.QUALITY CONTROL

Herbal medicine's efficacy and safety depend on phytochemical component quality control, which is complex. The drug's high quality ensures reliable pharmacodynamic, pharmacokinetic, and clinical research results. According to I. eriocarpa literature, water concentration should not exceed 10% and total ash content 15%. Water had 10.47 extractive value, while alcohol had 21.53 [97]. The fluorescence analysis[98] of the entire powder under UV light with a wavelength of 366 nm exhibited a brick-red colour. The crude drug turned reddish-green when mixed with 1N NaOH (alcoholic). Powder added to 1N HCl produced a dark brown colour, while powder added to H_2SO_4 produced a brown colour. The crude drug turned orange when mixed with acetic acid and greenish-yellow when mixed with ammonia. The phytoprofile analysis [99] of the aerial parts of I. eriocarpa revealed the following results: Petroleum ether has a green sticky consistency with a yield of 1.4%; chloroform has a dark green sticky consistency with 0.18%; acetone has 0.99%; methanol has 7.07%; and water has 1.5% [100].

11.CLINICAL STUDIES

No clinical data or ongoing clinical trials are reported on I. eriocarpa. Therefore, expansion of the study will assess its potential efficacy, side effects, drug interactions, and contraindications in humans.

12.CONCLUSION AND FUTURE PERSPECTIVES

This article reviews I. eriocarpa research in conventional applications, chemical components, pharmacological effects, clinical and food applications, and quality control. I. eriocarpa research is summarized to give readers a complete picture. The Indian Medicinal Plant promotes I. eriocarpa for headaches, rheumatism, leprosy, epilepsy, ulcers, and fever. According to ancient literature and everyday use, it is consumed as a cooked vegetable, in soups, or in other dishes in India. Ugandan women use

root-based herbal remedies for period pain. Veterinary medicine treats cow lesions with oil extract. I. eriocarpa has a higher survival rate than other weeds, according to research. They adapt to different weather and thrive in subtropical and semi-arid soil with a slightly acidic pH. This plant's powdered and whole forms were identified. Alkaloids, flavonoids, terpenoids, saponins, carbohydrates, proteins, phenols, and phytosterols are the main phytoconstituents. The petroleum ether extract of I. eriocarpa did not kill rats or change their behaviour in acute and sub-acute toxicity studies. Pharmacognostic and phytochemical metrics are also established. In cerebral ischemia, the ethanolic extract of I. eriocarpa reduces behavioural abnormalities, increases locomotor activity, and preserves neuronal function. It outperforms BHT in antioxidant activity. It inhibits Staphylococcus aureus, Pseudomonas aeruginosa, Bacillus subtilis, Escherichia coli, and Aspergillus oryzae and niger. The whole plant extract protects the liver by increasing liver cell protein and lowering ALT, ALP, bilirubin, and AST. I. eriocarpa AgNPs were more potent as anti-inflammatory agents than the plant's aqueous extract, according to research. Absorbance, XRD, TEM, and zeta potential were also measured. I. eriocarpa leaf extract prevents urinary stones and urolithiasis. According to XRD, FT-IR, and TG-DTA, increasing the ethanolic extract concentration reduces struvite stones in gel-like material. I. eriocarpa extracts prevent protein denaturation, which is anti-arthritic. Terpenoids in chloroform and petroleum ether extracts inhibit amylase enzymes better than water extracts.

Despite extensive research, I. eriocarpa has many drawbacks. The structure-activity relationship of I. eriocarpa was complicated by the lack of phytoconstituent information in the chemical composition literature. The study also fails to isolate I. eriocarpa's non-volatile chemicals. Besides the leaves and bark, I. eriocarpa may be studied in other ways. To fully understand I. eriocarpa's healing abilities, we must study its non-therapeutic components. This study also highlighted I. eriocarpa growth limitations and may inform future research and implementation.

I,eriocarpa's diverse chemical components and unique biological properties make it popular in traditional medicine. I. eriocarpa research currently emphasizes molecular and cellular pharmacology rather than chemistry. New pharmacology and medicinal uses are the most significant developments in this field.

ABBREVIATIONS

I. eriocarpa- Ipomoea eriocarpa, T.C- Transverse Cut, L.C- Longitudinal Cut, S. aureus-Staphylococcus aureus, P. aeruginosa-Pseudomonas aeruginosa, B. subtilis-Bacillus subtilis, E. coli- Escherichia coli, A. oryzae- Aspergillus oryzae, and A. niger- Aspergillus niger, BHT-Butylated hydroxyl toluene, ALT- Alanine Transaminase, ALP- alkaline phosphatase, AST- Aspartate Transaminase, TEM- Transmission electron microscopy, IR- Infrared, XRD- X-Ray diffraction analysis, FT-IR- Fourier transform infrared, TG-DTA- Thermogravimetry Differential Thermal Analysis, UV- Ultra-Violet, GC-MS- Gas Chromatography- Mass Spectroscopy, p.o- Per oral, HCl- Hydrochloric Acid, AgNPs- Silver Nanoparticles, OECD- Organisation for Economic Co-operation and Development, NaOH- Sodium Hydroxide, H_2SO_4- Sulfuric Acid BCAO- Bilateral Carotid Artery Occlusion

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