IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.53

Volume 4, Issue 3, June 2024

Development and Assessment of Turmeric- Based Hydrogel for Psoriasis Therapy

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Abstract*: Psoriasis is a chronic inflammatory skin disorder impacting millions globally. Standard treatments such as topical corticosteroids, immunomodulators, and phototherapy often have limited efficacy or cause adverse side effects. Curcumin, a natural compound known for its anti-inflammatory and antioxidant properties, has shown promise as an alternative treatment for psoriasis. However, the low solubility and bioavailability of curcumin reduce its effectiveness when used orally or topically. To overcome these challenges, a topical curcumin hydrogel has been developed. This review examines the current research on curcumin hydrogel as a treatment for psoriasis, discussing its pharmacological properties, formulation, and the findings from preclinical and clinical studies regarding its efficacy and safety. The evidence indicates that curcumin hydrogel could be a promising alternative treatment for psoriasis, potentially reducing inflammation, aiding wound healing, and enhancing the quality of life for patients. Further research is required to fully understand the mechanism of action of curcumin hydrogel and to optimize its formulation and delivery for maximum effectiveness.*

Keywords: Psoriasis, Inflammatory Skin disorder, anti- oxidant properties, curcumin hydrogel)

I. INTRODUCTION

Traditional medicine has a long-standing history of utilizing natural and herbal products to treat various human diseases. This practice has evolved into a multi-billion-dollar industry, currently valued at USD 10 billion per year. One prominent example of an herbal compound used for medical purposes is curcumin, a polyphenol obtained from the turmeric plant (Curcuma longa) of the Zingiberaceae family. Curcumin possesses a variety of therapeutic properties. For centuries, curcumin has been employed in various applications, including as a culinary spice, food additive (found in products like ice cream, yogurt, orange juice, biscuits, popcorn, cakes, cereals, sauces, and gelatins), cosmetic ingredient, and natural remedy for treating numerous diseases, especially chronic inflammatory conditions. While its therapeutic advantages have been acknowledged for ages, scientific investigation into its pharmacological properties has only intensified over the past century. Currently, the extensive medical uses of curcumin are attributed to its diverse properties, such as antioxidant, anti-inflammatory, antiproliferative, anti-carcinogenic, and antimicrobial effects.

Fig.1.1 Curcumin Powder

II. THE HISTORICAL & CONTEMPORARY USE OF TURMERIC

The use of turmeric, a perennial plant native to South Asia (Curcuma longa), has a rich historical and contemporary significance. Its rhizome, known for its vibrant yellow color, is widely used as a spice in cooking and as a natural preservative. Traditional Chinese and Indian medicine have long utilized turmeric for treating inflammatory conditions, employing it to alleviate inflammation, purify the blood, and promote wound healing.

Turmeric is also recognized for its pharmacological properties, including antibacterial and antioxidant effects. One of its most studied components, curcumin, is attributed with anti-inflammatory properties that are explored in cancer treatment and various disorders such as ulcerative colitis, inflammatory diseases, and joint-related conditions like osteoarthritis and rheumatoid arthritis. Additionally, in vivo studies have highlighted turmeric's potential therapeutic benefits in addressing Alzheimer's disease.

Turmeric:

- **Synonyms of Curcuma longa:**

Sanskrit: Amgeshta
English: Indian yellow spice
Hindi: Haldi
Marathi: Halad

- **Biological sources:**

Curcuma longa Linn, also known as C. Domestica, belongs to the Zingiberaceae family and is recognized for producing both fresh and dried rhizomes used in the production of turmeric. These rhizomes contain a minimum of 1.5% curcumin.
Microscopic characteristics:
Color: Yellowish-brown
Odour: Distinctive aroma
Taste: Mildly bitter

- **Chemical Constituents:**

Turmeric contains approximately 5% volatile oil, resin, abundant zingiberene starch grains, and curcuminoids, which impart its characteristic yellow color. Curcumin is the main component among the curcuminoids. Turmeric oil also includes other compounds such as turmerone, zingiberene, borneol, and caprylic acid. Studies indicate that curcumin possesses antimicrobial and anti-inflammatory properties.

- **Taxonomical Classification of Curcuma longa:**

Scientific Name: Curcuma longa
Kingdom: Plantae (Plants)
Subkingdom: Tracheobionta (Vascular plants)
Superdivision: Spermatophyta (Seed plants)
Division: Magnoliophyta (Flowering plants)
Class: Liliopsida (Monocotyledons)
Subclass: Zingiberidae
Order: Zingiberales
Family: Zingiberaceae (Ginger family)
Genus: Curcuma L. (Turmeric)
Species: Curcuma longa L. (Common turmeric)

- **History:**

Turmeric has been part of India's Vedic civilization for about 4000 years, valued both as a culinary spice and for its religious significance. By 700 A.D., its use had likely spread to China, East Africa, West Africa, and Jamaica. It reached China by 1200 A.D., and Marco Polo, in 1280, described it as a remarkable spice resembling saffron in appearance. In South Asia, turmeric has a longstanding medical history documented in Sanskrit texts, Ayurvedic practices, and Unani medicine. Dating back to 250 B.C., Socrata's Ayurvedic Compendium suggests using a turmeric-based ointment to alleviate the effects of food poisoning.

Mechanisms of Action

● **Antioxidant Properties:**

Curcumin's beneficial effects across various diseases discussed in this review largely stem from its antioxidant and anti-inflammatory properties. Studies have shown that curcumin helps reduce oxidative stress by enhancing systemic indicators such as superoxide dismutase (SOD) activity and other antioxidants in the bloodstream. Recent systematic reviews and meta-analyses of randomized controlled trials examining the supplementation of purified curcuminoids have consistently demonstrated significant improvements in oxidative stress parameters. These include increased plasma activities of SOD and catalase, elevated serum levels of glutathione peroxidase (GSH), and reduced concentrations of lipid peroxides.

● **Anti-Inflammatory Properties:**

Oxidative stress is closely associated with numerous chronic diseases, often sharing similar pathological processes with inflammation. Inflammatory cells release reactive species at sites of inflammation, contributing to oxidative stress. Moreover, reactive oxygen and nitrogen species can trigger intracellular signaling pathways that promote the production of pro-inflammatory genes. Many chronic conditions, such as Alzheimer's disease, Parkinson's disease, multiple sclerosis, epilepsy, cardiovascular diseases, metabolic syndrome, cancer, allergies, asthma, bronchitis, colitis, arthritis, renal ischemia, psoriasis, diabetes, obesity, depression, fatigue, and AIDS, have been linked to inflammation during their progression.

Health Benefits of Turmeric in Everyday Life

1. Acts as a natural antiseptic and antibacterial agent, effectively disinfecting cuts and burns.
2. When paired with cauliflower, it has demonstrated potential in preventing prostate cancer and halting the progression of existing prostate cancer.
3. Shown to inhibit the spread of breast cancer to the lungs in animal studies.
4. May have protective effects against melanoma and induce apoptosis (cell death) in existing melanoma cells.
5. Reduces the risk of childhood leukemia.
6. Functions as a natural detoxifier for the liver.
7. Could potentially prevent and slow the advancement of Alzheimer's disease by clearing amyloid plaques from the brain.
8. Acts as a powerful natural anti-inflammatory agent, comparable in effectiveness to many anti-inflammatory drugs but without their associated side effects.
9. Shows promise in aiding the treatment of psoriasis and other inflammatory skin conditions.
10. Accelerates wound healing and aids in the regeneration of damaged skin tissues.

III. OVERVIEW OF PSORIASIS

3.1 Epidemiology

Psoriasis impacts both men and women, typically manifesting earlier in women and individuals with a family history of the condition. The onset of psoriasis displays a bimodal distribution, with peak occurrences in men between the ages of 30–39 and 60–69, while in women, these peaks occur approximately ten years earlier.

3.2 Aetiology

The development of psoriasis is influenced by multiple factors, with genetics playing a significant role, particularly in cases of early-onset plaque psoriasis (before age 40). Twin, family-based, and large-scale population studies have shown a heritability estimate of 60–90%. Over 60 susceptibility loci have been identified through genome-wide association studies. Many of the potential causal genes are involved in antigen presentation (HLA-C and ERAP1), NF-kappa B signaling (TNIP1), the Type 1 interferon pathway (RNF113 and IFIH1), the interleukin (IL)-23/Th17 axis (IL23R, IL12B, and TYK2), and skin barrier function (LCE3). This indicates a complex interaction between T cells, dendritic cells, and keratinocytes in the pathophysiology of psoriasis, with the IL-23/Th17 axis being a key driver of immune activation, chronic inflammation, and keratinocyte proliferation. Environmental factors such as obesity, stress, beta-blockers, smoking, and lithium have been known to worsen psoriasis. Although data is relatively scarce, pustular psoriasis seems to be genetically distinct, with different susceptibility genes implicated (IL36RN, AP1S3 in individuals of European descent, and CARD14).

3.3 Pathophysiology of Psoriasis:

The pathophysiology of psoriasis involves the infiltration of the skin by activated T-cells, which stimulate keratinocyte proliferation. This dysregulation in keratinocyte turnover leads to the formation of thick plaques. Other features include epidermal hyperplasia and parakeratosis. Additionally, the failure of epidermal cells to secrete lipids results in the flaky and scaly skin characteristic of psoriasis. The pathophysiology is multifactorial and involves epidermal hyperproliferation, abnormal differentiation of epidermal keratinocytes, and inflammation with immunologic changes in the skin. The hyperproliferation is marked by increased DNA synthesis and a significantly decreased turnover rate for the epidermis. Abnormal keratinocyte differentiation involves increased expression of certain keratins (6 and 16) and a delay in the expression of others (1 and 10) typically seen in normally differentiating skin. Inflammation results from the infiltration of neutrophils in the epidermis and superficial dermis, as well as an infiltration of T lymphocytes in the dermis, predominantly CD8+ cells.

3.4 Symptoms and Triggers of Psoriasis:

Common signs and symptoms of psoriasis include:

1. A patchy rash that can appear differently from person to person, ranging from small areas with dandruff-like scaling to large eruptions covering much of the body.
2. Rashes that vary in color, often appearing purple with gray scales on brown or black skin, and pink or red with silver scales on white skin.
3. Small, scaly spots (often seen in children).
4. Dry, cracked skin that may bleed.
5. Itching, burning, or soreness.

Psoriasis Triggers:

Many individuals who are predisposed to psoriasis might not exhibit symptoms for years until the disease is activated by an environmental factor. Common triggers for psoriasis include:

- Infections, such as strep throat or skin infections
- Weather conditions, particularly cold and dry climates
- Skin injuries
- Smoking and exposure to second hand smoke
- Heavy alcohol use
- Certain medications, including lithium, high blood pressure drugs, and antimalarial medications
- Rapid discontinuation of oral or injected corticosteroids.

3.5 Complications:

- Secondary infections
- Poor cosmetic appearance
- Psoriatic arthritis
- Increased risk of lymphoma
- Higher risk of adverse cardiac events

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- Psoriatic arthritis, leading to pain, stiffness, and swelling in and around the joints
- Temporary skin color changes (post-inflammatory hypopigmentation or hyperpigmentation) where plaques have healed
- Eye conditions such as conjunctivitis, blepharitis, and uveitis
- Obesity
- Type 2 diabetes
- Cardiovascular disease
- Other autoimmune diseases, such as celiac disease, scleroderma, and Crohn's disease
- Mental health issues, including low self-esteem and depression

3.6 Types of Psoriasis:

There are several types of psoriasis:

Chronic Plaque Psoriasis:

The most prevalent form of psoriasis is plaque psoriasis, also known as psoriasis vulgaris. Approximately 85 percent of individuals with psoriasis have this type, which is characterized by thick, red patches of skin often covered with a silver or white flaky layer.

Fig.1.2 Chronic Plaque Psoriasis

Guttate Psoriasis:

A distinct variant of psoriasis called guttate psoriasis is often triggered by streptococcal infections, such as pharyngitis or perianal infection. This type is more commonly seen in children and adolescents than in adults. Patients typically present with numerous small, drop-like lesions, which generally respond well to topical treatments and phototherapy.

Fig.1.3 Guttate Psoriasis

Erythrodermic Psoriasis:
Erythrodermic psoriasis is a severe and rare form of psoriasis characterized by widespread redness and scaling of the skin, affecting 90% or more of the body's surface area. This condition is a type of scaly and inflamed dermatitis that can be caused by various skin conditions, with psoriasis and eczema being the most common underlying dermatoses. Additionally, erythroderma may also result from certain types of skin lymphomas involving T cells.

Fig.1.4. Erythrodermic Psoriasis

Pustular Psoriasis:
Individuals with pustular psoriasis or related conditions often exhibit genetic abnormalities that affect key components of the skin's innate immune system. The identification of these abnormalities has recently shifted our understanding of these diseases significantly.

Fig.1.5. Pustular Psoriasis

Palmoplantar Psoriasis:
Palmoplantar psoriasis refers to plaque psoriasis specifically affecting the palms of the hands and soles of the feet. This variant poses a significant challenge for dermatologists due to its resistance to both topical and systemic treatments.

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Fig. 1.6. Palmoplantar Psoriasis

Scalp Psoriasis:

Scalp psoriasis can significantly impact patients' quality of life and is frequently difficult to treat, with limited scientific research dedicated to its management. This analysis assesses the effectiveness of secukinumab based on patient-reported outcomes for scalp psoriasis.

Fig.1.7. Scalp Psoriasis

Nail Psoriasis:

Approximately 80% of individuals with psoriasis may develop nail psoriasis due to its impact on the nails, which are considered extensions of the skin's epidermis. Psoriasis can lead to two distinct patterns of nail disorders.

Fig.1.8. Nail psoriasis

Psoriatic Arthritis:

Psoriatic arthritis is an inflammatory joint condition that occurs in patients with psoriasis, although its exact cause is unknown. Recently, the Classification Criteria for Psoriatic Arthritis group has developed a validated set of criteria for diagnosing psoriatic arthritis. These criteria are highly specific (98.7% specificity) and sensitive (91.4% sensitivity).

Fig. 1.9. Psoriatic Arthritis

3.7. Current Treatments for Psoriasis:

1) Topical Treatments:

These are applied directly to the skin and are typically the first approach doctors recommend. Some contain steroids to slow down skin cell growth and reduce inflammation, while others do not.

2) Phototherapy:

This treatment involves exposing the skin to ultraviolet light. It can be administered at a doctor's office or at home using a phototherapy unit.

3) Systemic Medications:

Prescription drugs that work throughout the body are used for moderate to severe psoriasis that doesn't respond well to other treatments. These medications can be taken orally or administered as injections (subcutaneous or intravenous). Biologics, a type of systemic medication, specifically target parts of the immune system involved in the inflammatory process.

4) Corticosteroids:

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These are commonly prescribed medications for mild to moderate psoriasis. They come in various forms such as oils, ointments, creams, lotions, gels, foams, sprays, and shampoos. Mild corticosteroid ointments like hydrocortisone are often recommended for sensitive areas and widespread patches.

5) Vitamin D Analogues:

Synthetic forms of vitamin D, such as calcipotriene (Dovonex, Sorilux) and calcitriol (Vectical), slow down the growth of skin cells. They can be used alone or in combination with topical corticosteroids, with calcitriol being gentler on sensitive areas.

6) Retinoids:

Tazarotene (Tazorac, Avage) is available as a gel or cream and is applied once or twice daily. It helps reduce psoriasis symptoms but can cause skin irritation and increased sensitivity to light. It is not recommended during pregnancy, breastfeeding, or if planning pregnancy.

7) Light Therapy:

Also known as phototherapy, this treatment involves exposing the skin to controlled amounts of natural or artificial light. It is effective for moderate to severe psoriasis and may be used alone or combined with medications.

8) Sunlight:

Brief daily exposures to sunlight (heliotherapy) can benefit psoriasis symptoms. Before starting sunlight therapy, it's important to consult with a healthcare provider to determine the safest approach.

9) Antibiotics:

In some cases, systemic antibiotics like tetracycline and penicillin are used to treat psoriasis, although their mechanism of a ction in psoriasis treatment is not fully understood.

10) Lithium:

Initially used for bipolar disorder, lithium has been associated with triggering or exacerbating psoriasis in some individuals. The exact mechanisms linking lithium to psoriasis are still under investigation.

IV. HYDROGELS

A hydrogel is a network of polymer chains arranged in three dimensions, capable of absorbing and retaining significant quantities of water or biological fluids. Its applications span diverse fields like biomedical engineering, drug delivery, tissue engineering, and agriculture (37-40). Hydrogels are created by linking polymer chains together to form a structure that can absorb water or biological fluids such as blood or urine. This linking process can be achieved through physical, chemical, or biological means, depending on the specific polymer and its intended use in the hydrogel.

Various polymers are used to formulate hydrogels, including polyethylene glycol (PEG), polyvinyl alcohol (PVA), polyacrylamide (PAAm), and hyaluronic acid (HA), each contributing distinct characteristics to the hydrogel such as swelling behavior, mechanical strength, and biocompatibility .

☆Types of Hydrogels:

Hydrogel can be classified on different bases as detailed below:

1) Classification based on source :

1) Natural hydrogels
2) Synthetic hydrogels
3) Hybrid hydrogels

2) Classification based on polymeric composition:

1) Homo-polymeric hydrogels
2) Co-polymeric hydrogels
3) Multi-polymer interpretating polymeric hydrogels (IPN)

3) According to Biodegradability:

1) Biodegradable hydrogels
2) Non- Biodegradable hydrogels

4) Classification based on Configuration:

1) Amorphous
2) Non- Crystalline

3) Semi-Crystalline
4) Crystalline

5) Classification based on type of Cross-linking :
1) Chemically cross-linked networks
2) Physical networks

6) Classification based on physical appearance:
1) Matrices
2) Films
3) Microspheres

V. MATERIALS AND METHODS

Method of Preparation:

There are various methods for preparing curcumin hydrogels.

1) Physical Crosslinking Method:

The physical crosslinking technique is commonly used for hydrogel preparation, utilizing natural polymers and non-toxic crosslinking agents. In this approach, a gel forms through the physical crosslinking of a natural biopolymer like gelatin or chitosan with an appropriate crosslinking agent.

The process involves dissolving the natural biopolymer in distilled water to create a homogeneous solution with a concentration of approximately 2-3% w/v. The pH of this solution is then adjusted to the desired level using a buffer, such as phosphate or acetate buffer. The solution is subsequently heated to a temperature above the biopolymer's gelation temperature to form a solution.

A suitable physical crosslinking agent, such as Pluronic F127, is then added to the sol and mixed thoroughly. The physical crosslinking agent could also be influenced by temperature, ionic strength, or light. As the physical crosslinking reaction occurs, the sol begins to gel. Stirring continues for around 30 minutes to ensure complete crosslinking.

Finally, the hydrogel is transferred to an appropriate container and allowed to dry in a sterile environment. The resulting hydrogel exhibits excellent mechanical properties and is suitable for various biomedical applications. The physical crosslinking method is simple, cost-effective, and efficient, avoiding the need for harmful chemicals or complex procedures.

2) Chemical Cross-Linking Method:

Chemical crosslinking is a common technique for creating hydrogels, which involves forming covalent bonds between polymer chains to develop a gel network. Here's a description of the chemical crosslinking method for hydrogel preparation:

1. Dissolve the polymer in an appropriate solvent to achieve a homogeneous solution. The polymer concentration should be about 10-15% w/v.
2. Introduce a suitable crosslinking agent, such as N,N'-methylene bis(acrylamide), into the polymer solution.
3. Add an appropriate initiator, like ammonium persulfate, to the solution and mix thoroughly.
4. Transfer the solution to a mold and initiate polymerization by heating it to the required temperature for a specific duration.
5. Once polymerization is complete, wash the hydrogel with water and allow it to dry in a sterile environment.
6. The resulting hydrogel will have good mechanical properties and can be utilized in various biomedical applications.

Chemical crosslinking is a flexible method for preparing hydrogels, providing greater control over their mechanical and chemical properties. However, this method requires the use of potentially harmful chemicals and involves more complex procedures.

3) Ionic Gelation Method:

Ionic gelation is a widely used technique for preparing hydrogels by crosslinking a natural polymer with an appropriate ionic crosslinking agent. Here's an alternative description of the ionic gelation method for hydrogel preparation:

1. Dissolve the natural polymer, such as chitosan, in an acidic solution like acetic acid to create a uniform solution. The polymer concentration should be approximately 1-2% w/v.
2. Introduce a suitable ionic crosslinking agent, such as sodium tripolyphosphate, into the polymer solution while stirring vigorously.
3. The crosslinking agent will react with the polymer, forming a hydrogel.
4. After crosslinking, wash the hydrogel with water and allow it to dry in a sterile environment.

4) Inverse Gelation Method:

The inverse gelation method is a popular technique for creating hydrogels, involving the crosslinking of a water-soluble polymer with a crosslinking agent in an organic solvent. Here is an alternative description of the inverse gelation method for hydrogel preparation:

1. Dissolve the water-soluble polymer, such as polyethylene glycol (PEG), in an organic solvent like dichloromethane to achieve a uniform solution. The polymer concentration should be about 10-15% w/v.
2. Introduce an appropriate crosslinking agent, such as diisocyanate, into the polymer solution while stirring vigorously.
3. The crosslinking agent reacts with the polymer to form a hydrogel.
4. After crosslinking, wash the hydrogel with water to eliminate any residual solvent and dry it in a sterile environment.
5. The resulting hydrogel has excellent mechanical properties and can be used for various biomedical applications.
6. The inverse gelation method allows for greater control over the hydrogel's mechanical and chemical properties, but it requires the use of potentially hazardous organic solvents and involves more complex procedures.

List of Chemicals & Reagents:

Chemicals	Quantity taken	Purpose
Curcumin powder	0.5 gm	Reduces inflammatory activity of cytokines
Poly vinyl alcohol	2 gm	Serves as a film forming agent
Methanol	5 ml	Improves solubility and uniformity
Hydrogen peroxide	0.1 ml	Acts as an antimicrobial agent
Peppermint oil	0.5 ml	Provides cooling & Soothing effect
Distilled water	Q.S.	

☆ Preparation of Turmeric Hydrogel:

1. Dissolve 0.5 g of curcumin powder in 5 mL of methanol to create a concentrated solution.
2. Dissolve 2 g of PVA in 50 mL of distilled water by heating the mixture to 70-80°C while stirring on a hot plate.
3. Thoroughly mix the curcumin solution with the PVA solution.
4. Gradually add 0.1 mL of hydrogen peroxide dropwise into the mixture while continuously stirring to crosslink the polymer chains and form a hydrogel.
5. Continue stirring the mixture for 10-15 minutes until the gelation process is complete using a magnetic stirrer.
6. Rinse the hydrogel multiple times with distilled water to remove any remaining crosslinking agent.
7. Allow the hydrogel to air dry in a sterile environment.

VI. MECHANISM OF ACTION

1. Curcumin hydrogel is applied directly to the psoriasis-affected area.
2. The hydrogel is absorbed into the skin, gradually releasing curcumin.
3. Curcumin blocks the activity of inflammatory cytokines, including IL-6 and TNF-alpha.
4. It also inhibits enzymes involved in inflammation, such as COX-2 and LOX.
5. By reducing inflammation, curcumin can help relieve psoriasis symptoms like redness, scaling, and itching.
6. Curcumin may also aid in wound healing by activating growth factors that promote tissue regeneration.

7. The hydrogel provides a sustained release of curcumin, ensuring prolonged exposure to the affected area.

VII. ADVANTAGES OF CURCUMIN HYDROGEL

Anti-inflammatory and Antioxidant Benefits:

Curcumin, a natural compound, has strong anti-inflammatory and antioxidant effects, making curcumin hydrogel effective in wound healing and tissue repair.

Biocompatibility:

Curcumin hydrogel is biocompatible, allowing it to be used in various biomedical applications without causing harmful effects to living tissues.

Drug Delivery:

Curcumin hydrogel can serve as a drug delivery system for curcumin and other medications, offering sustained release and controlled distribution.

Biodegradability:

Being biodegradable, curcumin hydrogel can be broken down by the body's biological processes over time, reducing the risk of long-term accumulation or toxicity.

Antioxidant Properties:

Curcumin is a powerful antioxidant, which may help protect skin cells from damage caused by free radicals.

Low Toxicity:

Curcumin is generally considered safe and has low toxicity, making it a potentially attractive alternative to traditional psoriasis treatments that may have more severe side effects.

Natural Origin:

Derived from turmeric, a widely used spice in many cultures, curcumin is considered a natural compound.

Cost-effective:

Curcumin is relatively inexpensive compared to many traditional psoriasis treatments, making it a more accessible option for patients.

VIII. EVALUATION OF TURMERIC HYDROGEL

Swelling Behavior:

The swelling behavior is an essential parameter that indicates the hydrogel's capacity to absorb water and other fluids. Measuring the equilibrium swelling ratio and the swelling kinetics can help understand the hydrogel's swelling properties.

Mechanical Properties:

The mechanical characteristics of hydrogels can be assessed through various methods such as compression testing, tensile testing, and rheometry. These tests provide insights into the hydrogel's strength, elasticity, and deformation behavior.

Biocompatibility:

Evaluating the biocompatibility of hydrogels involves assessing their cytotoxicity, hemocompatibility, and potential to cause inflammation or immune reactions. This can be done through in vitro assays or in vivo studies.

Drug Release Behavior:

For hydrogels used in drug delivery, evaluating their drug release behavior is critical. This includes studying the release kinetics, mechanism, and rate of drug release from the hydrogel.

Degradation Behavior:
The degradation behavior of hydrogels can be examined to understand their stability and durability. Measuring mass loss, mechanical properties, and changes in chemical structure over time can help determine the degradation characteristics.

Imaging Techniques:
Techniques such as scanning electron microscopy (SEM) and confocal microscopy can be utilized to visualize the structure and morphology of hydrogels, providing detailed images of their physical structure.

IX. CONCLUSION

Curcumin hydrogel shows significant potential as a treatment for psoriasis, although further research is essential to confirm its effectiveness and safety. Future investigations should aim to optimize the delivery system, determine the ideal dosage and treatment duration, and assess the long-term safety and efficacy of curcumin hydrogel. Moreover, additional studies are necessary to elucidate the mechanism by which curcumin acts in psoriasis treatment.Curcumin hydrogel has emerged as a promising option for managing psoriasis, a chronic inflammatory skin condition. The strong anti-inflammatory and antioxidant properties of curcumin make it well-suited for alleviating psoriasis symptoms such as scaling, redness, and inflammation. The use of curcumin hydrogel allows for sustained release of curcumin at the application site, providing effective treatment with minimal systemic side effects. Additionally, the biocompatibility and biodegradability of the hydrogel make it a safe and effective topical therapy for psoriasis.

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