
“FORMULATION AND EVALUATION OF ANTI-INFLAMMATORY GEL CONTAINING CURCUMIN EXTRACT”

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1.0 ABSTRACT:

Curcumin, a polyphenol extracted from turmeric, has been widely studied for its potent antioxidant and anti-inflammatory properties. However, its poor bioavailability and limited topical delivery have hindered its therapeutic potential. To address these challenges, we have developed a novel curcumin gel formulation that enhances bioavailability and targets delivery to the affected area. Our curcumin gel exhibits improved solubility, stability, and permeability, allowing for efficient absorption and retention in the skin. In vitro and in vivo studies demonstrate its efficacy in reducing inflammation, promoting wound healing, and exhibiting anti-cancer properties. This topical formulation offers a promising solution for various health and cosmetic applications, including pain management, skin care, and anti-aging. With its enhanced bioavailability and targeted delivery, curcumin gel has the potential to unlock the full therapeutic potential of curcumin, providing a natural and effective treatment option for a range of conditions.

2.0 KEYWORDS:

- TurmericGel
- CurcuminExtract
- HerbalCosmetic
- HerbalSkincaregel

3.0 INTRODUCTION:

Traditional medicine plays an important role in health care services. The large number of medicinal plants are used with Various pharmacological activities. Gel formulations are used

to deliver topical drug delivery system because of easy Application also with increases penetration time and lesser side effects. As per the I. P the gel is defined as homogeneous Semi-solid preparation consists of dispersion of neormo remedocaments in suitable hydrophobic or hydrophilic bases. The gel formulations was designed by using aqueous extract of turmeric rhizomes. Topical anti-inflammatory activity of The gel was also evaluated. The ayurveda is a science based on Indigenous system of medicine. The turmeric has been Used as a non toxic drUg in ayurveda for treatment of various diseases including skin diseases, inflammation hepatic Disorders etc.

The plant selected for present work are curcumin longa which contain the high percentage of flavonoids & Also responsible for anti-inflammatory activity. The herbal medicines are more accepted in the world for their lesser side Effects & low cost. It has great significance drug delivery system is to Provide a therapeutic amount of drug to the Proper site in the body to promptly achieve and Then maintain the desired drug concentrations. The route of administration has a significant Impact on the therapeutic outcome of a drug. Turmeric is best known for that bold yellow-orange color that it gives to curry. Turmeric has been in use in Asia for thousands of years. History shows that by 800 AD, the cultivation and trade of Turmeric had spread across much of Asia, including China, and also across much of Africa. By the 18th century, as it continued to become increasingly popular, Turmeric spread to Jamaica and other tropical locations. Today, it can also be found in Hawaii and Costa Rica.

Before it was commonly used as a spice for food, it was used to as a natural dye for skin and clothing and as medicine. Turmeric is often referred to as "Indian saffron" because of its deep yellow-orange color. It is some time instead of saffron because it is similar in color and less expensive than saffron. Many consider Turmeric to be a super spice because it is high in antioxidants and contains powerful anti-inflammatory properties.

Ayurved, a position of turmeric poste is med it rest common eye infections, and to dress wound, this burn, acne and various skin diseases. A poultice of tanic is she applied to 4 the perineum to aid in the hing of any laceations in the birth canal Powdered tumeric is nim with bled milk to cure cough and related restrly aments and eased tameric is an ingredient wed as an analysenteric for children. This is ahoed in digestive doondes like dyspepsia and acidity, indigestion, fandence, done, as well as alleviate the hallucinatory effects of hashesh and other psychotropic drags "Iti sale used in food and perfumes and yellow colouring At as well as as approved food additive to flavou various types of cures and m Recent emphasis on the use of tand and complementary ouses in Westemnlcoloe derstheatratriation of the scientific community to this ancient remedy. Research has evealed that canie has vuurprisingly wide range of

beneficial properties, including anti-inflammatory Characteristics of the Turmeric Plant is well known for its vibrant golden. A member of the rhizomatous ginger family Zingiberaceae, *Curcuma longa* is a perennial plant native to tropical South Asia.¹ Turmeric thrives in warm climates and requires a considerable amount of annual rainfall to flourish. Individual plants grow to a height of 3–4 feet and have long, oblong leaves. These plants are gathered annually for their tuberous rhizomes, which can be eaten fresh or dried and ground into a bright golden powder. As many as 133 species of *Curcuma* have been identified worldwide, many of which have common local names and have been used throughout time for their beneficial properties.

In Northern India, turmeric is sometimes called by its Sanskrit name *haridra*, and in other parts of the country it is referred to as “Indian saffron” because of its brilliant yellow color. The Latin root of turmeric is *terremerita*, or meritorious earth, in homage to its mineral-colored ochre hue. And in many places, turmeric is simply referred to as “yellow root.”

Alleppey turmeric comes from Kerala, especially from the region of Thodupuzha and Muvattupuzha taluks. It is characterized by deep yellow to orange TO yellow in color and has high curcumin, up to 6.5%. U.S. has a special preference to Alleppey Finger Turmeric, where it is used as food colorant preferred for curcumin extraction. In India, it was traditionally used for disorders of the skin, upper respiratory tract, joints, and digestive system. Today, turmeric is promoted as a dietary supplement for a variety of conditions, including arthritis, digestive disorders, respiratory infections, allergies, liver diseases. Turmeric is a common spice that comes from the root of *Curcuma longa*. It contains a chemical called curcumin, which might reduce swelling. Turmeric has a warm, bitter taste and is frequently used to flavor or color curry powders, mustards, butters, and cheeses. Because curcumin and other chemicals in turmeric might decrease swelling, it is often used to treat conditions that involve pain and inflammation, e.g., depression, and many others.

People commonly use turmeric for osteoarthritis. It is also used for hay fever, depression, high cholesterol, a type of liver disease, and itching, but there is no good scientific evidence to support most of these uses. There is also no good evidence to support using turmeric for COVID-19. Don't confuse turmeric with Javanese turmeric root or tree turmeric. Also, don't confuse it with zedoary or goldenseal, which are unrelated plants that are sometimes called turmeric.

Origin and distribution

The greatest diversity of *Curcuma* species by number alone is in India, at around 40 to 45

species. Thailand has a comparable 30 to 40 species. Other countries in tropical Asia also have numerous wild species of *Curcuma*. Recent studies have also shown that the taxonomy of *Curcuma longa* is problematic, with only the specimens from South India being identifiable as *C. longa*. The phylogeny, relationships, intraspecific and interspecific variation, and even identity of other species and cultivars in other parts of the world still need to be established and validated. Various species currently utilized and sold as “turmeric” in other parts of Asia have been shown to belong to several physically similar taxa, with overlapping local names.

Turmeric is a herbaceous perennial that reaches about three feet tall with grass-like leaves and greenish-yellow flowers. Turmeric thrives in rainy tropical areas such as the Indian subcontinent and Southeast Asia. Turmeric is often referred to as a root but this is technically incorrect. Rhizomes are underground stems that grow horizontally underground (and have smaller roots growing from them). The underground rhizome of turmeric consists of two distinct parts: the egg-shaped primary or mother rhizome, which is an extension of the stem, and the long cylindrical, multi-branched secondary rhizomes, growing downward from the primary rhizomes

Gel:

A gel is a solid or semisolid system of at least two constituents, consisting of a condensed mass enclosing and interpenetrated by a liquid. Gels and jellies are composed of small amount of solids dispersed in relatively large amount of liquid, yet they possess more solid-like than liquid-like character. The characteristic of gel and jelly is the presence of some form of cutaneous structure, which provides solid-like properties.

- Turmeric gel for Clear skin
- Turmeric gel For treat Dark circles
- For glowing Skin
- Remove Facial hair
- Combats Acne



(Turmeric root *Curcuma longa*) herb plant

Figno1: Turmeric Root.

Gel represent a versatile and widely utilized dosage form in pharmaceutical and cosmetic industries, offering unique properties that make them suitable for various applications. A gel is a semi-solid system composed of a network of interlinked colloidal particles dispersed within a liquid medium, resulting in a viscoelastic consistency that falls between that of solids and liquids. This distinctive structure imparts gels with desirable characteristics such as ease of application, adhesion to surfaces, and controlled release of active ingredients. Gels find extensive use in topical formulations for drug delivery, skincare products, and industrial applications due to their ability to encapsulate and deliver active compounds efficiently.

The composition of a gel typically consists of three primary components: the gelling agent, the solvent or vehicle, and the active ingredient(s). The gelling agent, also known as the gel matrix, plays a crucial role in determining the rheological properties and stability of the gel. Common gelling agents include natural polymers such as carbomers, cellulose derivatives (e.g., hydroxypropyl methylcellulose), and synthetic polymers like polyvinyl alcohol (PVA) and polyethylene glycol (PEG). These gelling agents form a three-dimensional network structure interactions, trapping the solvent and active ingredients within the gel matrix.

The choice of solvent or vehicle depends on the desired properties of the gel, including viscosity, transparency, and compatibility with the active ingredients. Water is the most commonly used solvent due to its biocompatibility and ability to dissolve a wide range of hydrophilic and hydrophobic compounds. However, other solvents such as alcohols, glycols, and oils may be used to tailor the properties of the gel to specific applications. Solvents also serve as carriers for the active ingredients, facilitating their dispersion and absorption into the target tissues upon application.

Active ingredients are incorporated into gels to impart therapeutic, cosmetic, or functional

benefits to the final product. These ingredients may include drugs for topical administration, such as analgesics, anti-inflammatories, and antimicrobials, as well as botanical extracts, vitamins, and antioxidants for skincare formulations. The concentration and compatibility of active ingredients with the gel matrix and solvent are critical considerations to ensure stability and efficacy. Additionally, excipients such as preservatives, antioxidants, and pH adjusters may be added to enhance the stability, shelf-life, and performance of the gel.

Turmeric

is a flowering plant, *Curcuma longa*. Of the ginger family, Zingiberaceae, the rhizomes of which are used in cooking. The plant is a perennial, rhizomatous, herbaceous plant native to the Indian subcontinent and Southeast Asia.

It thrives in warm, humid climates, typically found in tropical and subtropical regions of Asia that requires temperatures between 20 and 30 °C (68 and 86 °F) and high annual rainfall to thrive. Plants are gathered each year for their rhizomes, some for propagation in the following season and some for consumption.

Beyond its medicinal virtues, turmeric occupies a revered place in culinary traditions, particularly in South Asian cuisines. It imparts a warm, slightly bitter flavor and a vibrant yellow hue to dishes, ranging from curries and soups to rice and beverages. Turmeric is a staple ingredient in spice blends like curry powder and masala, where its distinctive flavor profile complements a diverse range of ingredients. Its culinary versatility extends to pickling, where turmeric is used to preserve vegetables and fruits, adding both flavor and color to the final product. Additionally, turmeric finds its way into a variety of beverages, including golden milk, a traditional Ayurvedic tonic made by combining turmeric with milk and spices like cinnamon and ginger, revered for its purported health benefits and comforting properties.

In addition to its culinary and medicinal applications, turmeric holds significant cultural and religious symbolism. It is deeply intertwined with rituals and ceremonies in many societies, where it symbolizes purity, prosperity, and auspiciousness. In Hinduism, turmeric holds particular significance, featuring prominently in wedding ceremonies, festivals, and religious offerings. In wedding rituals, turmeric paste is applied to the bride and groom in a ceremony known as the Haldi, believed to purify the body and soul and bestow blessings for marital harmony and prosperity. Turmeric is also used in religious ceremonies and festivals, where it adorns altars, temples, and deities as a symbol of divine grace and protection. Its association with fertility and abundance makes it a common offering to deities and a cherished ingredient in rituals seeking blessings for prosperity and well-being.



(Curcumin powder)

Figno2: Curcumin powder. (Curcumin powder)

Turmeric powder and roots, Asian origin plant containing curcumin has very power ful anti-inflammatory and antioxidant properties.

Turmeric powder and roots, Asian origin plant containing curcumin has very powerful anti-inflammatory and antioxidant properties.

Turmeric has been put to use as a foodstuff, cosmetic, and medicine. It is widely used as a spice in South Asian and Middle Eastern cooking. It lends currys distinctive yellow color and flavor. It is used as a coloring agent in cheese, butter, and other foods Govindarajan (1980); Ammon and Wahl (1991).

The burgeoning field of natural product pharmaceuticals has seen significant interest in developing novel formulations for therapeutic use, with curcumin, a principal component of turmeric (*Curcuma longa*), standing out for its potent anti-inflammatory properties. The increasing awareness of the adverse effects associated with long-term use of synthetic anti-inflammatory drugs has catalyzed the exploration of safer, natural alternatives. This context provides the impetus for the formulation and evaluation of an anti-inflammatory gel containing curcumin extract, aiming to harness its therapeutic potential in a user- friendly and defective topical application.

Curcumin, known chemically as diferuloylmethane, is celebrated for its extensive pharmacological activities, which include anti-inflammatory, antioxidant, and antimicrobial effects. These properties are largely mediated through its ability to modulate various molecular targets and signaling pathways involved in inflammation. For instance, curcumin inhibits the

activity of nuclear factor-kappa B (NF- κ B), cyclooxygenase-2(COX-2), and lipoxygenase, enzymes that play critical roles in the inflammatory response. Additionally, curcumin's capacity to scavenge reactive oxygen species (ROS) contributes to its antioxidant effects, further mitigating inflammation and associated tissue damage. Despite its promising therapeutic profile, curcumin's clinical application is hindered by its poor solubility in water, low stability, and rapid metabolism, which result in limited bioavailability when administered orally. These challenges necessitate innovative formulation strategies to enhance its bioavailability and therapeutic efficacy. Topical delivery systems, such as gels, offer a viable solution by bypassing the gastrointestinal tract, thereby reducing first-pass metabolism and directly targeting inflamed tissues.

The development of an anti-inflammatory gel formulation containing curcumin extract involves several critical steps, beginning with the selection of appropriate gelling agents and excipients that ensure stability, efficacy, and user compliance. Hydrogels, due to their high water content and biocompatibility, are particularly suitable for this purpose. Common gelling agents include carbomers, hydroxypropyl methylcellulose (HPMC), and xanthan gum, each contributing to the gel's viscosity, spread ability, and stability. The incorporation of curcumin extract into the gel matrix requires careful consideration of solubilizers and stabilizers to enhance its solubility and prevent degradation.

The formulation process also involves optimizing the concentration of curcumin extract to achieve the desired anti-inflammatory effect without causing irritation or adverse reactions. Pre-formulation studies, including solubility tests, compatibility studies, and stability assessments, are essential to identify the optimal formulation parameters. These studies help in understanding the interaction between curcumin and other components of the gel, ensuring that the final product is both effective and stable over its intended shelf life.

Once the formulation is developed, rigorous evaluation is necessary to assess its physicochemical properties, efficacy, and safety. Key parameters include pH, viscosity, spread ability, and homogeneity, which influence the gel's performance and user experience. Additionally, the release profile of curcumin from the gel matrix must be characterized to ensure sustained and controlled delivery to the target site. In vitro release studies using dialysis membranes or Franz diffusion cells provide valuable insights into the release kinetics and potential bioavailability of curcumin from the gel.

The anti-inflammatory efficacy of the curcumin gel is typically evaluated using in vitro and in

vivo models. In vitro assays, such as the inhibition of COX-2 activity and measurement of pro-inflammatory cytokines like interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF- α), offer preliminary evidence of the gel's therapeutic potential. Complementary in vivo studies using animal models of inflammation, such as carrageenan-induced paw edema in rats, provide more comprehensive data on the gel's efficacy in reducing inflammation and pain.

Safety and toxicity studies are also crucial components of the evaluation process. These studies assess the potential for skin irritation, sensitization, and systemic toxicity, ensuring that the gel is safe for human use. Standardized protocols, such as the Draize test for skin irritation and patch tests on human volunteers, help in determining the gel's dermatological safety.

The formulation and evaluation of an anti-inflammatory gel containing curcumin extract not only aim to provide an effective therapeutic option but also seek to enhance patient compliance and convenience. The topical delivery system offers several advantages, including ease of application, targeted delivery, and reduced systemic side effects. Additionally, the use of natural curcumin aligns with the growing consumer preference for natural and holistic healthcare products.

In conclusion, the development of an anti-inflammatory gel containing curcumin extract represents a promising approach to leveraging the therapeutic benefits of curcumin in a user-friendly and effective manner. By addressing the challenges associated with curcumin's bioavailability and stability through innovative formulation strategies, this gel has the potential to offer a safe and effective alternative to conventional anti-inflammatory medications. Rigorous evaluation of its physicochemical properties, efficacy, and safety ensures that the final product meets the necessary standards for clinical use, paving the way for its successful integration into therapeutic regimens for inflammatory conditions. As research and development in this area continue to evolve, the anti-inflammatory gel formulation stands as a testament to the potential of natural products in modern medicine, offering hope for improved management of inflammation and associated disorders.

The formulation of an anti-inflammatory gel containing curcumin extract also opens avenues for personalization and innovation in delivery systems. Modern pharmaceutical technologies enable the customization of gel formulations to cater to specific patient needs and preferences. For example, incorporating essential oils with complementary anti-inflammatory properties, such as eucalyptus or tea tree oil, can enhance the gel's therapeutic effects and provide additional benefits like antimicrobial activity and soothing fragrance. Additionally,

advances in nanotechnology offer the potential to encapsulate curcumin in nanoparticles within the gel matrix, further improving its penetration through the skin and ensuring a more controlled and sustained release. This nano technological approach can enhance the bio availability of curcumin at the site of inflammation, potentially leading to more effective and longer-lasting relief.

Curcumin Gel

Curcumin gel is commonly used for its anti-inflammatory and antioxidant properties. When evaluating the effectiveness of Curcumin gel, researchers typically look at various factors:

- 1. Anti-inflammatory Properties:** Researchers assess the ability of Curcumin gel to reduce inflammation in conditions like arthritis, skin disorders, or muscle injuries. They may measure inflammatory markers before and after using the gel.
- 2. Antioxidant Activity:** Curcumin is known for its antioxidant properties. Studies may evaluate how well the gel can neutralize free radicals and prevent oxidative damage.
- 3. Absorption and Bioavailability:** Researchers analyze how well the skin absorbs Curcumin from the gel and how much of it reaches systemic circulation to exert its effects.
- 4. Safety and Side Effects:** Evaluation includes monitoring for any adverse reactions or side effects associated with the use of Curcumin gel.
- 5. Efficacy in Targeted Conditions:** Studies may focus on specific conditions like acne, psoriasis, or wound healing to determine the effectiveness of Curcumin gel in treating these conditions.
- 6. Comparative Studies:** Researchers may compare the effectiveness of Curcumin gel with other standard treatments to assess its superiority or non-inferiority.
- 7. Clinical Trials:** Clinical trials involving human participants are conducted to evaluate the real-world effectiveness and safety of Curcumin gel.

During the evaluation process, researchers use various scientific methods, such as in vitro studies, animal models, and human trials, to gather data on the efficacy and safety of Curcumin gel. The results of these evaluations help determine the potential benefits and limitations of using Curcumin gel for different health conditions.

Benefits of Turmeric:

Turmeric, specifically its active compound curcumin, is linked to numerous health benefits. These include anti-inflammatory properties, improved antioxidant capacity, enhanced brain

function, reduced risk of heart disease, and potential cancer-fighting properties. Additionally, it may aid in easing arthritis symptoms and supporting digestive health. However, it's essential to note that while promising, more research is needed to fully understand the extent of its benefits.



FigNo3: Health Benefits.

Turmeric, renowned for its vibrant golden color and distinct earthy flavor, is more than just a culinary spice—it is a powerhouse of health benefits deeply rooted in traditional medicine and supported by modern scientific research. Derived from the rhizome of the *Curcuma longa* plant, turmeric has been prized for centuries in Ayurveda, Traditional Chinese Medicine (TCM), and other healing traditions for its multifaceted therapeutic properties. The key to turmeric's impressive array of benefits lies in its bioactive compounds, particularly curcuminoids, with curcumin being the most extensively studied and well-known component. Here, we delve into the myriad benefits of turmeric, spanning from its anti-inflammatory and antioxidant effects to its potential in preventing and treating various diseases. At the forefront of turmeric's health benefits is its potent anti-inflammatory action, attributed primarily to curcumin. Chronic inflammation is a hallmark of many diseases, including

Garthritis, cardiovascular disease, and neurodegenerative disorders. Curcumin exerts its anti-inflammatory effects by inhibiting the activity of inflammatory enzymes and cytokines, thereby reducing inflammation and associated tissue damage. Studies have shown that curcumin can be as effective as non-steroidal anti-inflammatory drugs (NSAIDs) in alleviating symptoms of conditions like osteoarthritis and rheumatoid arthritis, with the added advantage of fewer side effects.

In addition to its anti-inflammatory properties, turmeric is a powerful antioxidant, capable of neutralizing harmful free radicals and protecting cells from oxidative stress. Free radicals are highly reactive molecules that can damage cellular structures and contribute to aging and chronic diseases. Curcumin's antioxidant activity helps counteract oxidative damage, preventing cellular dysfunction and degeneration. This antioxidant capacity is particularly beneficial for cardiovascular health, as it helps reduce the risk of atherosclerosis, hypertension, and other cardiovascular diseases by protecting against lipid peroxidation and endothelial dysfunction.

Furthermore, turmeric has demonstrated promising anti cancer properties, making it a subject of intense research in oncology. Curcumin's ability to inhibit cancer cell proliferation, induce apoptosis (programmed cell death), and suppress tumor growth has been observed in various types of cancer, including breast, prostate, colorectal ,and pancreatic cancer. Additionally, curcumin may enhance the effectiveness of conventional cancer therapies like chemotherapy and radiation ntherapy ,while also mitigating their side effects. Its role in cancer prevention and treatment underscores its potential as a natural adjuvant therapy in integrative cancer care.

Turmeric's benefits extend beyond physical health to encompass mental well-being and cognitive function. Curcumin has neuroprotective properties that make it promising in the prevention and management of neurodegenerative diseases like Alzheimer's and Parkinson's .By reducing neuro inflammation, amyloid plaque formation, and oxidative stress in the brain, curcumin helps preserve cognitive function and delay the progression of age-related cognitive decline. Moreover, turmeric may have mood-enhancing effects, as studies suggest that curcumin can increase levels of serotonin and dopamine, neurotransmitters associated with feelings of happiness and well-being.

In addition to its direct effects on health, turmeric has a positive impact on digestive health and gastrointestinal function. Traditionally used to aid digestion and relieve gastrointestinal discomfort, turmeric's anti-inflammatory and antimicrobial properties make it beneficial for conditions like irritable bowel syndrome (IBS), inflammatory bowel disease (IBD), and

gastric ulcers. Curcumin's ability to modulate gut microbiota composition and reduce gut inflammation contributes to its therapeutic effects on digestive disorders, promoting gut health and overall well-being.

Moreover, turmeric exhibits antimicrobial activity against a wide range of pathogens, including bacteria, viruses, and fungi. This antimicrobial action makes turmeric useful in preventing and treating infections, both internally and externally. Turmeric preparations have been used traditionally to treat wounds, cuts, and skin infections due to their antimicrobial and wound-healing properties. Additionally, turmeric's antiviral activity has potential implications in preventing viral infections, though more research is needed to elucidate its efficacy against specific viruses.

Furthermore, turmeric plays a role in metabolic health and weight management, with studies suggesting that curcumin may help regulate blood sugar levels, improve insulin sensitivity, and reduce obesity-related inflammation. These metabolic effects make turmeric a valuable adjunct

in the prevention and management of type 2 diabetes and metabolic syndrome. Moreover, turmeric's ability to modulate lipid metabolism and promote fat metabolism may aid in weight loss and obesity prevention, though further research is warranted to confirm these effects in humans.

Uses of Turmeric:

Turmeric, with its active compound curcumin, has garnered significant attention for its multifaceted benefits, particularly in skincare and wound management. Its therapeutic properties extend beyond the kitchen to the realm of topical applications, where curcumin gel emerges as a versatile remedy for various conditions. Let's delve into the intricate details of how turmeric gel, enriched with curcumin, serves as a potent tool for promoting skin health, wound healing, and pain relief.

Anti-inflammatory Properties: Curcumin's potent anti-inflammatory effects make it a valuable asset in topical formulations for reducing inflammation associated with conditions like arthritis or skin irritation. Inflammation is a natural response to injury or infection, but chronic inflammation can contribute to various diseases. Curcumin inhibits inflammatory enzymes and mediators, such as cyclooxygenase-2 (COX-2) and prostaglandins, thereby alleviating inflammation and associated discomfort. When incorporated into a gel formulation, curcumin penetrates the skin's layers, targeting inflamed tissues directly, making it an

effective option for managing inflammatory skin conditions like eczema, psoriasis, and dermatitis.

Wound Healing: Turmeric gel's antimicrobial properties and ability to reduce inflammation contribute to its efficacy in wound healing. When applied topically, curcumin inhibits the growth of harmful bacteria, preventing infection and promoting a clean wound environment conducive to healing. Additionally, curcumin's anti-inflammatory action reduces swelling and accelerates the resolution of tissue damage, facilitating the wound healing process. Turmeric gel forms a protective barrier over the wound site, shielding it from external contaminants and promoting tissue regeneration. Studies have demonstrated the efficacy of curcumin gel in promoting faster wound closure and reducing the risk of complications, making it a valuable adjunct in wound care management.

Skin Care: Curcumin's antioxidant properties are particularly beneficial for skin health, protecting against damage caused by free radicals and ultraviolet (UV) radiation. Free radicals are unstable molecules that can damage cellular structures and contribute to premature aging and skin disorders. By scavenging free radicals and neutralizing oxidative stress, curcumin helps maintain skin integrity and resilience. Turmeric gel is often incorporated into skincare products like creams, serums, and masks for its ability to rejuvenate and protect the skin. It can help improve skin tone, reduce

Pain Relief: Topical application of curcumin gel provides localized pain relief, particularly in conditions like osteoarthritis or muscle soreness. Curcumin's analgesic properties help alleviate pain by blocking pain signals and reducing inflammation in affected tissues. When applied directly to the skin, turmeric gel penetrates deep into the underlying tissues, delivering curcumin directly to the site of pain. This targeted approach allows for effective pain relief with minimal systemic side effects, making curcumin gel a preferred option for individuals seeking natural alternatives to conventional pain medications.

Scar Reduction: Curcumin gel may aid in reducing the appearance of scars by promoting collagen synthesis and tissue regeneration. Scars form as a result of the body's natural healing process, but excessive scarring can be cosmetically and functionally problematic. Curcumin stimulates fibroblasts, the cells responsible for producing collagen, leading to improved wound remodeling and reduced scar formation. Additionally, curcumin's anti-inflammatory properties help minimize scar tissue formation by reducing inflammation and preventing excessive collagen deposition. When applied regularly to scars, turmeric gel can help soften and fade their appearance, restoring skin texture and tone.

In summary, turmeric gel enriched with curcumin offers holistic approaches to skin care, wound healing, and pain management. Its anti-inflammatory, antimicrobial, antioxidant, and analgesic properties make it a versatile remedy for a wide range of conditions, from inflammatory skin disorders to wound care and pain relief. As research continues to uncover the mechanisms underlying its therapeutic effects, turmeric gel remains a promising natural alternative.



Fig No 4: Use of Turmeric.

Turmeric has numerous uses:

1. **Culinary:** It is a staple spice in many cuisines, adding flavor and color to dishes like curries, rice, soups, and sauces.
2. **Medicinal:** It has been used in traditional medicine for its anti-inflammatory and antioxidant properties, often taken as a supplement or brewed into teas.

3. **Skincare:** Its anti-inflammatory and antibacterial properties make it a popular ingredient in skincare products, like face masks and creams.
 4. **Dyeing:** Turmeric can be used as a natural dye for fabrics, giving them a vibrant yellow color.
 5. **Rituals:** In some cultures, turmeric is used in religious ceremonies and rituals for purification and spiritual cleansing.
- 6. Therapeutic Uses:**
1. **Anti-inflammatory Properties:** Curcumin is renowned for its potent anti-inflammatory effects. It inhibits inflammatory pathways in the body, potentially reducing the risk of chronic diseases associated with inflammation, such as arthritis and heart disease.
 2. **Antioxidant Effects:** As a powerful antioxidant, curcumin scavenges free radicals, protecting cells from oxidative damage. This property is crucial in combating oxidative stress, which contributes to aging and various diseases.
 3. **Pain Management:** Curcumin's anti-inflammatory properties also make it effective in alleviating pain. It may help reduce pain associated with conditions like arthritis, headaches, and muscle soreness.
 4. **Potential Cancer Prevention:** Some studies suggest that curcumin may have anticancer properties, inhibiting the growth and spread of cancer cells. While more research is needed, it shows promise in cancer prevention and adjunctive therapy.
 5. **Neuroprotective Effects:** Curcumin exhibits neuroprotective properties, potentially aiding in the prevention and treatment of neurodegenerative diseases like Alzheimer's and Parkinson's disease. It may help reduce inflammation in the brain and promote the growth of new brain cells.
 6. **Cardiovascular Health:** Research indicates that curcumin may benefit cardiovascular health by improving endothelial function, reducing inflammation, and lowering the risk of heart disease.
- **Culinary Uses:**
1. **Spice:** Curcumin lends turmeric its distinctive yellow color and warm, earthy flavor, making it a popular spice in culinary dishes worldwide. It's a staple ingredient in curries, soups, stews, and rice dishes, adding both flavor and color.
 2. **Food Coloring:** Beyond flavor, curcumin serves as a natural food coloring agent, imparting a vibrant yellow hue to foods like mustard, sauces, pickles, and dairy products.

- **Cosmetic Applications:**

1. **Skin Care:** Curcumin's anti-inflammatory and antioxidant properties make it a valuable ingredient in skincare products. It may help reduce acne, soothe irritation, promote wound healing, and prevent premature aging.
2. **Hair Care:** Some hair care products contain curcumin for its potential to strengthen hair, improve scalp health, and enhance shine.

- **Emerging Research Areas:**

1. **Gut Health:** Curcumin shows promise in promoting gut health by modulating gut microbiota, reducing inflammation in the gastrointestinal tract, and potentially alleviating symptoms of digestive disorders like irritable bowel syndrome (IBS) and inflammatory bowel disease (IBD)
2. **Metabolic Health:** Research suggests that curcumin may have benefits for metabolic health, including weight management, blood sugar regulation, and lipid metabolism.
3. **Mood and Mental Health*:** Preliminary studies indicate that curcumin may have antidepressant and anxiolytic effects, possibly through its anti-inflammatory and neuroprotective mechanisms.

Turmeric, a vibrant yellow spice derived from the Curcuma longa plant, boasts a plethora of uses across various domains

Culinary Uses:

1. **Flavoring Agent:** Turmeric adds a warm, earthy flavor to dishes, enhancing the taste of curries, stews, soups, and rice dishes.
2. **Food Coloring:** Its intense yellow color serves as a natural food dye, giving foods a visually appealing hue. It's commonly used in mustard, sauces, pickles, and even baked goods.
3. **Marinades and Rubs:** Turmeric is often included in marinades and spice rubs for meats, fish, and vegetables, infusing them with flavor and color.

- **Medicinal and Health Benefits:**

1. **Anti-inflammatory Properties:** Turmeric contains curcumin, a compound with potent anti-inflammatory effects, which may help alleviate symptoms of inflammation-related conditions like arthritis.
2. **Antioxidant Activity:** Curcumin's antioxidant properties scavenge free radicals,

reducing oxidative stress and potentially lowering the risk of chronic diseases.

3. **Digestive Aid:** In traditional medicine, turmeric is used to aid digestion, relieve bloating, and soothe stomach discomfort.
4. **Immune Support:** Some research suggests that turmeric may support immune function, helping the body fight off infections and illnesses.

- **Beauty and Skin care:**

1. **Face Masks:** Turmeric is a common ingredient in home remedies, believed to brighten skin, reduce acne, and improve complexion.
2. **Skin Healing:** Its anti-inflammatory and antimicrobial properties may promote wound healing and soothe skin irritations.
3. **Anti-aging:** Turmeric's antioxidant activity may help protect skin from premature aging by combating oxidative stress and reducing the appearance of fine lines and wrinkles.

- **Household Uses:**

1. **Stain Removal:** Turmeric paste is sometimes used to remove stains from fabrics, carpets, and kitchen utensils.
2. **Natural Dye:** It serves as a natural dye for fabrics and yarn, producing shades of yellow ranging from pale to deep golden hues.

Cultural and Ritualistic Practices:

1. **Religious Ceremonies:** Turmeric holds significance in many cultures and is used in religious ceremonies and rituals for purification and auspiciousness.
2. **Traditional Medicine:** In various traditional medicine systems like Ayurveda and Traditional Chinese Medicine (TCM), turmeric is utilized for its healing properties to treat a wide range of ailments.

In essence, turmeric's versatility extends far beyond the kitchen, encompassing a rich tapestry of culinary, medicinal, cosmetic, and cultural applications, making it a truly indispensable ingredient in many parts of the world.

Curcumin, the active compound found in turmeric, has garnered significant attention in recent years due to its potential health benefits. In this comprehensive exploration, we will delve into the multifaceted properties, therapeutic applications, research findings, and

considerations surrounding curcumin.

- **Introduction to Curcumin:**

Curcumin is a polyphenolic compound derived from the rhizome of the *Curcuma longa* plant, commonly known as turmeric. It is responsible for the vibrant yellow color of turmeric and has been used for centuries in traditional medicine systems such as Ayurveda and traditional Chinese medicine.

- **Chemical Structure and Properties:**

Chemically, curcumin is a diarylheptanoid, belonging to the curcuminoid family. Its molecular formula is $C_{21}H_{20}O_6$, and it exhibits poor water solubility but is soluble in organic solvents like ethan (DMSO). ,anti- inflammatory, antimicrobial, and anticancer properties, which have been extensively studied in both preclinical and clinical settings.

- **Mechanisms of Action:**

Curcumin exerts its diverse biological effects through multiple molecular mechanisms. It modulates various signaling pathways, including NF- κ B, STAT3, MAPK, and Nrf2, thereby regulating inflammation, oxidative stress, apoptosis, and cell proliferation. Additionally, curcumin interacts with numerous molecular targets, such as enzymes, transcription factors, and cytokines, contributing to its pleiotropic activities.

- **Clinical Evidence and Research Findings:**

While numerous preclinical studies have demonstrated the efficacy of curcumin in various disease models, translating these findings into clinical practice has been challenging due to factors like low bioavailability and inconsistent study results. However, several clinical trials have reported promising outcomes, particularly in conditions such as osteoarthritis, ulcerative colitis, and certain cancers.

- **Bioavailability and Formulation Considerations:**

The poor bioavailability of curcumin, characterized by low absorption, rapid metabolism, and rapid systemic elimination, has spurred extensive research into enhancing its delivery and efficacy. Strategies such as nanoparticle formulations, liposomal encapsulation, and the use of adjuvants like piperine have shown promise in improving curcumin's bioavailability and therapeutic potential.

- **Safety Profile and Considerations:**

Curcumin is generally regarded as inculinary amounts, but high doses or long- termuse may cause gastrointestinal discomfort or interact with certain medications. Individuals with gallbladder issues, bleeding disorders, or those taking blood-thinning medications should

exercise caution when using curcumin supplements.

Curcumin Family:

The curcumin family consists of a group of bioactive compounds found in turmeric, a perennial herbaceous plant belonging to the ginger family, Zingiberaceae. While curcumin is the most studied and well-known member of this family, it also includes other curcuminoids such as and bisdemethoxycurcumin.

The curcumin family, primarily known for its potent bioactive compound curcumin, represents a significant category of natural phenolic compounds derived from the rhizomes of the turmeric plant (*Curcuma longa*). Curcumin is the most well-studied and recognized member of this family, characterized by its distinctive yellow pigment and extensive therapeutic potential. Belonging to the broader class of curcuminoids, this family includes dimethoxy curcumin and bisdemethoxycurcumin, each varying slightly in chemical structure but collectively contributing to the biological activities attributed to turmeric. Curcuminoids are renowned for their anti-inflammatory, antioxidant, anti-cancer, and neuroprotective properties, making them subjects of intense research in the fields of medicine and pharmacology.

The mechanisms through which curcuminoids exert their effects are diverse, involving the modulation of various signaling pathways, suppression of pro-inflammatory cytokines, inhibition of reactive oxygen species, and interaction with molecular targets like nuclear factor-kappa B (NF- κ B) broadening their therapeutic applicability. Despite their significant health benefits, curcuminoids face challenges such as poor bioavailability, rapid metabolism, and low systemic bioavailability, which have spurred the development of various formulations, including nanoparticles, liposomes, and phospholipid complexes, to enhance their absorption and efficacy. The safety profile of curcuminoids is generally favorable, with high doses being well-tolerated in humans, though some concerns about possible adverse effects, such as gastrointestinal disturbances and interactions with certain medications, persist. Curcuminoids' integration into traditional and modern medicine underscores their importance, with turmeric being a staple in Ayurvedic and traditional Chinese medicine for centuries. Its applications extend beyond health, permeating the food industry as a coloring agent and preservative, and cosmetics for its skin-enhancing properties.

- **Member so the Curcumin Family:**

- 1. Curcumin:**

The most prominent and extensively studied member of the curcumin family, curcumin (diferuloylmethane) is responsible for the characteristic yellow color of turmeric. It exhibits a wide range of biological activities, including potent anti-inflammatory, antioxidant, anti-cancer, and neuroprotective properties. Curcumin's mechanisms of action involve modulating various molecular targets such as nuclear factor-kappa B (NF- κ B), cyclooxygenase-2 (COX-2), and reactive oxygen species (ROS), making it a subject of significant interest in medical research. Despite its broad therapeutic potential, curcumin faces challenges such as poor bioavailability, rapid metabolism, and low systemic absorption, which have led to the development of various formulations like nanoparticles and liposomal encapsulations to enhance its efficacy

- 2. Demethoxy curcumin:**

Another important curcuminoid, dimethoxy curcumin, differs from curcumin by having one less methoxy group on its aromatic ring. This structural difference contributes to distinct biological activities, although many properties overlap with those of curcumin. Demethoxy curcumin also exhibits anti-inflammatory, antioxidant, and anti-cancer effects, and it plays a role in modulating similar molecular pathways. Research suggests that dimethoxy curcumin may have better stability and slightly improved bioavailability compared to curcumin, adding to its therapeutic potential.

- 3. Bisdemethoxy curcumin:**

The simplest of the three major curcuminoids, bisdemethoxycurcumin lacks two methoxy groups. This compound shares many of the beneficial properties of curcumin and dimethoxy curcumin, including anti-inflammatory, antioxidant, and anti-cancer activities. Its mechanisms of action are similar, involving the inhibition of pro-inflammatory cytokines and modulation of key signaling pathways. Bisdemethoxycurcumin's simpler structure might confer different pharmacokinetic properties, which could be advantageous in certain therapeutic contexts.

- 4. Other Curcuminoids:**

While curcumin, dimethoxy curcumin, and bisdemethoxycurcumin are the primary constituents of the curcumin family, other minor curcuminoids and related compounds have been identified in turmeric. These include cyclo curcumin, curcumin glucuronide, and curcumin sulfate, among others. These minor compounds are less studied but may contribute to the overall therapeutic effects of turmeric, offering additional bioactive benefits and

expanding the scope of curcuminoid research.

Collectively, the members of the curcumin family exhibit a remarkable range of pharmacological activities that have significant implications for health and disease management. Their potential applications span from treating chronic inflammatory conditions, cancer, and neurodegenerative diseases to serving as dietary supplements and components in functional foods. Despite their promise, the challenge of improving their bioavailability remains a critical area of research, driving the innovation of advanced delivery systems. The curcumin family thus represents a valuable group of natural compound with multifold benefits and ongoing scientific and clinical interest.

Biological Activities and Health Benefits:

Members of the curcumin family share similar pharmacological properties, including antioxidant, anti-inflammatory, antimicrobial, and anticancer activities. They exert their effects through modulation of various cellular signaling pathways, enzyme activities, and gene expression.

- **Synergistic Effects:**

Studies suggest that the different curcuminoids may act synergistically to enhance their overall biological potency. This synergy could result from their complementary mechanisms of action or their ability to modulate multiple targets within cells.

The curcumin family comprises a group of bioactive compounds found in turmeric, a perennial herbaceous plant belonging to the ginger family, Zingiberaceae. This family primarily includes curcumin, dimethoxy curcumin, and bisdemethoxycurcumin, each possessing distinct chemical structures and biological activities. Let's delve deeper into each member of the curcumin family, their biological properties, therapeutic applications, and considerations regarding their use.

Curcumin, scientifically known as diferuloylmethane, is the most abundant and well-studied curcuminoid in turmeric. It is responsible for the vibrant yellow color of turmeric and constitutes approximately 2-5% of its total weight. Curcumin possesses remarkable antioxidant, anti-inflammatory, antimicrobial, and anticancer properties, making it a subject of extensive research in both preclinical and clinical settings. It scavenges free radicals, inhibits inflammatory pathways, and modulates various cellular processes involved in cancer development and progression. Additionally, curcumin exhibits neuroprotective effects and helps protect against cardiovascular diseases.

Demethoxy curcumin, structurally similar to curcumin but lacking one methoxy group, is

present in smaller quantities in turmeric compared to curcumin. Despite its lower abundance, dimethoxy curcumin contributes to the pharmacological properties of turmeric. It exhibits antioxidant and anti-inflammatory activities, albeit to a lesser extent than curcumin. Like curcumin, dimethoxy curcumin may offer therapeutic benefits in conditions characterized by oxidative stress and inflammation.

Bisdemethoxycurcumin, the least abundant curcuminoid in turmeric, lacks two methoxy groups from the curcumin molecule. While less studied compared to curcumin and dimethoxy curcumin, bisdemethoxycurcumin also possesses antioxidant and anti-inflammatory properties. It acts as an antioxidant and modulates inflammatory pathways, contributing to its anti-inflammatory effects. Bisdemethoxycurcumin may have potential therapeutic applications in conditions involving oxidative stress and inflammation.

Despite their potent biological activities, members of the curcumin family face challenges related to poor bioavailability, limiting their therapeutic potential. Factors such as low absorption, rapid metabolism, and rapid systemic elimination hinder their efficacy in clinical settings. Various formulation strategies, including nanoparticle formulations and the use of adjuvants like piperine, aim to enhance their bioavailability and therapeutic efficacy.

In conclusion, the curcumin family encompasses curcumin, demethoxycurcumin, and bisdemethoxycurcumin, each offering unique biological activities and potential therapeutic benefits. Understanding their individual properties and interactions could lead to the development of novel interventions for various health conditions. Further research is warranted to elucidate their mechanisms of action, optimize their bioavailability, and validate their clinical efficacy.

Biological activities of curcumin :- Curcumin, the bioactive compound found in turmeric, exhibits a wide range of biological activities and potential health benefits. In this comprehensive exploration, we will delve into the diverse pharmacological properties of curcumin, its mechanisms of action, and its therapeutic applications in various health conditions.

- **Anti-Inflammatory Properties:**

Curcumin is renowned for its potent anti-inflammatory effects. It modulates inflammatory pathways by inhibiting the activity of enzymes such as cyclooxygenase-2 (COX-2) and lipoxygenase (LOX), which are involved in the synthesis of pro-inflammatory mediators like prostaglandins and leukotrienes. By downregulating the expression of inflammatory genes and cytokines, curcumin helps to alleviate inflammation associated with conditions such as

arthritis, inflammatory bowel disease (IBD), and chronic inflammatory disorders.

- **Antioxidant Activity:**

Curcumin possesses strong antioxidant properties, which play a crucial role in protecting cells from oxidative damage. It scavenges free radicals, neutralizes reactive oxygen species (ROS), and enhances the activity of anti-oxidant enzymes like superoxide dismutase (SOD) and catalase. By reducing oxidative stress and lipid peroxidation, curcumin helps to mitigate cellular damage and may contribute to the prevention of age-related diseases.

- **Anti cancer Potential:**

Numerous studies have investigated curcumin's potential as a natural anticancer agent. It exhibits diverse anti-cancer activities, including the inhibition of cancer cell proliferation, induction of apoptosis (programmed cell death), suppression of angiogenesis (blood vessel formation), and inhibition of metastasis (spread of cancer cells). Curcumin's multi-targeted approach makes it a promising candidate for cancer prevention and treatment, with research focusing on its efficacy against various cancer types, including breast, colon, prostate, lung, and pancreatic cancer.

- **Neuroprotective Effects:**

Curcumin exerts neuroprotective effects by modulating multiple pathways involved in neuroinflammation, oxidative stress, and neurodegeneration. It inhibits the activation of microglia, the immune cells of the central nervous system, thereby reducing neuroinflammatory responses. Curcumin also enhances the expression of neurotrophic factors, which promote neuronal survival and plasticity. Additionally, curcumin's antioxidant properties help to counteract oxidative damage in the brain, making it a potential therapeutic agent for neurodegenerative diseases such as Alzheimer's disease, Parkinson's disease, and multiple sclerosis.

- **Cardio vascular Health:**

Curcumin has been shown to have beneficial effects on cardiovascular health, primarily attributed to its anti-inflammatory, antioxidant, and lipid-lowering properties. By reducing inflammation and oxidative stress in the blood vessels, curcumin helps to improve endothelial function and vascular health. It also inhibits the progression of atherosclerosis, a major risk factor for heart disease, by preventing the formation of plaque deposits in the arteries. Additionally, curcumin may help to regulate lipid metabolism by lowering levels of LDL (bad) cholesterol and triglycerides while increasing HDL (good) cholesterol levels.

- **Gastro intestinal Benefits:**

Inflammatory bowel disease (IBD), including conditions like Crohn's disease and ulcerative colitis, is characterized by chronic inflammation of the gastrointestinal tract. Curcumin's anti-inflammatory properties make it a potential therapeutic agent for managing IBD symptoms and promoting mucosal healing. Studies have shown that curcumin can reduce inflammation, oxidative stress, and immune cell infiltration in the gut, leading to improvements in symptoms such as abdominal pain, diarrhea, and rectal bleeding.

- **Joint Health:**

Curcumin has been traditionally used for centuries in Ayurvedic medicine to support joint health and alleviate symptoms of arthritis. Its anti-inflammatory properties help to reduce joint pain, stiffness, and swelling associated with osteoarthritis and rheumatoid arthritis. Curcumin may also inhibit the degradation of cartilage and promote its regeneration, thereby preserving joint function and mobility.

- **Metabolic Support:**

Curcumin has shown promise in supporting metabolic health and may be beneficial for individuals with conditions such as diabetes and metabolic syndrome. It improves insulin sensitivity and glucose metabolism by enhancing insulin signaling pathways and reducing insulin resistance. Curcumin also helps to regulate lipid metabolism by lowering levels of triglycerides and LDL cholesterol while increasing HDL cholesterol levels. These metabolic effects contribute to the prevention and management of diabetes, obesity, and related complications.

- **Skin Health:**

Curcumin's anti-inflammatory, antioxidant, and antimicrobial properties make it a valuable ingredient in skincare products. It helps to reduce inflammation and redness associated with skin conditions like acne, eczema, and psoriasis. Curcumin also scavenges free radicals and protects against UV-induced damage, promoting skin health and preventing premature aging. Additionally, curcumin's antimicrobial activity helps to inhibit the growth of acne-causing bacteria and fungi, making it effective in the treatment of acne and other skin infections.

- **Considerations and Future Directions:**

While curcumin offers numerous potential health benefits, its bioavailability and pharmacokinetics present challenges for clinical translation. Strategies to enhance curcumin's bioavailability, such as nanoparticle formulations, lipid-based delivery systems, and co-administration with bioenhancers like piperine, are being explored to maximize its

therapeutic efficacy. Additionally, further research is needed to elucidate the optimal dosage, formulation, and long-term safety of curcumin for various health conditions. Despite these challenges, the cumulative evidence suggests that curcumin holds promise as a natural, multi-targeted therapeutic agent with broad-ranging health benefits.

Chemical constituents of curcumin :- Curcumin, the primary bioactive compound found in turmeric (*Curcuma longa*), is renowned for its diverse pharmacological properties and potential health benefits. In this comprehensive exploration, we will delve into the chemical constituents of curcumin.

Chemical Structure:

Curcumin, scientifically known as diferuloylmethane, belongs to a class of compounds called curcuminoids. It has a distinctive chemical structure characterized by two aromatic rings connected by a seven-carbon linker with two methoxy (-OCH₃) and two hydroxyl (-OH) groups on each aromatic ring. This unique structure imparts the characteristic yellow color and biological activities to curcumin.

Chemical Constituents:

The chemical constituents of curcumin can be categorized into three main groups:

- **Curcuminoids:**

Curcumin is just one member of the curcuminoid family, which also includes dimethoxy curcumin and bisdemethoxy curcumin. These curcuminoids share similar chemical backbones but differ in the number and position of methoxy groups. Demethoxy curcumin lacks one methoxy group, while bisdemethoxy curcumin lacks two methoxy groups. Despite their structural similarities, each curcuminoid exhibits distinct biological activities and pharmacokinetic properties.

Curcumin (diferuloylmethane): The most abundant and well-studied curcuminoid, responsible for the majority of turmeric's pharmacological properties.

Demethoxy curcumin: Similar to curcumin but with one methoxy group removed, contributing to turmeric's bioactivity.

Bisdemethoxy curcumin: The least abundant curcuminoid, lacking two methoxy groups, but still possessing biological activity.

- **Volatile Oils:**

- Turmeric also contains volatile oils, which contribute to its aroma and flavor. These oils con
- Example of volatile constituent include α -turmerone, β -turmerone, γ -turmerone, and

zingiberene

- **Polysaccharides:**

- Turmeric contains polysaccharides, complex carbohydrates composed of long chains of sugar molecules.
- These polysaccharides have been less studied compared to curcuminoids but may contribute to turmeric's biological activities, such as immunomodulation and antioxidant effects.

- **Metabolism:**

Upon ingestion, curcumin undergoes extensive metabolism in the body, which influences its bioavailability and pharmacological effects. The primary metabolic pathways of curcumin include:

- **Reduction:** Curcumin can undergo reduction reactions, leading to the formation of dihydro curcumin and tetrahydro curcumin metabolites.
- **Conjugation:** Curcumin and its metabolites can be conjugated with glucuronic acid, sulfate, or glutathione, facilitating their elimination from the body.

Properties Of Curcumine:

Curcumin, the principal bioactive compound found in turmeric (*Curcuma longa*), is renowned for its multifaceted properties, spanning physical characteristics, medicinal applications, and pharmaceutical relevance. Here is an in-depth exploration of curcumin's properties, organized into three sections: physical properties, and pharmaceutical properties.

- **Physical Properties of Curcumin**

Curcumin, chemically known as diferuloylmethane, is a bright yellow compound that belongs to the curcuminoid family. It has several distinctive physical properties:

1. **Chemical Structure:** Curcumin has the molecular formula $C_{21}H_{20}O_6$ and a molecular weight of 368.38 g/mol. Its structure comprises two aromatic ring systems (phenolic groups) connected by a seven-carbon linker consisting of an α , β -unsaturated β -diketone moiety.
2. **Appearance:** Curcumin appears as an orange-yellow crystalline powder. This vivid color is due to its extensive conjugated double-bond system, which also contributes to its chemical reactivity and stability.
3. **Solubility:** Curcumin is sparingly soluble in water but dissolves well in organic solvents like ethanol, dimethyl sulfoxide (DMSO), and acetone. Its poor water solubility poses a

challenge for its bioavailability in aqueous biological environments.

4. **Stability:** Curcumin is relatively unstable and degrades under alkaline conditions, light exposure, and in the presence of oxidizing agents. It remains more stable under acidic to neutral pH conditions, which is favorable for its use in the gastrointestinal tract.
5. **Melting Point:** The melting point of curcumin is approximately 183°C (361°F), indicating its crystalline nature.

- **Pharmaceutical Properties of Curcumin**

The pharmaceutical properties of curcumin are crucial for its therapeutic applications, addressing challenges like its poor bioavailability and optimizing its delivery in the body.

Bioavailability: One of the major challenges with curcumin is its low bioavailability, attributed to poor absorption, rapid metabolism, and systemic elimination. Various strategies have been developed to enhance its bioavailability, including the use of adjuvants like piperine, which inhibit metabolic pathways and increase absorption.

Delivery Systems: Advanced drug delivery systems have been designed to improve curcumin's pharmacokinetic profile:

Nanoparticles: Encapsulation of curcumin in nanoparticles enhances its solubility, stability, and bioavailability. These nanoparticles can target specific tissues, providing controlled release of curcumin.

Liposomes: Liposomal formulations encapsulate curcumin in phospholipid bilayers, protecting it from degradation and improving its systemic circulation time.

Phytosomes: These are complexes of curcumin with phospholipids, enhancing its bioavailability by promoting better absorption through the gastrointestinal tract.

Solid Lipid Nanoparticles (SLNs): SLNs improve curcumin stability and facilitate sustained release, enhancing its therapeutic efficacy.

Polymeric Micelles: These are used to solubilize curcumin, enhancing its aqueous solubility and systemic delivery.

2. **Pharmacokinetics:** Studies have shown that curcumin undergoes extensive metabolism in the liver and intestines, leading to the formation of metabolites like curcumin glucuronide and curcumin sulfate. Enhancing curcumin pharmacokinetics involves using inhibitors of glucuronidation or modifying its chemical structure to resist rapid metabolism.

3. Safety and Efficacy: Curcumin is generally recognized as safe (GRAS) by the FDA. High doses of curcumin have been used in clinical trials with minimal adverse effects, typically limited to mild gastrointestinal disturbances. Its safety profile makes it an attractive candidate for long-term therapeutic use.

Formulations: Curcumin is available in various formulations for medicinal use, including capsules, tablets, powders, and topical creams. Each formulation is designed to maximize its stability and efficacy for specific therapeutic applications.

curcumin is a multifaceted compound with impressive physical, medicinal, and pharmaceutical properties. Its vibrant color and chemical structure contribute to its physical characteristics, while its extensive therapeutic potential is harnessed in various medicinal applications. Despite challenges like poor bioavailability, innovative pharmaceutical strategies are continually enhancing curcumin's effectiveness, making it a valuable agent in modern medicine.

Collection of dride turmeric:

Dried turmeric is a vibrant yellow spice derived from the dried root of the *Curcuma longa* plant. It's known for its earthy flavor and is commonly used in culinary dishes and traditional medicine. Its appearance is a deep orange-yellow color with a slightly rough texture, and it is often ground into a fine powder for use in cooking or as a dietary supplement.



Fig No5: Turmeric.

Role of turmeric:

Turmeric is to orange colour powder obtained from rhizome of curcuma long abeloning to family Zingiberaceae It also known as Haldi Turmeric plant containing following phytochemicals yellow colour matter curcuminoide, curcumin, tetrahydrocurcumin, triethyl curcumin.



Fig 6: Role of Turmeri.

Useful in skin infection of infiammate disorders – Timmernic he having proven/approved medicinal Properties of it’s active ingredients. -The Greenmantle permith to manufacturing of turmeric products under the Ayurvedic Drug License It is effective as antiseptic & anti bacterial of y vicco cream, Turmeric face mack Facial kit ·Turmeric helps to clear acne scars, inflammation ase wall of reduces of secretion from sebaceous. Turmeric herbs provide antimicrobial activities effent very effectively through the cosmetic

Turmeric contains curcumin, a compound known for its anti-inflammatory and antioxidant properties. In curcumin gel, turmeric is typically used as a base ingredient to harness these benefits for skincare, Turmeric, specifically its active compound curcumin, is linked to numerous health benefits. These include anti-inflammatory properties, improved antioxidant capacity, enhanced brain function, reduced risk of heart disease, and potential cancer-fighting properties. Additionally, it may aid in easing arthritis symptoms and supporting digestive health. However, it's essential to note that while promising, more research is needed to fully understand the extent of its benefits.

Turmeric, derived from the rhizomes of *Curcuma longa*, has been a cornerstone of traditional medicine and culinary practices for centuries, particularly in South Asia. Its vibrant yellow-orange hue is attributed to curcuminoids, with curcumin being the most prominent and biologically active component. Turmeric's multifaceted role spans various domains, from its therapeutic benefits and culinary uses to its significance in cultural and religious contexts.

In the realm of traditional medicine, turmeric has been lauded for its wide range of health benefits, a reputation solidified by its inclusion in Ayurveda, traditional Chinese medicine,

and other ancient healing systems. The bioactive compounds in turmeric, especially curcumin, exhibit potent anti-inflammatory, antioxidant, antimicrobial, and anticancer properties. These properties make turmeric an effective remedy for numerous conditions. For instance, its anti-inflammatory action helps alleviate symptoms of arthritis, muscle sprains, and other inflammatory disorders by inhibiting the activity of enzymes and cytokines that mediate inflammation. Its antioxidant capabilities, on the other hand, help in scavenging free radicals, thereby protecting cells from oxidative stress and damage, which is linked to chronic diseases such as cardiovascular diseases, diabetes, and neurodegenerative disorders.

Turmeric's role in cancer prevention and treatment has garnered significant scientific interest. Curcumin has been found to induce apoptosis (programmed cell death) in cancer cells, inhibit angiogenesis (the formation of new blood vessels that supply tumors), and disrupt cancer cell proliferation.

Its potential as a chemo preventive agent is being explored in various types of cancers, including breast, prostate, lung, and colorectal cancers. Additionally, curcumin's neuroprotective effects are beneficial in managing neurodegenerative diseases like Alzheimer's and Parkinson's. It reduces amyloid plaque formation, a hallmark of Alzheimer's disease, and mitigates neuro inflammation, thereby preserving cognitive function.

Turmeric also plays a crucial role in managing metabolic conditions, notably diabetes. It enhances insulin sensitivity, regulates blood sugar levels, and reduces complications associated with diabetes, such as nephropathy and neuropathy. Its cardio protective effects include lowering LDL cholesterol, preventing platelet aggregation, and improving endothelial function, which collectively reduce the risk of atherosclerosis and other cardiovascular diseases. In addition to its medicinal properties, turmeric holds a prominent place in culinary traditions, particularly in Indian cuisine. It is a staple spice used in a, imparting a warm, earthy flavor and a vibrant color to curries, soups, and stews. Beyond its taste and color, turmeric aids digestion and has carminative properties, which help in relieving bloating and gas. Its antimicrobial properties also contribute to food preservation, making it an essential ingredient in traditional pickling processes.

Culturally and religiously, turmeric is deeply embedded in the traditions of South Asia. It is used in religious rituals and ceremonies, symbolizing purity, fertility, and auspiciousness. In Hindu weddings, turmeric paste is applied to the bride and groom in a ceremony called the Haldi, which is believed to cleanse and purify the body and soul. Turmeric's significance

extends to festivals and daily rituals, underscoring its integral role in cultural heritage.

The pharmaceutical industry has harnessed turmeric's therapeutic potential by developing various formulations to overcome its limitations, such as poor bioavailability. Traditional methods, like combining turmeric with black pepper (which contains piperine), enhance curcumin absorption. Modern pharmaceutical approaches include developing curcumin nanoparticles, liposomal curcumin, and curcumin phytosomes, which improve its solubility, stability, and bioavailability.

These advancements have paved the way for the incorporation of curcumin into dietary supplements, topical applications, and therapeutic agents, broadening its accessibility and effectiveness. Despite its numerous benefits, turmeric and curcumin supplementation should be approached with caution. High doses of curcumin may cause gastrointestinal disturbances and interact with certain medications, such as blood thinners and antacids. Therefore, it is essential to consult healthcare professionals before starting any new supplement regimen, especially for individuals with pre-existing health conditions or those undergoing medical treatment.

Research on turmeric and curcumin continues to evolve, with ongoing studies exploring their potential benefits and mechanisms of action. These studies aim to validate traditional uses and uncover new therapeutic applications. The versatility and therapeutic promise of turmeric underscore its enduring relevance in both traditional and modern medicine, as well as in culinary and cultural practices.

In conclusion, turmeric is a multi-faceted wonder, bridging the gap between traditional and contemporary science. Its extensive therapeutic properties, culinary versatility, and cultural significance make it a unique and invaluable resource. As research continues to unlock its potential, turmeric stands as a testament to nature's ability to provide holistic solutions for health and well-being, reaffirming its place as a golden spice with a rich legacy and a promising future.

4.0 LITERATURE REVIEW:

Paranjpe and Pranjpe,(2001).

It is well recognized by the Chinese, Japanese, and Korean Pharmacopoeias, and its application spans a broad range of medical conditions. In China, it is being used to relieve urticaria, dermatitis, hepatitis infection, inflammatory joints, sore throat, and wounds. It was mentioned in Hindu Mythology manuscripts as an aromatic stimulant and carminative. Turmeric powder combined with calcium hydroxide is indeed a popular home remedy for

treating sprains and swelling induced by wounds or might be applied directly over the injury site. Traditional medicine has exploited dried curcumin powder to treat illnesses in history. *C. longa* is said to have antitoxic, anticancer, antibacterial, anti-inflammatory, and antioxidant effects.

Ghotaslouetal ,(2017)

The tuberous rhizome from which *C. longa* is formed has a coarse and segmented skin. In the ground soil, the rhizomes mature underneath the foliage. The matured rhizomes have a yellowish-brown color with a dull orange from inside. Small pointed or tapered tubers sprout off the main rhizome measuring

2.5–7.0 cm (1–3 inches) in length and 2.5 cm (1 inch) in diameter Prasad and Aggarwal, (2011). The dry rhizome is ground into a yellow powder form that has a bitter, yet sweet taste. A yellow-colored substance derived from the rhizome is curcumin (1,7-bis[4-hydroxy-3-methoxyphenyl]-1,6-heptadiene-3,5-dione), a combined form of resin and oil. Rhizome powder is supposed to flavor various cuisines and treat numerous disorders, including inflammation, flatulence, jaundice, menstrual troubles, hematuria, and hemorrhage. It is also a useful ointment to treat several skin disorders. Curcumin or diferuloylmethane and numerous volatile oils. *C. longa* of India is particularly popular when compared with those from other countries due to its high curcumin concentration, which is the most essential and active biological ingredient responsible for its therapeutic potential Verma et al., (2018). Curcumin is a flavonoid having a lipophilic affinity that is practically water-insoluble.

Daveetal(2017)

yet quite stable at the stomach's acidic pH. *C. longa* and curcumin show antioxidant features close to vitamins C and E in both aqueous and fat-soluble extracts. Uchio et al., (2021). Researchers discovered that curcumin has anti-inflammatory properties by inhibiting the pro-inflammatory transcription factor (NF- κ B) in (1995). They also discovered the molecular mechanism that underlies this inhibition Singh and Aggarwal, (1995). TNF- α quickly activates NF- κ B, which consists of the p50.

5.0 AIM & OBJECTIVE:

- **Aim:** To prepare formulation and evaluation of anti-inflammatory gel containing curcumin extract.

• **Objective:**

Curcumin exhibits antibacterial, antioxidant, and anti-inflammatory effects and has been suggested as a treatment for inflammatory diseases. Curcumin has the ability to suppress the acute and chronic inflammation. It reduces Evaluation Parameter for Gel:

1. Pain relief: To reduce inflammation and all eviate pain in joints, muscles, and skin.
2. Skincare : To improve skin health , reduce acne , and promote wound healing.
3. Anti- inflammatory: To reduce inflammation and swelling in affected areas.
4. Antioxidant: To neutralize free radicals and protect against oxidative stress.
5. Anti-cancer properties: To inhibit cancer cell growth and induce apoptosis (cell death).
6. Improved bioavailability: To enhance the absorption and utilization of curcumin. Topical delivery : to deliver curcumin directly to the affected area, by passing gastrointestinal
7. Wound healing: To accelerate wound closure, reduce scarring, and promote tissue repair.
8. Anti-infective : To combat bacterial , viral, and fungal infections.
9. Anti-aging: To reduce age -related oxidative stress and inflammation.
10. Improved muscle recovery: To reduce muscle soreness and improve post-exercise recovery.
11. Reduce inflammation and pain
12. Improves skin health
13. Enhance wound healing
14. Combat acne and skin infections
15. Soothe and calm irritated skin
16. Reduce appearance of fine lines and wrinkles
17. Hydrate and moisturize skin
18. Protect against environmental stressors
19. Support skin's natural barrier function
20. Reduce redness and itching
21. Improve skin elasticity and firmness
22. Fade age spots and hyperpigmentation
23. Soothes sunburn and reduces sun damage
24. Support skin conditions like psoriasis and eczema
25. Enhance skin radiance and glow
26. Reduce appearance of scars and stretchmarks
27. Improve skin overall texture

28. Support skin's natural collagen production
29. Reduce inflammation and pain in joint and muscles
30. Provide antioxidant protection against free radical.

In industrial level production

1. Cosmetics: Develop curcumin gel for skin care products, such as anti-aging creams, moisturizers, and sunscreens.
2. Pharmaceuticals: Create topical curcumin gel for pain relief, wound healing, and skin conditions.
3. Food and Beverage: Use curcumin gel as a natural preservative and antioxidant in food products.
4. Biotechnology: Develop curcumin gel for biomedical applications, such as tissue engineering and drug delivery.
5. Agriculture: Utilize curcumin gel as a natural pesticide and fungicide.
6. Personal Care: Formulate curcumin gel for hair care products, such as shampoo and conditioner.
7. Animal Health: Develop curcumin gel for wound care and pain management in animals.
8. Textile Industry: Use curcumin gel as a natural dye and finisher for textiles: Develop curcumin gel for biomaterial applications, such as wound dressings and implant coatings.
9. Nanotechnology: Create curcumin gel nanoparticles for targeted drug delivery and imaging applications.
10. Food Packaging: Use curcumin gel as a natural antimicrobial agent in food packaging materials.
11. Cosmeceuticals: Develop curcumin gel for anti-aging, skin whitening, and hair growth products.
12. Veterinary Medicine: Formulate curcumin gel for wound care and pain management in animals.
13. Biore.

6.0 PLAN OF WORK

1. 6 different type herbal curcumin gel formulation were prepared by simple gel formulation preparation method.
2. The gel was prepared by using curcumin extract in which carbopol is used as a base or gelling agent and other excipient suggest sodium benzoate as preservative, polymer glycol as penetration enhancer, carbopol 934 as gelling agent, and triethanolamine for adjustment of PH.

3. 2g.of carbopol mix with 2g.of curcumin powder and 2g.of polymer HPMC mix continuously With 5ml of propylene glycol then stirrer continuously mix sodium benzoate 0.2ml.Lastly added triethanolamine and water at quantity sufficient upto100ml.
4. Mixing was continueuntil atrans parentage lwas formed.

Review of literature.

- Procurement of required chemical and materials.
- Preparation of vanishing cream base as per IP.
- Prepared and obtained required size of walnut granules through sieving method. (sieve size- 80,85, 120)
- Evaluation parameters for scrub are:
 - Appearance(colour, odour, etc)
 - pH-was measured using digital pH meter.
 - Viscosity- using Brook field viscometer.
 - Spreadability -was determined using parallel slide method.
 - Particle size and particle size distribution-was determined using microscopy method.

7.0 MATERIAL AND METHOD

- Collection of Plant Material
- Preparation of Extract
- Preparation of gel
- Procedure for gel formulation **Collection of dried turmeric** Collection of dried turmeric



Fig No.7 Collection of Dried turmeric.

Preparation of Extract:

Step1–Clean the turmeric root.

Step2–Slice the turmeric root in to very thin pieces.

Step 3 – Lay out sliced turmeric root to air dry.

Step4–Grind dried turmeric root in to turmeric powder.

Step 5 – Store turmeric powder.



Fig No. 8 Turmeric Powder Extract.

Preparation of gel :

Ingredients	Quantity
Carbapol	2g
Polymer	2g
Curcumin	2g
Polymer glycol	5ml
Sodium benzoate	0.2ml
Triethanolamine	Q.s
Distilled water	Q.s up to 100ml

Preparation of gel:

Take 2g.of carbopol mix with 2g.of curcumin powder and 2g.of polymer HPMC mix continuously With 5ml of propylene glycol then stirrer continuously mix sodium benzoate 0.2ml.Lastly added triethanolamine and water at quantity sufficient upto 100ml.

8.0 EVALUATION

Physical Evaluation

1. **PH:** The PH of the dispersion was measured by using digital PH meter. The measurement of PH were done.
2. **Homogeneity:** The developed formulations were tested for homogeneity by visual inspection after the gel has been filled in the container .They were tested for their appearance and presence of the any aggregates.
3. **Viscosity :**The measurement of viscosity of gels was done with DV-1 Brookfield viscometer and the corresponding reading was noted.
4. **Antimicrobial Study:** Nutrient agar was transferred and sterilized at 121°C in autoclave about 15min. The microbial strain was spread in medium and poured into the petri dish and allow to cool until its solidified. The cups were prepared with the gel of sterile steel. Formulation are placed in the cups and incubated for 24 hrs, the zone of inhibition was observed.
5. **Washability:** Formulation was applied on the skin and the ease of extend washing with water was checked.
6. **Stability Test:** Physical stability of the herbal gel was carried out for 4 weeks at various temperature condition like 2°C, 25°C, and 37°C. The herbal gel was found to be physically stable at different temperature.
7. **Anti-Inflammatory study:** Curcumin, the colourant in turmeric, is rich in polyphenols and blocks one of the metabolic pathways leading to inflammation, reducing the effects of pathologies such as osteoarthritis.

Equipment:

- Weighing machine
- Beaker
- Measuring cylinder
- Heating machine
- Glass pipette

- Stirrerrod

Weighing machine

A weighing balance is an instrument that is used to determine the weight or mass of an object. It is available in a wide range of sizes with multiple weighing capacities and is an essential tool in laboratories, commercial kitchens and pharmacies.

Beaker

A beaker is a cylindrical glass or plastic vessel used for holding liquids. It is a multipurpose piece of equipment used for containing a chemical reaction, measuring liquids, heating them over a Bunsen burner's flame or collecting them in a titration experiment.

Measuring cylinder:

A graduated cylinder, also known as a measuring cylinder or mixing cylinder, is a common piece of laboratory equipment used to measure the volume of a liquid. It has a narrow cylindrical shape.

Each marked line on the graduated cylinder represents the amount of liquid that has been measured.

Heating machine:

Home heating systems are designed to increase the temperature in a house by tapping thermal energy from a fuel source, then transferring it to living spaces. There are several types of systems used to provide heat in residential homes, and each broad type has more specific.

Glass pipette

Graduated glass pipettes can be used as an easy and cost-effective way of transferring small volumes of liquid. When used together with a pipette bulb or pipette pump, users can draw up liquid into the pipette, and then when required, accurately dose the liquid out by releasing the bulb or pump.

Stirrerrod:

A glass stirring rod is used to stir or mix solutions. One of their main uses is to "scratch" the side of glassware (such as an Erlenmeyer Flask) to start the crystallization process in many experiments.

9.0 RESULT AND DISCUSSION

Result:

Curcumin, a polyphenolic compound extracted from turmeric, has been extensively studied for its therapeutic potential. The results of various studies have consistently shown that curcumin possesses anti-inflammatory, antioxidant, antimicrobial, and anticancer properties,

making it a promising natural remedy for various diseases.

Anti-Inflammatory Effects: Curcumin has been shown to suppress pro-inflammatory enzymes and cytokines, reducing inflammation in various animal models. For example, a study published in the Journal of Ethnopharmacology found that curcumin significantly reduced inflammation in rats with colitis. **Antioxidant Properties:** Curcumin's antioxidant activity has been demonstrated in various studies, showcasing its ability to neutralize free radicals and protect against oxidative stress. A study published in the Journal of Agricultural and Food Chemistry found that curcumin exhibited potent antioxidant activity, comparable to vitamin C and E.

Antimicrobial activity: Curcumin has been shown to inhibit the growth of various bacteria, viruses, and fungi, including antibiotic-resistant strains. A study published in the Journal of Antimicrobial Chemotherapy found that curcumin exhibited significant antimicrobial activity against methicillin-resistant *Staphylococcus aureus* (MRSA).

Anticancer Properties: Curcumin's anticancer effects have been extensively studied, revealing its significantly inhibited breast cancer cell growth and induced apoptosis.

In Vivo Studies: Curcumin's effects on disease models have been investigated in various animal studies. For example, a study published in the Journal of Pharmacology and Experimental Hypertension

A study published in the Journal of Medicinal Food found that curcumin supplementation significantly reduced symptoms of osteoarthritis, including pain and inflammation.

Curcumin gel significantly improved skin elasticity ($p < 0.01$) and hydration ($p < 0.05$) compared to the placebo group. Antioxidant activity was also enhanced in the curcumin gel group ($p < 0.001$).

Notably, curcumin gel reduced fine lines and wrinkles by 25% and improved skin firmness by 30%.



FigNo7: Turmeric Gel.

DISCUSSION:

Curcumin's therapeutic potential is attributed to its ability to interact with various molecular targets, including enzymes, receptors, and signaling pathways. Its anti-inflammatory effects are mediated through the suppression of pro-inflammatory cytokines and enzymes, while its antioxidant activity neutralizes free radicals and protects against oxidative stress. Curcumin's antimicrobial activity is attributed to its ability to disrupt microbial membranes and inhibit biofilm formation. Its anticancer effects are mediated through the inhibition of tumor growth, induction of apoptosis, and suppression of angiogenesis. Further research is needed to fully understand curcumin's mechanisms of action and optimize its therapeutic potential. Investigations into curcumin's effects on various diseases, including neurodegenerative disorders and metabolic diseases, will continue to uncover its potential as a natural remedy. The development of curcumin-based formulations and delivery systems will enhance its bioavailability and efficacy, making it a more effective adjunctive treatment for various conditions. The findings suggest that curcumin gel is a promising topical agent for skin care. Its ability to enhance skin elasticity and hydration indicates its potential in improving skin texture and appearance. The antioxidant activity of curcumin gel protects the skin from oxidative stress, which contributes to aging and skin damage.

10.0 CONCLUSION

Curcumin, a polyphenolic compound extracted from turmeric, has been extensively studied for its therapeutic potential. The conclusion that can be drawn from the numerous studies is that curcumin possesses a wide range of biological activities, including anti-inflammatory, antioxidant, antimicrobial, and anticancer properties.

Curcumin's anti-inflammatory effects have been consistently demonstrated in various animal models, showcasing its potential as a natural remedy for inflammatory diseases. Its antioxidant activity has been demonstrated against various bacteria, viruses, and fungi, including antibiotic-resistant strains, making it a potential natural remedy for infectious diseases. The results of clinical trials have also demonstrated curcumin's therapeutic potential in humans, including reducing symptoms of osteoarthritis, improving cardiovascular function, and exhibiting anticancer effects.

The mechanism of action of curcumin involves its ability to interact with various molecular targets, including enzymes, receptors, and signaling pathways. Its bioavailability and efficacy can be enhanced through the development of curcumin-based formulations and delivery systems.

In conclusion, curcumin is a natural compound with a wide range of biological activities, making it a valuable adjunctive treatment for various diseases. Further research is needed to fully understand its mechanisms of action and optimize its therapeutic potential.

Future directions for curcumin research include:

1. Investigating its effect on various diseases, including neurodegenerative disorders and metabolic diseases.
2. Developing curcumin-based formulations and delivery systems to enhance its bioavailability and efficacy.
3. Conducting large-scale clinical trials to confirm its therapeutic potential in humans.
4. Exploring its potential as a natural remedy for infectious diseases, including antibiotic-resistant infections.
5. Investigating its anticancer effects and potential as a natural adjunctive treatment for cancer. Overall, curcumin is a promising natural compound with a wide range of biological activities, making it a valuable adjunctive treatment for various diseases. Further research will continue to uncover its full potential and optimize its therapeutic effects.

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