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Review Article

The Globe Amaranth in Focus: Therapeutic Prospects and Phytochemical Riches of *Gomphrena globosa* L.

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ABSTRACT

Gomphrena globosa L., commonly known as globe amaranth, is a traditional medicinal plant widely used in folk medicine across Asia, Africa, and Latin America. Known for its vibrant inflorescences and high phytochemical content, it has been increasingly studied for its pharmacological and therapeutic potential. This review systematically compiles experimental data from in vivo and in vitro studies, ethnomedicinal records, and phytochemical analyses. Literature was sourced from peer-reviewed journals, patents, and pharmacognosy databases, focusing on extraction methods, bioactive compounds, pharmacological activities, and traditional applications. Various plant parts, especially flowers and leaves, contain rich classes of phytochemicals including phenolics, flavonoids, betacyanins, saponins, and triterpenoids. Pharmacological studies demonstrate significant antioxidant, anti-inflammatory, anticancer, hepatoprotective, neuroprotective, antidiabetic, and analgesic activities. Multiple extracts (ethanolic, methanolic, aqueous) and fractions showed efficacy in models such as carrageenan-induced edema, CCl_4-induced hepatotoxicity, and cognitive impairment in mice. GC-MS profiling confirmed the presence of functionally relevant compounds, while traditional systems have long applied the plant in decoctions, infusions, and topical formulations for ailments ranging from cough and inflammation to liver disorders. Emerging commercial formulations and patents underscore its translational relevance. Gomphrena globosa exhibits broad pharmacological potential supported by traditional use and experimental validation. Future work should focus on clinical evaluation, standardization of extracts, and exploration of synergistic effects for drug development.

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INTRODUCTION

Gomphrena globosa L., commonly referred to as globe amaranth or "bachelor's button," is an annual herb belonging to the Amaranthaceae family. Native to Central America, it now flourishes in tropical and subtropical regions worldwide due to its heat tolerance and vibrant flowering habit [01][02]. The plant produces striking spherical inflorescences ranging from violet and red to orange, white, and pink that are widely used in ornamental gardening, drying for leis, and culinary decorations. [02][03] Traditionally, G. globosa has been used in various folk systems of medicine. In Chinese herbal practices, its flowers are brewed into teas or syrups to soothe coughs and respiratory ailments [02]. In South Asia and Latin America, the plant is valued for its soothing, anti-inflammatory, diuretic, and antidiabetic properties. Symbolically, it is also popular in cultural rituals, such as garlands worn for sibling ceremonies in Nepal.[03] Phytochemical research has revealed a diverse chemical profile in G. globosa, including flavonoids, phenolic acids, saponins, and betacyanins (e.g., gomphrenin I–III), which contribute to its rich antioxidant and anti-inflammatory potential. [01][03] These bioactive compounds have shown promising in vitro activity, such as free-radical scavenging and inhibition of nitric oxide production, underscoring its pharmacotherapeutic relevance. [01][03] Despite these findings, comprehensive reviews that integrate G. globosa's ethnobotanical significance, chemical characterization, cultivation practices, and pharmacological evidence remain scarce. This review aims to fill that gap by providing an updated, holistic perspective on G. globosa, emphasizing its potential as both a therapeutic herb and a botanical resource.

Taxonomy and Botanical Description

Taxonomy of Gomphrena globosa L.

Gomphrena globosa L. belongs to the family Amaranthaceae, which is well-known for its diverse genera comprising herbaceous plants and shrubs widely distributed across tropical and subtropical regions.

Table No.01 - The taxonomic classification of G. globosa

Taxonomic Rank	Classification
Kingdom	Plantae
Subkingdom	Tracheobionta (Vascular plants)
Superdivision	Spermatophyta (Seed plants)
Division	Magnoliophyta (Flowering plants)
Class	Magnoliopsida (Dicotyledons)
Order	Caryophyllales
Family	Amaranthaceae
Genus	*Gomphrena*
Species	*Gomphrena globosa* L.

The genus name Gomphrena is derived from the Greek word "gomphos," meaning "bolt" or "nail," referring to the firm, globular flower heads characteristic of this genus. The species epithet "globosa" highlights the spherical shape of the inflorescences, which is one of the most distinct morphological features of this plant. [04]

Botanical Description

Gomphrena globosa is a robust, annual herbaceous plant typically growing between 30 and 90 cm in height, although in optimal conditions, it may reach slightly taller heights. [05] The plant exhibits a bushy and branched habit with erect or slightly spreading stems that are often hairy, lending a soft texture to the plant. The leaves of G. globosa are simple, opposite, ovate to lanceolate in shape, and usually covered with fine hairs, which contribute to a grayish-green appearance. They measure approximately 2 to 7 cm in length and 1 to 3 cm in

width. The leaf margins are entire with a smooth texture, and the petioles are short and sturdy. [06] The most distinguishing feature of G. globosa is its compact, globe-shaped flower heads, which are composed of numerous tiny flowers densely packed together. These flower heads come in a variety of vibrant colors including purple, magenta, pink, red, white, and orange, making the species popular as an ornamental plant. [07] Each flower is small, tubular, and sessile, enclosed within papery bracts that give the flower head a papery texture, which also makes them suitable for dried floral arrangements. [05] The inflorescences typically bloom during the summer months and can last several weeks. The flowering is followed by small, inconspicuous seeds contained in dry fruit capsules. The seeds are minute, dark brown to black, and have a smooth surface that facilitates dispersal by wind or water. [06]

Ecological Preferences and Distribution

Gomphrena globosa thrives best in warm, sunny environments with well-drained soils. It prefers sandy to loamy substrates and can tolerate moderate drought conditions, making it well-suited for cultivation in tropical and subtropical climates. [07] The plant is widely distributed globally, having naturalized in many regions beyond its native range in Central and South America, including parts of Asia, Africa, and the southern United States. [04] Its resilience to adverse conditions, combined with its aesthetic appeal and medicinal uses, has contributed to its wide acceptance and cultivation in both home gardens and commercial horticulture.

Cultivation

Gomphrena globosa is relatively easy to cultivate and is well-suited for a variety of growing conditions, making it a popular choice among gardeners and commercial growers alike. The plant thrives best in warm, sunny locations with well-drained soils, preferably sandy loam to loam, which provide good aeration and moisture retention without waterlogging. [08] It exhibits moderate drought tolerance, although regular watering during dry spells enhances growth and flowering. Propagation is primarily done through seeds, which should be sown directly in the field or nursery beds after the last frost has passed, as G. globosa is sensitive to cold. [09] Seeds germinate optimally at temperatures between 20–30°C, usually within 7 to 14 days. For transplanting, seedlings are typically ready after 4–6 weeks, when they have developed 4–6 true leaves. The recommended spacing for planting is about 30–45 cm between plants and rows to allow adequate airflow and reduce competition for nutrients. [10] Fertilization practices involve the application of balanced NPK fertilizers to promote healthy vegetative growth and vibrant flowering. Organic compost or well-rotted manure can also be applied during soil preparation to improve soil fertility and structure. [08]

Flowering

Flowering in Gomphrena globosa generally begins 60 to 75 days after sowing, continuing for several weeks during the warm months, typically summer through early autumn. [09] The spherical inflorescences appear at the terminal ends of the branches and display a rich spectrum of colors including purple, magenta, red, and white, which are highly prized for ornamental use. [10] Environmental factors such as adequate sunlight (at least 6 hours daily), temperature, and soil fertility significantly influence flowering intensity and duration. The plant's flowering cycle can be extended by regular deadheading (removal of spent flower heads), which stimulates the production of new blooms and enhances overall visual appeal. [08]

Harvesting

The harvesting of Gomphrena globosa is mainly focused on flower heads, especially when used for dried flower arrangements or medicinal purposes. Flower heads are harvested at full bloom when the bracts are firm and papery but before they start to fade or lose structural integrity. [11] Harvesting is typically done in the morning hours to preserve the freshness and color vibrancy of the flowers. Cut flower heads can be used fresh or dried by air-drying in a shaded, well-ventilated area to retain color and shape for extended periods. [11] Seed harvesting occurs after flowering, usually when the seed capsules turn brown and dry, signaling seed maturity. Seeds are then collected and cleaned for subsequent planting or commercial use. [10] The timing and method of harvesting greatly affect the quality of both flowers and seeds, which in turn influence their commercial and medicinal value.

History and Discovery

Gomphrena globosa L., commonly known as globe amaranth, has a rich history that traces back to its origins in Central and South America. It was first described scientifically by Carl Linnaeus in 1753 in his work Species Plantarum, where it was classified under the genus Gomphrena.[12] The genus name Gomphrena is derived from the Greek word "gomphos," meaning "bolt" or "nail," which likely refers to the shape of the flower heads. [13] Historically, Gomphrena globosa was cultivated by indigenous peoples not only as an ornamental plant due to its vibrant, long-lasting flowers but also for its various traditional uses. The flowers were often used in ceremonial decorations and as natural dyes for textiles because of their vivid and enduring coloration.[14] Over centuries, the plant was introduced to other tropical and subtropical regions worldwide, including Asia and Africa, where it gained popularity as both an ornamental and medicinal plant. The plant's resilience and ability to thrive in diverse climates contributed to its widespread cultivation. Its significance extends beyond aesthetics; many traditional medicine systems have recognized its potential therapeutic properties, paving the way for scientific exploration in recent decades. [15]

Species of Gomphrena

The genus Gomphrena belongs to the family Amaranthaceae and includes around 120 species distributed mainly across tropical and subtropical regions. [16] Among these, several species have gained horticultural and medicinal importance, including:

- **Gomphrena globosa L.:** The most widely cultivated species, known for its bright, globe-shaped flower heads. It is used extensively in gardens and floral arrangements. [17]
- **Gomphrena haageana Klotzsch:** Commonly referred to as "strawberry globe amaranth," this species is native to Mexico and characterized by its bright pink flower clusters. [18]
- **Gomphrena celosioides Mart.:** A wild species often found in disturbed areas, known for its smaller, less showy flowers. It has some traditional medicinal uses in its native regions [19]
- **Gomphrena perennis L.:** Another species used ornamentally, notable for its prostrate growth habit and smaller flower heads. [16]

Each species within the genus shares similar botanical features but differs in flower color, growth habit, and geographic distribution. The diversity within the genus offers a wide range of potential uses in landscaping, medicine, and industry.

Description of Plant Parts and Identification

Gomphrena globosa L. is a charming herbaceous annual plant known for its distinctive globe-shaped flowers and vibrant colors, making it easily recognizable in gardens and wild settings alike. [20]

Roots

The plant has a fibrous root system that is shallow but well spread out, allowing it to absorb moisture efficiently in dry, well-drained soils. The roots are relatively thin and branched, anchoring the plant securely in the ground. [21]

Stem

The stems of Gomphrena globosa are erect, branched, and sturdy, typically growing between 30 to 90 cm in height. They are somewhat hairy, giving a slightly rough texture to the touch. The stem coloration ranges from green to reddish depending on environmental conditions. [22]

Leaves

The leaves are simple, opposite, and ovate to lanceolate in shape, measuring about 3–7 cm long and 1–3 cm wide. Their surface is slightly hairy, especially on the underside, which helps reduce water loss. The leaf margins are entire (smooth), and the color is a medium to dark green. The petiole is short, attaching the leaf blade directly to the stem [23]

Flowers

The most striking feature of Gomphrena globosa is its flower heads, which are round and clover-like, often called "globe amaranth." These compact flower clusters are made up of numerous tiny, papery bracts that maintain their bright colors (usually purple, magenta, red, pink, white, or lavender) even after drying. The flower heads are borne on long stalks at the end of the branches and bloom primarily in summer and autumn [24]

Fruits and Seeds

The fruits are small, dry, and one-seeded, enclosed within the persistent flower bracts. The seeds are tiny, brown to black, and smooth, which are dispersed naturally by wind or water. The plant's seeds are known for their good viability and easy germination [25]

Identification

- **Distinctive Globe-shaped Flower Heads:** The round, brightly colored flower clusters are the easiest way to identify Gomphrena globosa. No other common plant produces such compact, papery, globe-like flowers.
- **Hairy Leaves and Stems:** Both leaves and stems have fine hairs which give a slightly rough texture, helping to distinguish it from smooth-leafed species.
- **Growth Habit:** It is a bushy, low-maintenance annual, often found in sunny, well-drained places.
- **Flower Longevity:** The flowers last long on the plant and retain color well after drying, commonly used in dried flower arrangements. [26]

These features combined make Gomphrena globosa a unique and easy-to-identify species for botanists, gardeners, and herbalists alike.

Traditional Uses of Gomphrena globosa L.

Gomphrena globosa, known in traditional systems as globe amaranth, has been widely used across different cultures for its medicinal, ornamental, and spiritual value. It has a particularly long-standing presence in folk medicine in Asia, South America, and the Caribbean.

In Ayurvedic and Unani medicine, dried flowers and leaves are brewed into teas or decoctions to relieve respiratory ailments like cough, bronchitis, and asthma. The plant is considered cooling and soothing, used to balance excess heat and inflammation in the body. [27]

In Brazilian folk medicine, the infusion of flower heads is popularly consumed as a herbal tea ("chá de sempre-viva") to treat conditions like hypertension, diabetes, and gastrointestinal problems. [28] The plant has also been used to relieve urinary discomfort and menstrual irregularities.

In Caribbean traditional use, G. globosa is believed to have calming properties, often used for managing nervous disorders, insomnia, and fatigue, especially when combined with other herbs. [29]

Additionally, the flowers were used as natural dyes in textiles and foods due to their vibrant and lasting color, and symbolically in ceremonies for their association with immortality and vitality.

Modern Applications and Approved Pharmacological Activities

With increased scientific interest in ethnomedicine, Gomphrena globosa has gained attention in pharmacological research. Several studies have validated its bioactivity, leading to novel uses and product development.

1. Antioxidant Activity

Modern studies show that G. globosa contains phenolic compounds, flavonoids (such as vitexin and betacyanins), and saponins with significant antioxidant capacity. These constituents scavenge free radicals, suggesting its potential in anti-aging, cardiovascular protection, and neuroprotection. [30]

2. Anti-inflammatory and Analgesic Effects

Methanolic extracts from the plant have demonstrated anti-inflammatory effects in laboratory models, comparable to standard NSAIDs. The activity is believed to be mediated through the inhibition of cyclooxygenase (COX) enzymes and reduced expression of pro-inflammatory cytokines. [31]

3. Anticancer Potential

In vitro studies have shown that ethanol extracts of G. globosa exhibit cytotoxic activity against human cancer cell lines, including breast (MCF-7) and cervical (HeLa) cells. The flavonoids and glycosides are suggested to induce apoptosis via mitochondrial pathways, although further research is needed for clinical application. [32]

4. Antimicrobial Activity

Ethanolic and aqueous extracts of the flower heads have been reported to inhibit the growth of both Gram-positive and Gram-negative bacteria, as well as certain fungi. These effects support traditional uses in oral hygiene and skin infections. [33]

5. Neuroprotective and Antistress Properties

Animal models have shown that aqueous flower extracts can reduce stress-induced behavioral changes and enhance cognitive performance, potentially through GABAergic modulation and antioxidant defense mechanisms. This supports its use in folk medicine for anxiety and insomnia. [34]

Table No. 02 - Neuroprotective and Antistress Properties of Gomphrena globosa

Use Type	Application Area	Details & Bioactivity	Reference
Traditional Use	Respiratory relief	Tea from flowers used for cough, asthma	[27], [28]
Traditional Use	Nervous disorders	Calming herb for stress, fatigue, and insomnia	[29]

Traditional Use	Antihypertensive tea	Used in Brazil as a folk remedy for blood pressure control	[28]
Modern Application	Antioxidant	Rich in flavonoids, combats oxidative stress	[30]
Modern Application	Anti-inflammatory	Comparable to NSAIDs; COX inhibition	[31]
Modern Application	Anticancer	In vitro cytotoxicity against MCF-7 and HeLa cells	[32]
Modern Application	Antimicrobial	Broad-spectrum activity against pathogens	[33]
Modern Application	Neuroprotective	Reduces stress, enhances memory; supports GABA system	[34]

Ethnomedicinal and Traditional Uses of Gomphrena globosa L.

Gomphrena globosa L., commonly known as Globe Amaranth or "Bachelor's Button", holds a notable place in ethnomedicine across Asia, South America, and the Caribbean. The plant's therapeutic use is deeply rooted in indigenous traditions, where various parts especially the flowers and leaves are employed for a wide range of ailments.

1. Respiratory Disorders

In traditional medicine systems, the dried flowers of G. globosa are widely used to prepare herbal teas for asthma, bronchitis, and chronic coughs. The flowers are believed to have expectorant and soothing properties that help clear mucus and ease breathing difficulties. In Ayurvedic practice, decoctions made from the inflorescences are prescribed for respiratory imbalances associated with Kapha dosha. [35]

2. Digestive and Gastrointestinal Health

Folk healers in Brazil and parts of Southeast Asia use flower infusions to manage indigestion, flatulence, and gastric ulcers. The plant is considered cooling and carminative, and it is also consumed post-meal as a digestive tea. [36]

3. Antihypertensive and Cardioprotective Effects

Traditional healers in Northeastern Brazil prepare a tea called chá de sempre-viva using the dried flower heads, which is consumed regularly to regulate blood pressure and heart rate. This practice is passed down across generations and is based on the observed mild diuretic and vasorelaxant effects of the plant. [37]

4. Anti-aging and Skin Health

In Caribbean and Southeast Asian folk medicine, crushed flowers are mixed with oils or balms and applied topically to manage rashes, wounds, and sunburns. It is believed that the antioxidant content helps rejuvenate the skin, reduce inflammation, and slow signs of aging. Dried petals have also been used traditionally in herbal steam baths and facial rinses.[38]

5. Female Reproductive and Urinary Health

G. globosa is used in traditional Nepalese and Indian medicine to support menstrual regulation and alleviate leucorrhea. Women are advised to drink a decoction of flower heads for a few days during their menstrual cycle. The plant's mild diuretic and soothing properties also make it suitable for treating urinary tract infections. [39]

6. Mental Calm and Stress Relief

In Trinidad and Tobago, and in some parts of India, the plant is used as a nerve tonic, especially in the form of a tea consumed before bedtime. It is

used to relieve anxiety, insomnia, and stress-induced headaches, often in combination with other calming herbs such as lemon balm and chamomile. [40]

7. Miscellaneous Uses

- Used as an ingredient in herbal shampoos to treat dandruff and hair fall.
- In traditional rituals, dried flowers are offered for their symbolism of longevity and immortality.
- Occasionally used as a natural dye for food and textiles due to its color stability.

Table No. 03 - Ethnomedicinal Uses of Gomphrena globosa Across Different Regions

Ailment / Use Area	Plant Part Used	Mode of Application	Traditional System / Region	Reference
Asthma, Cough, Bronchitis	Flowers	Tea / decoction	Ayurveda, Caribbean, Brazil	[35]
Gastric issues, Flatulence	Flowers	Oral infusion	Southeast Asia, Brazil	[36]
High Blood Pressure	Flower heads	Herbal tea	Northeastern Brazil	[37]
Skin rejuvenation, Burns	Crushed flowers	Topical application	Southeast Asia, Caribbean	[38]
Menstrual issues, Leucorrhea	Flowers, whole plant	Decoction	Indian folk medicine, Nepal	[39]
Anxiety, Sleeplessness	Flowers	Night-time infusion	Caribbean, Indian traditional medicine	[40]

1. Traditional Aqueous Extraction

Aqueous extraction is the most common method used in folk medicine. This involves boiling dried or fresh plant parts (usually flowers) in water for 10–30 minutes, followed by cooling and filtration. This method is used primarily for infusions and decoctions, commonly consumed as herbal teas for respiratory, digestive, and calming effects. [41]

- Advantages: Simple, non-toxic, cost-effective.
- Limitations: Limited to water-soluble compounds; may degrade heat-sensitive constituents.

2. Maceration

In laboratory settings, maceration is frequently used for preliminary extraction. Dried plant material is soaked in solvents like methanol, ethanol, or hydroalcoholic mixtures (ethanol:water 70:30) for 24–72 hours at room temperature. This allows diffusion of soluble phytochemicals such as flavonoids, saponins, phenolics, and betacyanins. [42]

- Ideal for: Heat-sensitive compounds.
- Common solvents: Ethanol, methanol, acetone, chloroform, water.

3. Soxhlet Extraction

Soxhlet extraction is employed for exhaustive recovery of bioactives from the plant material using organic solvents. This method uses a continuous reflux system where the solvent evaporates, condenses, and passes through the sample repeatedly.

- Used for: Isolating thermally stable, non-polar compounds such as fatty acids and sterols.
- Common solvents: Hexane, ethyl acetate, methanol. [43]

4. Ultrasound-Assisted Extraction (UAE)

UAE is an advanced green extraction method where ultrasonic waves are used to disrupt plant cell walls, enhancing the release of intracellular compounds.

- Benefits: Shorter extraction time, better yield of flavonoids and antioxidants.
- Ideal for: Sensitive compounds like betacyanins and polyphenols from G. globosa flowers. [44]

5. Microwave-Assisted Extraction (MAE)

Microwave energy is used to heat polar solvents rapidly, which enhances mass transfer and breaks plant tissues, leading to efficient extraction of active compounds.

- Effective for: Thermostable flavonoids and phenolic acids.
- Not suitable: For volatile or highly heat-sensitive compounds. [45]

6. Supercritical Fluid Extraction (SFE)

Though less common for G. globosa, SFE using supercritical CO_2 has potential for isolating lipophilic compounds with minimal solvent residue. This eco-friendly technique may be explored for nutraceutical formulations.

- Best for: Volatile and non-polar constituents.
- Limitation: Expensive, requires specialized equipment. [46]

Table No. 04 - Extraction Strategies for Bioactive Compounds from Gomphrena globosa: Solvents, Targets, and Applications

Extraction Method	Solvent(s) Used	Target Compounds	Pros / Applications	Reference
Aqueous decoction/infusion	Water	Water-soluble polyphenols, saponins	Traditional use, herbal teas	[41]
Maceration	Methanol, ethanol, water	Flavonoids, saponins, phenolics	Simple, low-tech; ideal for routine screening	[42]
Soxhlet Extraction	Methanol, hexane, acetone	Lipids, sterols, alkaloids	Exhaustive recovery; for non-polar constituents	[43]
Ultrasound-Assisted Extraction (UAE)	Ethanol, water	Betacyanins, antioxidants	High efficiency, fast extraction	[44]
Microwave-Assisted Extraction (MAE)	Polar solvents	Polyphenols, flavonoids	High-speed extraction, reduced solvent use	[45]
Supercritical Fluid Extraction (SFE)	CO_2, ethanol modifiers	Lipophilic molecules, volatile oils	High purity extracts, solvent-free	[46]

Phytochemical Profile of Gomphrena globosa L.

The phytochemical richness of Gomphrena globosa L. is the foundation of its wide range of traditional and pharmacological applications. Multiple studies have confirmed the presence of both primary and secondary metabolites in various parts of the plant, particularly in its vibrant flowers and green aerial parts. The flowers are especially valued due to their high content of natural pigments (betacyanins) and antioxidants, while the leaves and roots contain bioactive molecules relevant to therapeutic functions.

Table No. 05 - Phytochemical Composition of Gomphrena globosa and Its Pharmacological Relevance

Phytochemical Class	Examples Identified	Plant Parts	Pharmacological Relevance	Reference

Betacyanins (betalain pigments)	Gomphrenin I, II, III, Isogomphrenin	Flowers	Antioxidant, anti-inflammatory, anti-cancer	[47]
Flavonoids	Quercetin, Rutin, Kaempferol derivatives	Leaves, flowers	Antioxidant, cardioprotective, anti-allergic	[48]
Saponins	Triterpenoid-type	Whole plant	Immunomodulatory, cholesterol-lowering, antimicrobial	[49]
Phenolic acids	Gallic acid, Ferulic acid, Caffeic acid	Flowers, stems	Free radical scavenging, anti-aging	[50]
Polysaccharides	Mucilage polysaccharides	Flowers, seeds	Anti-ulcer, demulcent, wound healing	[51]
Vitamins	Ascorbic acid (Vitamin C), Beta-carotene (provitamin A)	Flowers	Nutritional and antioxidant properties	[48]
Minerals	Calcium, Magnesium, Potassium, Iron	Aerial parts	Nutraceutical potential	[52]

2. Minor and Trace Constituents

Although present in lower concentrations, G. globosa also contains a variety of minor compounds that synergistically contribute to its therapeutic value:

- Alkaloids – Detected in root extracts in trace amounts; may contribute to sedative and anti-inflammatory actions. [49]
- Sterols – Including β-sitosterol and stigmasterol in stem and leaf fractions; relevant to anti-inflammatory and lipid-lowering activities. [50]
- Essential oils – Volatile compounds contributing to mild antimicrobial and aromatic effects; mainly in flower heads. [51]
- Amino acids – Proline, lysine, and glutamic acid, which support skin repair and tissue healing. [52]

Table No. 06- Mapping Bioactive Compounds in Gomphrena globosa Plant Parts and Their Therapeutic Potential

Plant Part	Key Compounds Found	Phytochemical Classes	Notable Functions
Flowers	Betacyanins (gomphrenins), flavonoids, phenolic acids	Pigments, polyphenols	Antioxidant, coloring agent, anti-inflammatory
Leaves	Flavonoids, tannins, saponins	Polyphenols, triterpenoids	Antimicrobial, hepatoprotective
Roots	Saponins, alkaloids	Glycosides, alkaloids	Immunomodulatory, analgesic
Seeds	Polysaccharides, oils	Mucilage, essential fatty acids	Demulcent, wound healing

Table No. 07 - Distribution of Phytochemicals by Plant Part

Plant Part	Key Compounds Found	Phytochemical Classes	Notable Functions	Plant Part
Flowers	Betacyanins (gomphrenins), flavonoids, phenolic acids	Pigments, polyphenols	Antioxidant, coloring agent, anti-inflammatory	**Flowers**
Leaves	Flavonoids, tannins, saponins	Polyphenols, triterpenoids	Antimicrobial, hepatoprotective	**Leaves**
Roots	Saponins, alkaloids	Glycosides, alkaloids	Immunomodulatory, analgesic	**Roots**
Seeds	Polysaccharides, oils	Mucilage, essential fatty acids	Demulcent, wound healing	**Seeds**

Phytochemical Isolation Techniques Used

- **HPLC and LC-MS/MS** for quantification of betacyanins and flavonoids [47]
- **GC-MS** for identification of volatile components and sterols [51]
- **UV-Vis spectrophotometry** for total phenolic and flavonoid content [48]
- **Gravimetric and colorimetric assays** for total saponin estimation [49]

Marketed Formulations and Patents of Gomphrena globosa L.

The transition of Gomphrena globosa L. from traditional ethnobotanical use to commercial formulations and patented applications reflects its growing relevance in modern herbal medicine, cosmetics, and nutraceuticals. Various pharmaceutical, cosmetic, and food-grade industries have capitalized on its vibrant betacyanins, antioxidants, and anti-inflammatory constituents to create both over-the-counter (OTC) and therapeutic products.

1. Phytocosmetic and Dermatology Products

One of the most prominent applications of G. globosa is in cosmeceuticals, where its natural pigments (gomphrenins) and polyphenolic antioxidants are incorporated into anti-aging creams, serums, and soothing emulsions. A patented formulation (US Patent No. 10,898,765) by Pierre Fabre Dermo-Cosmétique includes G. globosa flower extract in a topical cream designed to reduce oxidative stress and inflammation in sensitive skin conditions such as rosacea and eczema. [53]

- **Patent:**
  WO2020136783A1 details a dermatological emulsion containing purified Gomphrenin I, exhibiting skin barrier restoration and UV-protective activity. [54]

2. Nutraceutical & Functional Beverages

Due to its coloring and antioxidant properties, G. globosa flower extract is increasingly used in functional drinks, herbal teas, and dietary supplements. In Southeast Asia, dried flower formulations (under trade names like Globe Tea and VitaPurple) are marketed for liver detoxification, eye health, and relaxation. These teas often appear in Thailand, Vietnam, and India. [55]

- **Patent:**
  CN109284843A protects a natural health beverage composition made from G. globosa for enhancing immunity and reducing fatigue. [56]

3. Pharmaceutical Applications

G. globosa is being incorporated in polyherbal capsules and syrups for respiratory support and antioxidant therapy. In India, companies like Himalaya and Baidyanath include G. globosa extracts in combination formulations for bronchial relief and liver support.

- **Patent:**
  IN202041028930A describes a herbal syrup incorporating G. globosa and Tulsi (Ocimum sanctum) for pediatric cough relief. [57]

4. Food Industry Applications

As a natural, water-soluble red-violet pigment, betacyanins from G. globosa are being considered as an alternative to synthetic dyes in confectionery and beverages. European patent EP3205482A1 focuses on extracting gomphrenins for natural

food coloring, with applications in non-alcoholic drinks and jelly-based snacks. [58]

Table No. 08 - Formulations and Applications of Gomphrena globosa in Health and Industry

Application Area	Formulation Type	Key Uses / Benefits	Patent / Market Details	Reference
Cosmetics / Dermatology	Topical cream, serum, emulsion	Anti-aging, UV protection, reduces skin inflammation	US Patent 10,898,765; WO2020136783A1	[53], [54]
Nutraceuticals / Beverages	Herbal tea, supplement drinks	Detox, antioxidant, vision support, stress relief	CN109284843A; "Globe Tea", "VitaPurple" (SE Asian market)	[55], [56]
Pharmaceuticals	Polyherbal syrup, capsule	Respiratory wellness, pediatric cough, liver tonic	IN202041028930A; Ayurvedic OTC brands in India	[57]
Food Coloring	Extract concentrate (betacyanin)	Natural red/purple pigment for beverages and confections	EP3205482A1 – Gomphrenin-rich colorant	[58]

Experimental Evidence from Recent Studies on Gomphrena globosa L.

Preclinical research has increasingly supported the traditional uses of Gomphrena globosa L., particularly due to its potent antioxidant, anti-inflammatory, hepatoprotective, and anticancer properties. Various plant parts especially the flowers have been tested using in vitro and in vivo models.

Table No. 09- Pharmacological Activities of Gomphrena globosa L. Experimental Validation

Pharmacological Activity	Plant Part	Extract / Isolate	Dose / Route	Bioactive Dose	Positive Control	Negative Control	Animals / Cell Lines	Experimental Model & Parameters	Mechanism of Action	Inference	Reference
Antioxidant	Flowers	Ethanolic extract	50–200 mg/kg, oral	100 mg/kg	Ascorbic acid	Saline	Wistar rats	DPPH, FRAP assays, lipid peroxidation inhibition	Free radical scavenging, phenolic synergy	Strong antioxidant activity, dose-dependent response	[59]
Anti-inflammatory	Flowers	Methanolic extract	100, 200, 400 mg/kg, oral	200 mg/kg	Diclofenac sodium	CMC solution	Albino rats	Carrageenan-induced paw edema	Inhibition of COX pathway, cytokine suppression	Significant edema reduction after 3 hours	[60]
Anticancer	Flowers	Gomphrenin-rich fraction	5–50 µg/mL	25 µg/mL	Doxorubicin	Untreated cells	MCF-7 (breast), HeLa (cervix)	MTT, apoptosis markers, cell cycle arrest	Induction of apoptosis via mitochondrial pathway	Potent cytotoxicity against cancer cells	[61]
Hepatoprotective	Leaves	Aqueous extract	100, 200 mg/kg, oral	200 mg/kg	Silymarin	CCl_4-only group	Wistar rats	CCl_4-induced hepatotoxicity (ALT, AST, MDA)	Restoration of hepatic enzymes, antioxidant support	Significant liver protection at higher dose	[62]

Neuroprotective	Whole plant	Hydroethanolic extract	50, 100 mg/kg, oral	100 mg/kg	Piracetam	Vehicle-treated	Mice	Scopolamine-induced cognitive deficit, Y-maze, NOR test	Cholinergic enhancement, oxidative defense	Improved memory retention & learning behavior	[63]
Anti-inflammatory/ Antioxidant	Inflorescences	Decoction & betacyanin-rich extract	In vitro: up to 500 µg/mL	~500 µg/mL	LPS-stimulated cells	Unstimulated	RAW 264.7 macrophages	NO production in LPS-stim; scavenging of superoxide & other radicals; DPPH, FRAP assays (pubmed.ncbi.nlm.nih.gov, jddtonline.info)	Inhibition of NO and reactive species; phenolic/betacyanin synergy	Promising antioxidant and anti-inflammatory effects	[64]
Antiinflammatory + Phytochemical Profiling	Flowers	Decoction & hydroalcoholic extract	In vitro: 500 µg/mL	500 µg/mL	Aspirin, Diclofenac	Vehicle	Protein denaturation; HRBC stabilization; anti-protease	pH and heat-induced albumin denaturation, HRBC hemolysis assays	Protein stabilization; COX pathway; GC-MS identified actives	Dose-dependent potent anti-inflammatory activity	[65]
Antidiabetic, Antioxidant, Antiglycation	Leaves	Ethanolic leaf extract	In vitro: up to 500 µg/mL	~500 µg/mL	Acarbose?	Unstimulated	Enzyme assays	α-Amylase inhibition; DPPH + hydroxyl radical scavenging; antiglycation over 24–72 h	Inhibits carbohydrate digestion enzymes; radical scavenging; reduces AGEs	Multi-pronged antidiabetic potential in vitro	[66]
Phytochemical + GC-MS profiling	Flowers	Ethanolic extract	GC-MS qualitative	—	—	—	Chemical profiling	GC-MS identified 11 phytocompounds: sterols, triterpenoids, tannins, phenols; docosanoic acid esters	Presence of known anti-inflammatory/cytotoxic phytochemicals	Rationalizes in vitro bioactivity	[67]
Analgesic & Cardiovascular	Whole plant	Methanolic extract & fractions	400 mg/kg, oral	400 mg/kg	Aspirin	Vehicle	In vivo; hot plate/carrageenan-induced pain, plus separate cardiovascular	Central/peripheral analgesia assays; cardiovascular parameters	Likely modulates pain pathways centrally and peripherally	Identified fractions effective in analgesia & possible BP effects	[68]

Gomphrena globosa L., commonly known as globe amaranth, is a medicinal plant with a wide spectrum of pharmacological properties validated by in vivo and in vitro studies. Various parts of the plant, including flowers, leaves, and the whole

plant, have demonstrated significant therapeutic potential across multiple biological systems.

Antioxidant and Anti-inflammatory Activity

Multiple studies confirm the potent antioxidant capacity of G. globosa, attributed to its high phenolic and betacyanin content. Ethanolic and methanolic flower extracts showed strong free radical scavenging in DPPH and FRAP assays, with dose-dependent responses in animal models. Anti-inflammatory studies revealed suppression of nitric oxide (NO) production and cytokine release in LPS-stimulated macrophages and carrageenan-induced paw edema models, implicating COX pathway inhibition and protein stabilization as key mechanisms.

Anticancer Activity

Gomphrenin-rich fractions from the flowers showed notable cytotoxic effects on MCF-7 and HeLa cell lines. The activity was mediated via mitochondrial-induced apoptosis and cell cycle arrest, comparable to standard drugs like doxorubicin, suggesting promising anticancer potential.

Hepatoprotective and Neuroprotective Effects

Aqueous extracts of G. globosa leaves offered substantial hepatoprotection in CCl_4-induced liver toxicity models by restoring hepatic enzyme levels and reducing oxidative damage. Additionally, hydroethanolic extracts of the whole plant improved memory retention and learning in scopolamine-induced cognitive deficit models in mice, indicating cholinergic modulation and antioxidant defense as likely mechanisms

Antidiabetic and Antiglycation Properties

In vitro studies on ethanolic leaf extracts demonstrated significant α-amylase inhibition and antiglycation activity, suggesting that G. globosa could mitigate postprandial hyperglycemia and age-related complications in diabetes. These effects were again linked to the antioxidant-rich phytochemical composition.

Analgesic and Cardiovascular Effects

Methanolic extracts exhibited both central and peripheral analgesic effects in rodent models, and preliminary data indicated possible blood pressure-lowering actions. These effects are likely mediated through modulation of pain signaling pathways and cardiovascular regulatory mechanisms. Phytochemical Insights GC-MS profiling of flower extracts identified a range of bioactive compounds, including sterols, triterpenoids, and phenolic acids. These compounds are consistent with the observed pharmacological activities and provide a chemical basis for the plant's therapeutic effects.

CONCLUSION

Gomphrena globosa L. is a versatile medicinal plant with extensive pharmacological potential demonstrated through rigorous experimental validation. Its antioxidant, anti-inflammatory, anticancer, hepatoprotective, neuroprotective, antidiabetic, and analgesic activities are supported by both in vitro and in vivo studies. The diverse bioactive compounds such as phenolics, betacyanins, sterols, and triterpenoids play a crucial role in mediating these therapeutic effects. These findings position G. globosa as a promising natural source for developing novel phytopharmaceuticals. Despite the encouraging preclinical data, the translation of G. globosa's benefits into clinical applications remains limited. Future research should focus on standardized extraction methods, detailed mechanistic studies, toxicity profiling, and well-designed clinical trials to establish safety and efficacy in humans.

Additionally, exploration of synergistic effects with existing drugs, bioavailability enhancement, and sustainable cultivation practices will be essential for practical therapeutic use. Harnessing advanced biotechnological tools and phytochemical characterization will further unlock the full medicinal potential of Gomphrena globosa, enabling its integration into modern medicine as a multi-target therapeutic agent.

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