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Synergistic Potential of Murraya koenigii, Curcuma longa and Aloe vera in the Management of Atopic Dermatitis: Targeting Inflammation and Skin Barrier Dysfunction

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Abstract: *Atopic dermatitis (AD) is a persistent inflammatory skin condition characterized by intense itching, erythema, dryness, impaired skin barrier function, and recurrent exacerbations that negatively impact patients' quality of life. Although conventional treatments such as corticosteroids and immunomodulatory agents are widely used, their long-term application may result in undesirable side effects. As a result, increasing attention has been directed toward herbal therapies as safer and more effective alternatives. This review explores the therapeutic potential of a polyherbal combination consisting of Murraya koenigii, Curcuma longa, and Aloe barbadensis for the management of atopic dermatitis. These medicinal plants are rich sources of bioactive compounds, including carbazole alkaloids, curcuminoids, acemannan, phytosterols, flavonoids, and essential oils, which possess anti-inflammatory, antioxidant, antimicrobial, antipruritic, moisturizing, and wound-healing activities. The combined action of these phytoconstituents addresses multiple pathogenic factors associated with AD, such as excessive inflammatory responses, oxidative damage, Staphylococcus aureus colonization, and disruption of the epidermal barrier. In addition, topical gel formulations offer advantages including a skin-friendly pH, rapid absorption, non-greasy texture, enhanced patient acceptability, and localized drug delivery with minimal systemic exposure. Available clinical and experimental findings support the beneficial effects of these herbs in inflammatory skin disorders. Therefore, this polyherbal gel formulation may represent a promising therapeutic option for the management of atopic dermatitis. Further research involving nanogel-based delivery systems, nanoemulsions, phytosome formulations, detailed preclinical investigations, and well-designed clinical trials is required to confirm its safety, efficacy, and long-term therapeutic value.*

Keywords: Atopic dermatitis, eczema, polyherbal gel, Murraya koenigii, Curcuma longa, Aloe barbadensis, curcuminoids, acemannan, skin barrier dysfunction, herbal therapeutics.

I. INTRODUCTION

Atopic eczema is a type of eczema commonly known as atopic dermatitis. It is characterised by skin itching, redness, dryness, erythema, irritation. AD is distinguished by pruritus, which worsens at night, dry and leathery indurated skin, and intensely irritating papules that can leak clear fluid when scratched.[1] The fundamental building blocks of the epidermis is keratinocytes which represent the most abundant cell types in the skin. The outermost layer of the skin continuously removes old dead cells through desquamation, while new skin cells are formed and mature from the

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deeper layers by terminal differentiation. Proper coordination between these two processes is essential to preserve normal and healthy skin function.[2] keratinocytes and neutrophils and natural killer cell(NKs) together are the major producer of antimicrobial peptides (AMPs). AMPs help to protect the skin against infection and inflammation by covering the skin forming a chemical layer. Patients with AD have been documented to exhibit reduced levels of AMPs, specifically cathelicidin and β-defensins, exposing them to greater risk of Staphylococcus aurous infections. [3] Various treatment options available for eczema include moisturizers (emollients), topical and oral corticosteroids, antimicrobial drugs, and immune system–modulating agents.[4]Corticosteroids are commonly used for eczema treatment because they effectively reduce inflammation by stopping cytokine production, reducing immune cell activity, and preventing the movement of white blood cells to the affected area. However, long-term use of corticosteroids may cause side effects such as metabolic disturbances, growth suppression, and increased susceptibility to infections.[5]So far, no permanent cure for the disease has been discovered, which has led many patients to prefer herbal therapy, homeopathic medicines, special diets, and herbal treatments because they produce fewer side effects and help improve the patient's condition as well as quality of life.[6]

II. PATHOPHYSIOLOGY OF ECZEMA

Atopic dermatitis is a skin disorder in which primary (or secondary) skin barrier damage leads to (additional) skin inflammation, and in which S. aureus colonizing may rise, driving both eczema severity and the chronic sense of itch.[7]While the exact role of bacteria in Alzheimer's disease pathogenesis is unknown, S. aureus colonization is widespread in both lesion and non-lesion AD skin. Antimicrobial peptides, which operate as broad-spectrum antibiotics to kill Gram-negative and Gram-positive bacteria, reduce in people with AD, allowing bacteria to colonize the skin.[8]

S. aureus colonization on skin
↓
Release of serine proteases
↓
Breakdown of corneodesmosomes and weakening of skin barrier (9)
↓
Easy penetration of microbes and allergens into the skin
↓
Activation of Th2 cytokine production by bacterial proteases (10)
↓
Increased inflammatory response in eczema
↓
Release of toxins by S. aureus
↓
Activation of mast cells and enhancement of allergic reactions (11)
↓
Superantigen-mediated activation of T cells (12)
↓
Excessive immune response and chronic skin inflammation
↓
Release of α-toxins
↓
Formation of pores in keratinocyte membranes causing cellular damage (13)
↓
Filaggrin (FLG) mutation in atopic dermatitis patients
↓

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Increase in skin pH and reduction in antimicrobial activity (14,15)

↓

Higher susceptibility to S. aureus infection

↓

Reduced Natural Moisturizing Factor (NMF)

↓

Enhanced adhesion of S. aureus to corneocytes (16)

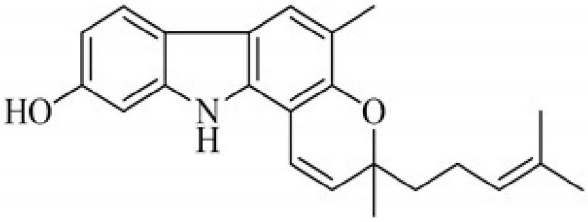
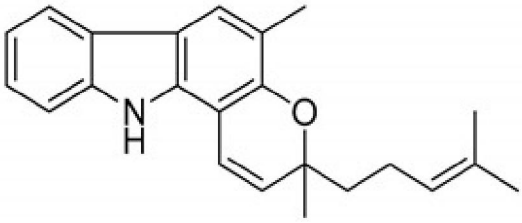
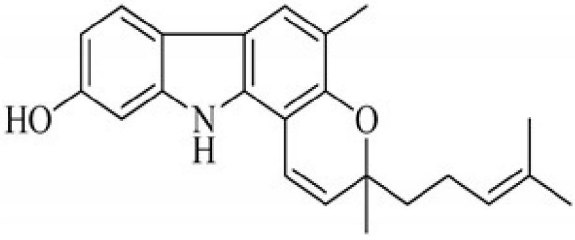
↓

Further bacterial colonization and worsening of eczema

Phytochemistry of M. koenigii

A variety of phytochemicals has been isolated from the leaves, roots, and stem bark of M. koenigii. Extracts of M. koenigii leaves, roots, stem bark, fruits, and seeds contained alkaloids, flavonoids, terpenoids, and polyphenols. A wide spectrum of carbazole alkaloids, essential oils, terpenoids, and flavonoids play several beneficial roles.(17)

Phytochemical compound identified from *M. koenigii*

Mahanine		**Cytotoxicity, anti-microbial, and anti-cancer**
Mahanimbine		**Cytotoxicity, anti-microbial, and Anti-diabetic, antioxidant Hyperlipidaemia**
Isomahanine		**Cytotoxicity, anti-microbial, and Anti-diabetic, antioxidant Hyperlipidaemia**

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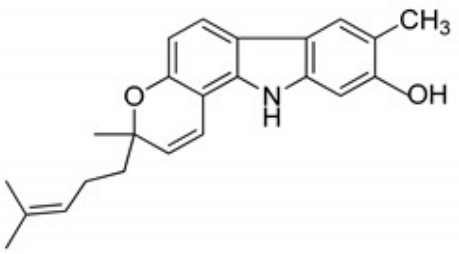
Pyrayafoline D		**Anti-cancer and anti-bacterial**

Phytochemistry of turmeric (curcuma longa)

Curcumin is a versatile chemical that was discovered to have antibacterial properties in 1949. Since then, this polyphenol has been demonstrated to have anti-inflammatory, hypoglycaemic, antioxidant, wound-healing, and antibacterial properties (18).

- **Phenolic compounds**

Phenolic compounds such as dimethoxycurcumin, dihydrocurcumin, and tetrahydrobisdemethoxycurcumin (19).

- **Phytosterols**

Phytochemical analyses confirmed the existence of bioactive phytosterols used GC-MS to identify three phytosterols, stigmasterol, b-sitosterol, and stigmast-4-en-3-one, as well as one monoterpene, terpinene-4-ol, in the ethanol oleoresin contents of fresh and dried C. longa rhizomes. (20)

- **ESSENTIAL OIL**

Several bioactive essential oils were identified in different parts of C. longa GC-MS analysis of C. longa rhizomes after hydrodistillation of the fresh rhizomes using Clevenger apparatus revealed the presence of pinene, β-myrcene, α-phellandrene, p-cymene, eucalyptol, γ-terpinolene, α-terpinolene, β-caryophyllene, β-farnesene, γ-curcumene, ar-curcumene, zingiberene, β-bisabolene, α-santalol, β-atlantol, humulene epoxide, zingiberenol, ar-tumerone, curlone, tumerone, artermisia ketone, khusimone, and myrcenon.(21)

Phytochemistry of Aloevera

Aloevera gel includes a variety of bioactive phytochemicals, including polysaccharides, anthraquinones, phytosterols, flavonoids, chromones, enzymes, and vitamins. Acemannan is the primary polysaccharide responsible for moisturizing, wound healing, and immunomodulatory properties. Anthraquinones like aloin and aloe-emodin have antibacterial and antioxidant qualities, while sterols like lupeol, campesterol, and β-sitosterol help reduce inflammation. These phytoconstituents work together to help restore the skin barrier and reduce inflammation caused by atopic dermatitis. (22)

Synergy Rationale: Why Combination Therapy is Better than Single Herb

The polyherbal combination of *Murraya koenigii*, *Curcuma longa*, and *Aloevera* demonstrates enhanced therapeutic potential in atopic dermatitis because the combined phytochemicals act on multiple pathological pathways simultaneously. Atopic dermatitis involves chronic inflammation, oxidative stress, intense pruritus, microbial colonization, and impairment of the skin barrier. Curcuminoids present in *Curcuma longa* exert potent anti-inflammatory and antioxidant activities by suppressing inflammatory mediators such as NF-κB and COX-2. Carbazole alkaloids from *Murraya koenigii* possess antihistaminic, antimicrobial and anti-inflammatory properties that help reduce itching and inhibit *Staphylococcus aureus* colonization commonly associated with eczema. In addition,

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acemannan and phytosterols from *Aloevera*promote skin hydration, collagen synthesis, wound healing, and epidermal regeneration. The combined action of these phytoconstituents provides broader pharmacological coverage, improves skin barrier restoration, reduces transepidermal water loss, and minimizes eczema flare-ups more effectively than individual herbal therapy.

Topical Delivery and Advantages of Gel Formulation

Topical administration is regarded as an effective strategy for managing atopic dermatitis because it enables direct delivery of active phytoconstituents to the affected skin region while reducing systemic adverse effects, and gel formulations provide several advantages over conventional creams and ointments.Moreover, gels are non-greasy, easily spreadable, and rapidly absorbed, enhancing their cosmetic acceptability among patients. Unlike ointments, gels do not produce excessive stickiness or occlusion, thereby improving comfort during prolonged application(23, 24).These formulations can be adjusted to a skin-friendly pH of approximately 5.5, which helps maintain epidermal barrier function and minimizes irritation. Gel formulations also enhance patient compliance because they are lightweight, washable, and less likely to stain clothing. Furthermore; the aqueous base of gels facilitates improved release and penetration of phytoconstituents into the epidermal layers, thereby enhancing therapeutic effectiveness in atopic dermatitis management (25).

III. CLINICAL EVIDENCE OF INDIVIDUAL HERBS IN ATOPIC DERMATITIS

***Murraya koenigii* (Curry Leaf)**

Although direct clinical investigations on Murraya koenigii in atopic dermatitis are lacking, multiple experimental studies have found powerful anti-inflammatory, antioxidant, and antibacterial properties in its carbazole alkaloids and phenolic compounds. These phytoconstituents suppress microbial infections, including Staphylococcus aureus, which is usually related with eczema aggravation. The plant also has free radical scavenging action, which may help reduce the oxidative stress and inflammation that contribute to the etiology of atopic dermatitis (26).

***Curcuma longa* (Turmeric)**

Clinical studies have shown that turmeric and its main bioactive ingredient, curcumin, have strong anti-inflammatory, antioxidant, and antibacterial properties that benefit inflammatory skin conditions such as atopic dermatitis. Curcumin reduces inflammatory mediators such NF-κB, COX-2, TNF-α, and interleukins, leading to reduced erythema, itching, and skin inflammation. A systematic analysis found that turmeric-based therapy, both topical and oral, improved various dermatological diseases (27).

Aloe barbadensis (aloevera)

Aloe vera's hydrating, wound-healing, anti-inflammatory, and skin-protective characteristics have led to substantial research into dermatological applications. AloeVera gel has been shown in clinical studies to increase skin hydration, expedite epidermal regeneration, minimize irritation, and support skin barrier restoration. These properties make aloeVera useful for eczema and other inflammatory skin problems (28).

IV.CONCLUSION AND FUTURE SCOPE

Murraya koenigii, Curcuma longa, and Aloe barbadensis polyherbal gel has significant potential in the treatment of atopic dermatitis due to its synergistic anti-inflammatory, antioxidant, antibacterial, antipruritic, moisturizing, and wound-healing qualities. Carbazole alkaloids, curcuminoids, acemannan, phytosterols, and other bioactive phytoconstituents work together to target numerous pathogenic pathways associated with eczema, including inflammation, oxidative stress, microbial colonization, and skin barrier dysfunction. Furthermore, the gel-based topical delivery system improves patient compliance due to its non-greasy texture, quick absorption, skin-friendly pH, and better cosmetic acceptance. As a result, this polyherbal formulation may be a viable alternative or complementary

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approach for the treatment of atopic dermatitis, with a lower risk of side effects associated with extended corticosteroid therapy.

Although the proposed polyherbal formulation demonstrates considerable therapeutic promise, additional research is required to confirm its clinical usefulness and pharmaceutical performance. Future studies should emphasize the design of advanced topical drug delivery systems, including nanogels, nanoemulsions, liposomal gels, and phytosome-based carriers, to enhance skin permeation, formulation stability, and bioavailability of the active phytoconstituents. Extensive preclinical investigations along with well-structured randomized controlled clinical trials are essential to establish the long-term safety, efficacy, and clinical benefits of the formulation in patients with atopic dermatitis. Moreover, stability evaluation, toxicity profiling, pharmacokinetic studies, and proper standardization of herbal extracts are necessary to ensure consistency, quality, and regulatory compliance. Further research focusing on molecular mechanisms related to immune regulation, cytokine modulation, and skin barrier repair may provide stronger scientific evidence supporting the development and therapeutic application of polyherbal nanogel-based formulations for atopic dermatitis management.

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