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Portulaca oleracea: A Comprehensive Review of its Phytochemistry, Medicinal Properties, and Therapeutic Applications

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Abstract : Dermatological problems are a growing global concern, with atopic dermatitis (eczema) being a particularly prevalent condition. While topical corticosteroids are a mainstay of eczema treatment, their potential adverse effects highlight the need for effective adjuvant therapies. Portulaca oleracea, a plant belonging to the Portulacaceae family, has demonstrated promise in the treatment of eczema and other dermatological conditions. Topical gel formulations offer a modern and efficient approach to drug delivery for such treatments. This article details the preparation of topical gels containing Portulaca oleracea extract and explores its relevant pharmacological activities, including anti-inflammatory, antimicrobial, and antioxidant properties

Keywords:

Eczema, Topical Gel, Formulation, *Portulaca Orelaca*, P*ortulacae*, Anti-Inflammatory activity, Anti-Microbial activity, Anti-Oxidant Activity

1. Introduction:

Eczema, also known as atopic dermatitis, is the most common type of dermatitis. Its development is likely influenced by both genetic and environmental factors.(1) While it can affect adults, eczema is more prevalent in children. A hallmark of the condition is dry, itchy skin, often described as the "itch that rashes," where scratching or rubbing exacerbates the rash. (2)

A compromised skin barrier is central to eczema. Healthy skin relies on properly functioning skin cells for hydration. In eczema, this barrier dysfunction leads to increased water loss and subsequent dryness. (3) This weakened barrier also makes individuals more susceptible to infections, as it allows irritants and allergens to penetrate the skin more easily. Furthermore, people with atopic dermatitis often exhibit an overactive immune response, making their skin highly sensitive to allergens and other environmental triggers. (4)

Genetic predisposition plays a significant role in atopic dermatitis. A common mutation has been identified in the filaggrin gene, which is crucial for the maturation of skin cells. (5) This gene is responsible for producing corneocytes, the flat, tightly packed cells that form the skin's outermost protective layer. In healthy individuals, these cells are well-organized, creating an effective barrier. However, a filaggrin mutation disrupts this organization, resulting in a defective, "leaky" skin barrier that loses water readily and offers less protection against harmful substances. (6) Additionally, individuals with eczema have reduced levels of beta-defensins, antimicrobial peptides vital for fighting certain bacteria, viruses, and fungi. This deficiency, particularly concerning Staphylococcus aureus, increases the risk of colonization and infection. (7)The histological features of atopic dermatitis vary depending on the stage of the lesion. Acute lesions, characterized by intensely itchy, red bumps (erythematous papules), show mild epidermal thickening (hyperplasia), infiltration of lymphocytes and macrophages around the dermal blood vessels, and fluid accumulation within the epidermis (spongiosis). (8) Chronic lesions, marked by thickened, leathery skin (lichenification) and firm, raised bumps (fibrotic papules), exhibit increased epidermal hyperplasia and hyperkeratosis (thickening of the stratum corneum). A chronic inflammatory infiltrate of lymphocytes and macrophages is also present. Importantly, the edema and spongiosis seen in acute lesions are absent in chronic lesions. (9)

Differential Diagnosis for Atopic Dermatitis (10) :

Atopic dermatitis can be challenging to diagnose due to its overlapping symptoms with other skin conditions. A thorough differential diagnosis is crucial. Here are ten conditions to consider:

- **Contact Dermatitis (Allergic or Irritant):** Distinguish between allergic (delayed hypersensitivity) and irritant (direct chemical damage) reactions. Patch testing can be helpful for allergic contact dermatitis.
- **Seborrheic Dermatitis**: Often presents with greasy scales and erythema, primarily affecting the scalp, face, and chest. Atopic dermatitis tends to be itchier and located in flexural areas.
- **Psoriasis**: Characterized by well-defined, erythematous plaques with silvery scales, often found on elbows, knees, and scalp. Nail involvement is common.

- **Cutaneous Fungal Infections (Tinea):** Consider tinea corporis (ringworm), tinea cruris, or other fungal infections. A skin scraping or fungal culture can confirm the diagnosis.
- **Scabies:** Intense itching, often worse at night, with characteristic burrows seen in the web spaces of fingers, toes, and genitalia.
- **Drug Eruptions:** A wide range of skin reactions can be caused by medications. A careful medication history is essential.
- **Ectodermal Dysplasia:** A group of genetic disorders affecting the skin, hair, nails, and teeth. Consider this if there are other associated findings.
- **Netherton Syndrome:** A rare genetic disorder characterized by ichthyosis, hair abnormalities (bamboo hair), and atopic dermatitis.
- **Wiskott-Aldrich Syndrome:** An X-linked recessive immunodeficiency characterized by eczema, thrombocytopenia, and recurrent infections.
- **Hyper IgE Syndrome (Job's Syndrome):** Characterized by recurrent skin and pulmonary infections, as well as severe eczema and elevated IgE levels.

Eczema, Topical Gel, Formulation, *Portulaca Orelaca*, P*ortulacae*, Anti-Inflammatory activity, Anti-Microbial activity, Anti-Oxidant Activity.

1. Gels as Topical Dosage Forms:

The term "gel" was first used in the late 1800s to describe certain semi-solid materials based on their physical properties, rather than their molecular composition. Gels are essentially dilute, crosslinked polymer networks that exhibit no flow in their resting state. [11] They consist of a two-component system: a liquid dispersed throughout a solid framework. This continuous structure gives gels their characteristic solid-like properties. Their biocompatibility, network structure, and ability to stabilize incorporated bioactive agents make gels ideal for drug delivery, particularly topical applications. [12]
Most topical gels utilize organic polymers, such as carbomers, which provide a clear, aesthetically pleasing appearance and facilitate easy removal from the skin with water. [13] The base used in a topical dermatological product significantly impacts its efficacy. Bases rich in oily substances provide emollient properties, soothing dry and irritated skin. Specifically, bases containing non-volatile oils (like hydrocarbon bases) create an occlusive barrier on the skin, preventing moisture loss. [14] This leads to moisture accumulation within the stratum corneum, hydrating it and improving drug penetration. Hydrated skin allows drug molecules to move more easily through intra- and intercellular pathways. The drug, typically dispersed as fine particles within this moisture layer, also acts as part of the cream's base. This occlusion effect generally enhances percutaneous drug absorption, as only dissolved drug molecules can penetrate the stratum corneum. [15]
A gel's integrity depends on the interaction between the polymer and solvent. Classical gel theory identifies three solvent types within the gel structure:

1. Free and mobile solvent.
2. Bound solvent, typically through hydrogen bonding, forming a solvation layer.
3. Solvent trapped within the polymer network.

a) Classification and Formulation of Gels [16]

Gels are semi-solid systems consisting of a dispersed phase (colloidal particles or large molecules) within a continuous liquid phase. They are classified based on the nature of the dispersed phase and the solvent used, and their formulation involves careful selection of gelling agents, drug substances, and penetration enhancers.

Classification of Gels:
Gels are broadly classified based on:

1. Colloidal Phase:

- **Organic (Single-Phase System):** These gels consist of large organic molecules dissolved in a liquid, forming a continuous network. Examples include gels made with carbomers, tragacanth, and plastibase.
- **Inorganic (Two-Phase System):** These gels consist of small, discrete particles (floccules) dispersed in a liquid. They often exhibit thixotropy, meaning they transition from a semi-solid to a liquid when agitated. Examples include bentonite magma and aluminum hydroxide gel

2. Nature of Solvent: [17]

- **Hydrogels (Water-Based):** These are three-dimensional networks of hydrophilic polymers that can absorb and retain large amounts of water. Examples include gels made with silica, bentonite, tragacanth, pectin, and sodium alginate. Hydrogels find applications in wound dressings, drug delivery systems, and medical electrodes.
- **Organogels (Non-Aqueous Solvent):** These gels contain a liquid organic phase trapped within a cross-linked network. They can be formed by gelation of lecithin solutions in organic solvents.
- **Xerogels:** These are solid gels formed by drying hydrogels or organogels, leading to shrinkage and a porous structure. Examples include silica gel and dried cellulose.

b) Formulation of Gels: Nature of Solvent: [18]

Topical gels typically consist of:

i. **Gel Forming Agent (Polymer)**: These provide the structural network of the gel. They can be:

- Natural Polymers:
  Proteins: Gelatin, Collagen, Xanthan Gum
  Polysaccharides: Agar, Alginic Acid, Tragacanth, Pectin, Guar Gum
- Semi-synthetic Polymers: Cellulose derivatives like Carboxymethyl Cellulose, Methylcellulose, Hydroxypropyl Methylcellulose, Hydroxyethyl Cellulose.
- Synthetic Polymers: Carbomers (e.g., Carbopol 934, 940, 941), Poloxamers, Polyacrylamide, Polyvinyl Alcohol, Polyethylene and its copolymers.
- Inorganic Substances: Aluminum Hydroxide, Bentonite.
- Surfactants: Sodium Lauryl Sulfate, Cetostearyl Alcohol.

ii. **Drug Substance**: [19]

The active pharmaceutical ingredient. Key physicochemical and biological properties influence drug delivery from gels:

- Physicochemical Properties: [20]
  - Molecular weight preferably below 400 Daltons.
  - Optimal lipophilicity for skin penetration.
  - pH ideally between 5 and 9.
- Biological Properties: [21]
  - Non-irritant to the skin.
  - Suitable for topical administration (e.g., drugs susceptible to GI degradation).
  - Non-sensitizing (does not induce an immune response).

c) Penetration Enhancers: [22]

These facilitate drug permeation through the skin. [23] Ideal properties include:

- Chemical and pharmacological inertness.
- Non-toxic, non-irritant, and non-allergenic.
- Odorless, colorless, and tasteless.
- Rapid and predictable onset of action. [24]

2. Portulaca Oleracea :

Portulaca oleracea, commonly known as moss rose, is a succulent annual prized for its vibrant, rose-like flowers. These ruffled blooms, up to one inch in diameter, appear in single, semi-double, or double forms and come in a wide range of colors, including red, rose, orange, yellow, white, and pastel shades. The plant's prostrate to slightly ascending stems create a moss-like mat of foliage, typically reaching a height of 6 to 8 inches and spreading 12 inches or more. The cylindrical, fleshy, medium-green leaves, up to one inch long, grow in clusters along reddish stems. Moss rose blooms profusely from summer until the first frost, though flowers remain closed on cloudy or rainy days. [25]

Image:- *Portulaca oleracea L.*

Common Name	: Rose moss
Type	: Annual
Family	: *Portulacaceae*
Zone	: 2 to 11
Height	: 0.25 to 0.75 feet
Spread	: 0.50 to 1.00 feet
Bloom Time	: June to frost
Bloom Description	: Red, rose, orange, yellow or white
Sun	: Full sun
Water	: Dry to medium
Maintenance	: Low
Suggested Use	: Annual, Ground Cover,

a). Phytochemical Analysis: [26]

Studies have identified a range of phytoconstituents in P. oleracea, including:

* Strongly present: Alkaloids, flavonoids, carbohydrates, steroids, and triterpenoids.
* Moderately present: Glycosides and coumarins.
* Present in small amounts: Tannins.
* Absent: Resinous compounds.

b). Thin Layer Chromatography (TLC) of the alcoholic extract revealed the presence of phytosterols, terpenoids, and flavonoids, indicated by light blue, violet, and greenish yellow spots, respectively. [27]

c). Chemical screening : further confirmed the presence of sterols (in both etheric and alcoholic solutions), phenolic carboxylic acids (in aqueous and alcoholic extracts), flavones (in ether, alcoholic, and aqueous extracts), carotenoids (strongly in ether and alcoholic, mildly in aqueous extracts), reducing agents (in alcoholic and aqueous extracts), and polysaccharides (in aqueous extract).

Bioactivity[28]

d). Anti-inflammatory and Immunomodulatory Activity: P. oleracea has demonstrated promising anti-inflammatory effects, particularly in the context of oral lichen planus (OLP). Its mechanism of action involves modulating mast cell degranulation and reducing pro-inflammatory cytokines such as TNF-α, IL-1, and IL-6. [29]

e). Antimicrobial Activity: Studies have investigated the antimicrobial activity of P. oleracea against a range of microorganisms, including Bacillus subtilis, Escherichia coli, Pseudomonas aeruginosa, Candida albicans, and Aspergillus Niger. [30] Alcoholic extracts of the aerial parts have shown broad-spectrum activity against both Gram-positive and Gram-negative bacteria, as well as fungi, using agar diffusion assays and determining zones of inhibition. [31]

f). Antioxidant Activity: P. oleracea exhibits significant antioxidant potential. DPPH assays have demonstrated its radical scavenging activity, with the aqueous extract showing the highest inhibitory activity (IC50 0.96 ± 0.013), along with corresponding GEAC (3.38 ± 0.02) and AEAC (21.58 ± 0.14) values. [32]

The alcoholic extract also exhibited notable antioxidant activity, surpassing that of Portulaca grandiflora [33]

Potential Therapeutic Applications: Eczema Treatment Eczema, or atopic dermatitis (AD), is a chronic inflammatory skin condition. While topical corticosteroids remain the first-line treatment for AD flare-ups, P. oleracea, with its anti-inflammatory properties, could potentially offer a complementary or alternative therapeutic approach. [34,35,36,37]

Current standard treatments for eczema include:

Topical Corticosteroids (TCS): These are the primary treatment for AD flare-ups, reducing inflammation by binding to steroid receptors and modulating cytokine production. TCS potency varies, ranging from low (e.g., hydrocortisone) to ultra-high (e.g., clobetasol). [38,39,40,41]

Topical Calcineurin Inhibitors (TCI): These steroid-free immunomodulators, such as tacrolimus and pimecrolimus, are used for moderate to severe AD in patients two years and older. They inhibit calcineurin, thereby suppressing T-cell activation and cytokine release. [42,43] TCIs are particularly useful for facial and flexural lesions and in patients with corticophobia. While effective, they carry a theoretical (though unsubstantiated) risk of cancer, leading to an FDA boxed warning. [44,45,46]

3. Preparation of Gel with *Portulaca Oleracea* :

The preparation and evaluation of a gel containing Portulaca oleracea (purslane) leaf extract, based on the methodology described by Arul Jothi et al. (2022) and other cited works. Purslane is known to be rich in various beneficial compounds, including omega-3 and omega-6 fatty acids, ascorbic acid, tocopherols, glutathione, and beta-carotene. This study aimed to develop a stable gel formulation and assess its antimicrobial, antioxidant, and cytoprotective properties for potential use. [47]

a) Preparation of collected leaves and extracts:

Freshly harvested *Purslane* leaves were washed, shade-dried, and ground. A dark-colored crude extract was obtained by ethanol extraction. This extract was then fractionated using ethyl acetate and water. The dried ethyl acetate fraction (5.2g yield from 380g of dried leaves) was used for gel preparation. [47]

b) Preparation of Gel: (47)

Gels were prepared using Carbopol 940 as the gelling agent. Several formulations with varying concentrations of the Portulaca oleracea leaf extract (5% and 10%) were tested. The optimal formulation, exhibiting stability and a smooth texture, was selected for further evaluation. A control gel (without the extract) was also prepared.

The chosen method involved:

- Dissolving 1g of Carbopol 940 in 10ml of distilled water and allowing it to swell for 30 minutes.
- Dissolving methylparaben and propylparaben in 5ml of heated distilled water.
- Adding propylene glycol 400 to the paraben solution after it cooled to room temperature.
- Incorporating the required amount of Portulaca oleracea leaf extract into the mixture.
- Neutralizing the Carbopol 940 gel with triethanolamine dropwise while stirring to achieve the desired consistency.

c) Phytochemical analysis of the prepared gel concentration

Phytochemical screening of the prepared gel revealed the presence of various constituents, including steroids, flavonoids, terpenoids, proteins, coumarins, glycosides, phenols & tannins, quinones, alkaloids, and diterpenes. This diverse phytochemical profile supports the potential of purslane as a valuable source of bioactive compounds. [48]

d) The Anti - microbial activity and minimum inhibitory concentration of *Portulaca Oleracae*: (49)

The antimicrobial activity of the extract and gel formulations against Staphylococcus aureus (Gram-positive) and Escherichia coli (Gram-negative) was assessed using the Resazurin reduction assay. This method provides a rapid and reliable way to determine the minimum inhibitory concentration (MIC).

- The 10% extract and 10% gel formulation demonstrated inhibitory activity against both S. aureus and E. coli at all tested concentrations (5-0.132 mg/ml).
- The 5% extract was active against S. aureus but inactive against E. coli.

e) The Anti Oxidant activity [50]

The antioxidant activity of the extract and gel formulations was also evaluated (method not specified in the provided text, but referenced as [50]. The 10% extract and 10% gel formulation exhibited antioxidant activity, while the 5% extract showed activity against S. aureus but not E. coli. (This section needs further clarification regarding the specific assay used).

f). Cytoprotective effect of extract in fibroblast cell using MTT assay :

The cytoprotective effect of the extract and gel formulations was evaluated using an MTT assay on fibroblast cells. The results indicated no cytotoxicity against human monocyte cell lines (THP-1) at the tested concentrations. [47,51]

4. Conclusion :

Portulaca oleracea (family Portulacaceae) is a plant rich in bioactive phytochemicals. Phytochemical screening has revealed the presence of alkaloids, flavonoids, carbohydrates, steroids, and triterpenoids in strong concentrations. Glycosides and coumarins were moderately present, tannins were present in small amounts, and resins were absent. These phytoconstituents contribute to the plant's diverse pharmacological activities, including anti-inflammatory, antimicrobial, and antioxidant effects.

A topical gel formulation of P. oleracea extract demonstrated broad-spectrum antibacterial activity, inhibiting both Gram-positive and Gram-negative bacteria at all tested concentrations. A 5% concentration showed reasonable inhibition against Staphylococcus aureus but not Escherichia coli at 0.132 mg/mL. A 10% formulation exhibited the highest radical scavenging activity, ranging from 25% to 75%. Both the 5% and 10% topical gels demonstrated considerable antioxidant activity.

Hydrocortisone, a known anti-inflammatory agent, is commonly used in a 1% topical gel for treating eczema. Combining 1% hydrocortisone with P. oleracea extract could represent a significant advancement in the treatment of atopic dermatitis and other topical conditions.

Topical application of P. oleracea extract shows promise for anti-inflammatory, antimicrobial, and antioxidant activity. However, the limited existing research highlights the need for further investigation into the phytochemical profile and therapeutic potential of P. oleracea.

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6. Conflict of Interest :

The authors have declared no conflict of interest during this study.

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