PHYTOCHEMICAL & PHARMACOLOGICAL EVALUATION OF HERBAL PLANT FOR ANTI-INFLAMMATORY DRUGS

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Submitted By

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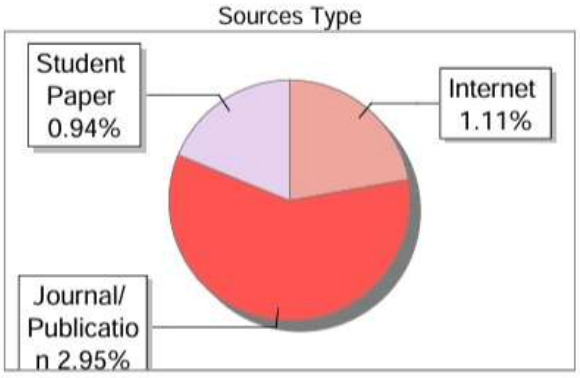
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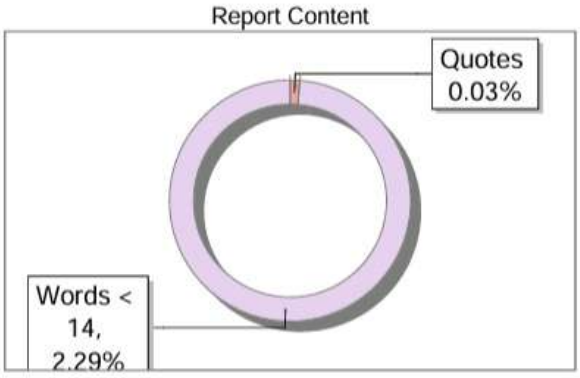
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ABSTRACT

As an alternative to traditional synthetic medications, which might have unwanted side effects, herbal remedies have been studied for their anti-inflammatory benefits. Curcumin, gingerols, boswellic acids, and catechins are just a few examples of plant-derived chemicals with potent anti-inflammatory properties. Turmeric, frankincense, ginger, and green tea are just a few examples. These chemicals work therapeutically by lowering oxidative stress, limiting altering inflammatory pathways such NF-κB, COX, and LOX, and producing cytokines that promote inflammation. In order to find out if these herbal remedies are safe, effective, and are very important since they may one day replace traditional anti-inflammatory medications, especially in light of the growing interest in natural remedies. Research has shown that sophisticated drug delivery techniques such nanoformulations, liposomal encapsulation, and phytosomal technologies are necessary to optimize the pharmacokinetic characteristics of herbal medicines. These methods may greatly improve the therapeutic potential of bioactive substances by increasing their absorption, stability, and targeted distribution. Also, herbal medications can't be accepted by traditional healthcare systems unless large-scale clinical studies prove they're safe and effective. under order to keep quality control and market uniformity of herbal formulations under check, regulatory frameworks should be improved as well. Clinical data and patient-specific factors should inform recommendations on the use of natural remedies to inflammatory disorders. Standardized extracts, suitable dosage recommendations, and safety studies are crucial for reducing the likelihood of adverse effects and drug-herb interactions. To further improve therapeutic effectiveness and lessen reliance on synthetic medications, it is important to investigate the interaction between herbal ingredients and current pharmacological therapies. Healthcare providers and researchers need to work together to create anti-inflammatory treatments that combine traditional wisdom with new scientific discoveries, as consumers are increasingly interested in natural solutions. Potential advances in biotechnology, genetic engineering, and AI-based medication development open up enormous possibilities for the future of herbal medications in inflammatory control. Metabolomics, transcriptomics, and computational modeling are advanced research approaches that may aid in the discovery of new bioactive chemicals and the optimization of existing pharmacological profiles. Individuals with inflammatory diseases may also find tailored therapy choices via personalized herbal medicine

techniques that are based on metabolic and genetic testing. To guarantee that traditional treatments live up to the requirements of contemporary pharmacology, herbal medicine research should use a multidisciplinary approach, which is especially important given the growing popularity of complementary and integrative medicine. To sum up, herbal remedies show great potential as anti-inflammatory drugs, but only if modern science keeps closing the gap between folk wisdom and its practical use in medicine. Safer and more long-term alternatives to traditional anti-inflammatory medications may be provided by herbal medicine if its bioavailability, standardization, and regulatory issues are adequately addressed..

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Chapter 1

INTRODUCTION

1.1 INTRODUCTION

Intrusion of toxic substances, damaged cells, or viruses triggers the intricate biological reaction known as inflammation. Inflammation is associated with many illnesses, including arthritic pain, cardiovascular disease, and neurological disorders, despite its role in the body's defensive mechanisms and healing processes. Inflammation is commonly treated in conjunction with corticosteroids and nonsteroidal anti-inflammatory medications (NSAIDs). However, there are certain major side effects associated with these medications that may occur with long-term usage. These include renal failure, stomach ulcers, and an increased risk of cardiovascular disease. Find safer, more natural alternatives with significant anti-inflammatory benefits is, therefore, becoming more vital.

Ayurveda, (TCM), and Unani medicine are some of the traditional medical systems that have long relied on herbal remedies to alleviate inflammatory diseases. The study found that several plant-derived chemicals, including terpenoids, polyphenols, alkaloids, and flavonoids, had potent anti-inflammatory properties.To reduce inflammation, block pro-inflammatory enzymes like COX and LOX, or eliminate inflammatory cytokines like TNF-α and interleukins. hese bioactive components regulate important processes associated with inflammation.

Modern scientific approaches have made it possible to conduct comprehensive in vitro, and clinical studies to evaluate the safety and effectiveness of herbal remedies. New analytical methods have made it easier to identify and describe bioactive substances with anti-inflammatory properties. Among these techniques are high-performance liquid chromatography (HPLC), nuclear magnetic resonance (NMR), and mass spectrometry (MS). Molecular docking and computational biology have also improved our understanding of the molecular interactions between phytochemicals and inflammatory mediators.There are a number of obstacles that prevent herbal medications from being widely used in contemporary medicine, despite their great promise. Important challenges include the need to standardize herbal formulations, the fact that bioactive ingredient

quantities might vary, and the possibility of herb-drug interactions. It is essential to develop stringent quality control procedures and clinical validation since regulatory frameworks for herbal medicine vary among nations. However, there is hope for the future of herbal anti-inflammatory drugs in conventional medicine thanks to joint studies between experts in traditional medicine and contemporary scientists.

Examining the effectiveness, mechanisms of action, and prospective therapeutic uses of a selection of herbal medicines with anti-inflammatory qualities is the goal of this research. This study will better comprehend herbal alternatives to synthetic anti-inflammatory medications by examining current scientific literature and experimental data. It will promote their usage in a safer and more effective way.

1.2 HERBAL MEDICINES: AN OVERVIEW

For centuries, cultures have used herbal remedies to cure a variety of ailments. Ayurveda, TCM, and Unani are just a few examples of traditional medical systems that have long used medicines derived from plants to treat illness and promote wellness. Due to its supposed safety, all-natural composition, and possible health advantages, herbal medications have recently seen a boom in popularity. Herbal remedies may have synergistic effects on the body due to the presence of several active chemicals, in contrast to synthetic pharmaceuticals that frequently target particular biochemical pathways.

The leaves, stems, roots, blossoms, seeds, and bark of plants are the primary ingredients of herbal remedies. The techniques of production, use, and extraction allow for the categorization of these medications. Extracts are concentrated preparations of herbs that are produced using solvents like water, ethanol, or methanol, as opposed to utilizing whole herbs directly in medical treatments.

The bioavailability and storage stability of plant extracts are improved in tinctures by dissolving them in an alcohol or glycerin solution. Essential oils have antibacterial and anti-inflammatory effects due to the volatile molecules they contain, which are derived from plants. For the release of bioactive chemicals, herbs are steeped in hot water in the form of teas and decoctions. For convenience of intake and dose management, herbs may also be pulverized and placed in capsules or powders.

Traditional and Modern Perspectives on Herbal Medicine

Herbal remedies have long played a significant role in conventional medical practice. The therapeutic benefits and ability of medicinal plants to balance the doshas are the primary criteria for their classification in Ayurveda. When it comes to treating ailments, Traditional Chinese Medicine places an emphasis on Yin and Yang balance. Herbs like ginseng, licorice, and astragalus are used to bring about this equilibrium. Herbs with restorative and therapeutic qualities, such as ashwagandha and saffron, are used in Unani medicine, which descends from the Greco-Arabic tradition. Research into and use of herbal remedies have recently expanded alongside developments in pharmacology and biotechnology. The discovery of bioactive chemicals in plants via scientific study has made it possible to standardize and regulate the quality of these plants. Herbal medicine is the original source of many modern medications, including aspirin made from willow bark and artemisinin from Artemisia annua. For the purpose of improving effectiveness and safety, modern herbal compositions often include both traditional knowledge and scientific confirmation.

Phytochemicals in Herbal Medicines

Because of their phytochemical components, herbal medications have the ability to treat certain medical conditions. For example, quinine is used to cure malaria and morphine is used to alleviate pain; both are examples of alkaloids, which are nitrogen-containing chemicals having strong pharmacological effects. The anti-inflammatory, cardioprotective, and neuroprotective effects of flavonoids are well-documented in plant-based foods. In addition to their fragrant qualities, the terpenoids found in essential oils have therapeutic uses, including anti-inflammatory and antibacterial actions. Commonly found in tea and medicinal plants, saponins are glycosides that modulate the immune system and decrease cholesterol. Tannins, on the other hand, are polyphenols that have astringent and antibacterial characteristics. Digitalis, a medicine used to treat heart conditions, contains glycosides, which are chemicals bonded to sugar.

These glycosides have an effect on cardiovascular health.

Mechanisms of Action in Herbal Medicines

There are a number of paths in the body that herbal medicines might use to exert their effects. A number of herbs, including ginger and turmeric, have anti-inflammatory properties that reduce inflammation-related disorders by blocking inflammatory

mediators such as cyclooxygenase (COX) and nuclear factor-kappa B (NF-κB). Protecting cells and tissues from oxidative stress is possible with the aid of herbal antioxidants, which scavenge free radicals. Some herbs, such ashwagandha and echinacea, aid in illness prevention and immune system enhancement. Allicin, found in garlic, and berberine, found in goldenseal, are herbal chemicals with antimicrobial, antifungal, and antiviral capabilities. Ginkgo biloba and Bacopa monnieri are two examples of the neuroprotective herbs that may aid in the treatment of neurodegenerative diseases like Alzheimer's by bolstering cognitive function. Also, phytoestrogens in soy and red clover help regulate hormones; they behave similarly to estrogen and help keep hormones in check, which is especially helpful for women going through menopause.

Scientific Evaluation of Herbal Medicines

Scientific investigations are adding weight to the claims made about the efficacy of herbal remedies. In vitro investigations, which examine the pharmacological characteristics of herbal extracts via laboratory experiments with cell cultures, are one research methodology used to evaluate the effectiveness of herbal medicines. To learn Researchers test herbal treatments on humans to evaluate their safety, efficacy, and optimal doses. Mass spectrometry and HPLC are used in phytochemical analysis to quantify herbal extract active compounds. These methods guarantee that herbal remedies are of high quality and have real health effects.

Regulation and Standardization of Herbal Medicines

Compositional heterogeneity, lack of quality control, and the possibility of interactions with conventional pharmaceuticals are some of the regulatory hurdles that herbal medicines confront, although their extensive usage. A number of governing authorities and worldwide organizations keep an eye on the standards of herbal medicine. Herbal supplements are regulated by the United States Food and Drug Administration (FDA) under the Dietary Supplement Health and Education Act (DSHEA), while the World (WHO) establishes standards for the safety and effectiveness assessment of herbal medications. Herbal medical products are subject to quality control methods and monographs established by the (EMAPharmacopeias like the USP and BP regulate herbal medication quality, purity, and potency, Ayurvedic, and Chinese pharmacopeias. Good Manufacturing Practices (GMP) and standardization processes enable uniformity in herbal formulations, which is crucial for consistency and safety.

Herbal remedies have great promise, but there are still many obstacles that must be overcome. Herbal products' consistency is affected by the absence of standardization, which causes diversity in plant sources, growing conditions, and extraction procedures. Some herbs may have negative effects when used with prescription drugs, therefore it's important to research their possible toxicity and drug interactions thoroughly. More large-scale clinical studies are required to support the effectiveness of herbal remedies for different health issues, making scientific validation a crucial concern. Additional difficulties could arise from regulatory constraints, such as the fact that there is no universally accepted set of standards for herbal medicines, which might delay their introduction to the market. Overharvesting and environmental degradation endanger herbal resources in the long run, thus it's important to think about sustainability and ethical sourcing when purchasing medicinal herbs. Herbal remedies may become more accurate and effective as pharmacogenomics, nanotechnology, and biotechnology progress. Herbal therapy combined with evidence-based healthcare may treat a broad variety of illnesses safely and effectively. This would close the gap between traditional and modern medicine.

For ages, herbal remedies have been an integral aspect of medical practice, and this is true in both conventional and alternative medicine. Their medicinal value stems from the wide variety of bioactive chemicals that, when combined, have a multiplicative effect on health and illness. Standardization, safety concerns, and regulatory frameworks are some of the obstacles that must be overcome, even if scientific study has confirmed many traditional applications of herbal medicines. Herbal remedies have the potential to become a long-term, viable substitute for synthetic pharmaceuticals in the future of world healthcare if scientific understanding and technological capacity are to continue to grow.

1.3 METHODS OF EVALUATING ANTI-INFLAMMATORY ACTIVITY IN HERBAL MEDICINES

Tissues in the body go through a complicated biological reaction called inflammation when they encounter damaging stimuli like irritants, damaged cells, or infections. Acute inflammation aids recovery, but long-term inflammation may cause arthritis, cancer, and cardiovascular disease. Traditional herbal remedies for inflammatory disorders are being professionally tested. Clinical trials, in vitro methods,

and other methods may evaluate herbal treatments' anti-inflammatory properties. This research digs into these methods.

In Vitro Methods

Experiments performed in a controlled laboratory setting with cell cultures or isolated biochemical processes are known as in vitro research. These investigations do not include any live organisms. These approaches provide preliminary understanding of how herbal medications reduce inflammation.

1. Enzyme Inhibition Assays

Inflammation is greatly aided by pro-inflammatory enzymes including LOX and cyclooxygenase (COX-1 and COX-2). Inhibitors of the enzymes that produce prostaglandins and leukotrienes, two inflammatory mediators, may be identified in herbal extracts. Common tests include of:

- **COX inhibition assay**: This test determines whether or not herbal substances may inhibit prostaglandin synthesis.
- **LOX inhibition assay**: Assesses the efficacy of leukotriene suppression.

2. Nitric Oxide (NO) Assay

Inducible nitric oxide synthase (iNOS) in macrophages produces nitric oxide, an important mediator of inflammation. When testing cell culture supernatants for NO levels, the Griess reagent technique is often used.

Potential anti-inflammatory benefits of herbal extracts are suggested by a reduction in NO generation.

3. Cytokine Quantification

TNF-α, IL-6, and IL-1β are key cytokines in the inflammatory response. QPCR or ELISA may be used to evaluate herbal extracts' cytokine-regulating capabilities.

4. Reactive Oxygen Species (ROS) Inhibition Assay

The production of reactive oxygen species (ROS) by oxidative stress damages tissues and activates inflammatory pathways, which in turn leads to inflammation. Fluorescent probes like dichlorofluorescein diacetate (DCFDA) may monitor ROS

levels, which may be decreased by herbal medications that have antioxidant characteristics.

Clinical Trials

The most reliable method for proving that herbal remedies are effective against inflammation is to conduct clinical studies on human participants.

1. Randomized Controlled Trials (RCTs)

In randomized controlled trials, herbal remedies are compared to either a placebo or conventional anti-inflammatory medications. Pain ratings, inflammatory markers, and improvements in quality of life are some of the parameters that are examined over a specific period of time.

2. Biomarker Analysis

In order to find out how well the herbal medication works, researchers look for inflammatory biomarkers in the blood of trial participants. These include CRP, ESR, and cytokines.

3. Patient-Reported Outcomes

By using surveys and questionnaires, researchers may measure how well herbal medicines work to improve overall health and alleviate specific ailments.

In order to assess the anti-inflammatory effectiveness of herbal medications, a multi-faceted approach is required, including in vitro, clinical, and ex vivo methods. Each approach has the potential to provide light on the workings and efficacy of herbal remedies. By combining these methodologies, we can accomplish comprehensive validation, which might lead to the incorporation of herbal medications into conventional medicine.

1.4 HERBAL ANTI-INFLAMMATORY MEDICINES

Inflammation is a natural biological response to injury or disease; it is essential for the body to heal. However, chronic inflammation worsens a variety of health conditions. This include inflammatory diseases, heart conditions, diabetes, and arthritic conditions. Many people seek for alternatives to prescription anti-inflammatory medications because to the hazards linked with them. Herbal treatments for inflammation reduction have a long history of use in many traditional medical systems, including

Ayurveda, Traditional Chinese Medicine (TCM), and Western herbalism. Scientists have recognized the anti-inflammatory properties of some plants, and they are both safe and effective.

One common all-natural treatment for inflammation is curcuma longa, also often known as turmeric. Curcumin, the bioactive ingredient responsible for this spice's distinctive golden-yellow color, is an effective antioxidant and anti-inflammatory. The anti-inflammatory molecule nuclear factor-kappa B (NF-kB) is one target that curcumin may be able to inhibit, according to recent research. By influencing cytokine production, curcumin lowers levels of pro-inflammatory substances in the blood. Although curcumin's low bioavailability renders it ineffective, it might be enhanced by combining it with piperine, found in black pepper, or by using a liposomal formulation.

Another well-liked plant with anti-inflammatory qualities is ginger, scientifically known as Zingiber officinale. Resveratrol and shogaol are anti-inflammatory compounds derived from ginger rhizome that inhibit cyclooxygenase (COX) and lipoxygenase (LOX) pathways, respectively. The inflammatory mediators prostaglandins and leukotrienes are produced via these routes. Arthritis, whether rheumatoid or osteoarthritis, may find relief with ginger. As a natural remedy with potential for easing both physical pain and period cramps, ginger has been the subject of many scientific investigations.

Another powerful anti-inflammatory plant with deep Ayurvedic roots is Boswellia serrata, sometimes called Indian frankincense. Resin from the Boswellia tree contains boswellic acids, which inhibit 5-lipoxygenase (5-LOX), an enzyme implicated in leukotriene production. Inflammatory diseases are exacerbated by leukotrienes. This includes inflammatory bowel disease (IBD), asthma, arthritis, and many more. According to studies, boswellia extracts may help with a variety of ailments. These include mobility difficulties, indications of ulcerative colitis, and joint discomfort. Boswellia is advantageous for long-term use compared to other NSAIDs as it does not induce stomach irritation.

Camellia sinensis, the scientific name for green tea, is one of the most versatile plants and possesses anti-inflammatory properties. The polyphenols in green tea, including epigallocatechin gallate (EGCG), have anti-inflammatory and antioxidant

properties. One method EGCG controls inflammatory pathways is by lowering NF-kB activity and blocking pro-inflammatory cytokines. Chronic diseases such as cardiovascular disease, neurological disorders, metabolic syndrome, and others are less common in those who regularly consume green tea, according to research. Green tea's anti-inflammatory properties make it a valuable tool in the fight against skin conditions including acne and eczema.

Willow bark's (Salix spp.) analgesic and anti-inflammatory effects have been known in traditional medicine for quite some time. Because it contains salicin, it is a forerunner of aspirin. As a result of salicin's metabolism, the body produces salicylic acid, which inhibits the COX enzymes responsible for inflammation and pain. Willow bark has a long history of use in traditional medicine for the relief of fever, joint pain, and headaches. Compared to synthetic aspirin, willow bark is gentler on the stomach and has less gastrointestinal side effects. Anyone with an intolerance to aspirin should avoid using willow bark because of their same mechanism of action.

A popular analgesic and anti-inflammatory, devil's claw (Harpagophytum procumbens) is an African herb. What makes them tick are the active ingredients, known as harpagosides, reduce inflammation by blocking the COX and LOX enzymes. Among the many conditions that devil's claw effectively treats are tendonitis, arthritis, and lower back discomfort. It aids those with osteoarthritis in moving about more easily and with less pain, according to the research. It is often well-tolerated, although those with gastrointestinal problems should be careful when taking this herb since it may increase stomach acid production.

Licorice root, scientifically known as Glycyrrhiza glabra, is famous for its ability to modulate the immune system and reduce inflammation in traditional medicine. A chemical in licorice called glycyrrhizin inhibits the adrenal glands' capacity to break down the anti-inflammatory hormone cortisol.

Licorice root helps reduce inflammation in autoimmune diseases, gastrointestinal issues, respiratory infections, and other conditions by prolonging the effects of cortisol. People with hypertension should exercise extra caution while consuming licorice since it may lead to electrolyte imbalances and high blood pressure if consumed in large quantities.

Commonly referred to as rosemary, the plant Rosmarinus officinalis has several uses in medicine and the kitchen, including a potent anti-inflammatory effect. Because of its neuroprotective, antioxidant, and anti-inflammatory benefits, rosemary's high polyphenol content—which includes rosmarinic acid and carnosic acid—is to blame. Because of its free radical scavenging and COX and LOX pathway regulation capabilities, it has anti-inflammatory actions. Some studies have shown that rosemary may help with digestion, aches and pains in the muscles, and cognitive function. Because of its antibacterial properties, it might potentially aid in the prevention of infections.

Chameli (Matricaria chamomilla) is famous for its calming and anti-inflammatory properties. One of the active components of chamomile is apigenin, which has anti-inflammatory and oxidative stress-lowering properties. If you suffer from indigestion, muscle cramps, or overall uneasiness, you may find relief by sipping some chamomile tea. When used topically, chamomile extracts may help reduce inflammation, eczema, and minor wounds.

The anti-inflammatory and relaxing properties of aloe vera make it stand out among the several well-liked herbal medicines. The anti-inflammatory glycoproteins and polysaccharides included in aloe vera gel make it a potential treatment for burns, wounds, and skin irritations. Aloe vera juice has a calming effect on the stomach and may assist with digestion for those with acid reflux or irritable bowel syndrome (IBS). Its relaxing and healing properties make it a popular choice in complementary and alternative medicine.

Holy basil, or Tulsi, is highly esteemed by Ayurvedic practitioners for its potent anti-inflammatory properties (Ocimum sanctum). It has anti-inflammatory bioactive compounds including rosmarinic acid and eugenol and supports the immune system. Holy basil's Traditional medicine has long recognized the sedative effects on the respiratory system, joints, and neurological system. When drunk on a daily basis, tulsi tea offers anti-inflammatory and other health advantages.

Last but not least, herbal anti-inflammatory therapies are an excellent and safe substitute for conventional anti-inflammatory drugs. Holy basil, turmeric, boswellia, green tea, willow tree bark, licorice root, devil's claw, rosemary, chamomile, aloe vera, and devil's claw are among the plants that have shown potential anti-inflammatory

qualities. Try taking these herbs orally, topically, or in tea form every day if you have inflammation-related health problems. While most people may safely use herbs for treatment, those with underlying health conditions or who are on any medications should see their doctor before starting any herbal therapy. The integrative nature of herbal anti-inflammatory medications has made them a staple in health promotion for quite some time.

1.5 IMPORTANCE OF HERBAL MEDICINES IN INFLAMMATION MANAGEMENT

Pathogens, damaged cells, irritants, and other potentially hazardous stimuli trigger the intricate biological reaction known as inflammation. Arthritis, cardiovascular disease, diabetes, and cancer are just a few of the many disorders associated with chronic inflammation, in contrast to acute inflammation, which is a protective process that restores tissue homeostasis. Traditional NSAIDs and corticosteroids, which are anti-inflammatory medications, alleviate pain but often come with side effects. Because of their effectiveness, safety, and low side effects in inflammation management, herbal treatments have become more popular.

Herbal medicines include bioactive ingredients with anti-inflammatory properties, such as polyphenols, flavonoids, alkaloids, saponins, and others. These phytochemicals impact inflammatory pathways by modulating immune responses, decreasing oxidative stress, and inhibiting the production of pro-inflammatory cytokines. Some of the most well-known herbs that reduce inflammation are ginger, turmeric, green tea, turmeric, and Boswellia serrata. Many studies have looked at the anti-inflammatory and pain-relieving effects of these plants.

Curcumin, a potent polyphenol, is present in the ancient medicinal plant turmeric and has strong anti-inflammatory and antioxidant properties. The reason curcumin reduces the generation of inflammatory mediators like TNF-α and interleukins is because it inhibits nuclear factor-kappa B (NF-κB), a crucial regulator of inflammation. Turmeric is a great natural option for managing inflammation, and studies have shown that curcumin is useful in rheumatoid arthritis and inflammatory bowel illness.

Another popular plant with anti-inflammatory and pain-relieving properties is ginger. Gingerol and shogaol are bioactive chemicals found in it. They reduce

prostaglandin production by inhibiting the cyclooxygenase (COX) and lipoxygenase (LOX) pathways. Supplemental ginger may help rheumatoid arthritis and osteoarthritis sufferers greatly reduce joint stiffness and discomfort, according to the available research. Ginger has the ability to alleviate chronic inflammation due in part to its antioxidant qualities, which help reduce oxidative stress.

Epigallocatechin gallate (EGCG), a catechin found in abundance in green tea, has shown promising anti-inflammatory properties. The generation of inflammatory cytokines is decreased and the activation of NF-κB is inhibited by EGCG. Drinking green tea on a daily basis may aid in the management of autoimmune diseases like MS and lupus, according to research. Additionally, it promotes heart health via its polyphenolic components, which lessen endothelial dysfunction caused by inflammation.

The Ayurvedic community has long recognized the anti-inflammatory properties of Boswellia, more often known as Indian frankincense. Boswellic acids, the active ingredient, block the action of 5-lipoxygenase (5-LOX), an inflammatory enzyme that is essential for the formation of leukotrienes. Boswellia extracts provide a safe and natural alternative for treating inflammatory bowel illnesses and osteoarthritis, according to clinical investigations.

Researchers have looked at the synergistic benefits of polyherbal combinations and herbal formulations in inflammatory therapy, in addition to individual herbs. Ayurveda, TCM, and Unani are among the traditional medical systems that place an emphasis on the holistic use of herbal combinations to improve the effectiveness of treatment. The use of polyherbal formulations may improve treatment results and decrease the risk of adverse effects linked to synthetic medications by targeting several inflammatory pathways.

Extensive scientific study has shown the efficiency of herbal medications for inflammation control, which has contributed to their increasing popularity. Modern pharmacology and biotechnology have made it easier to isolate and standardize bioactive chemicals, which has increased the stability and efficacy of herbal remedies. Nevertheless, there are still concerns about issues including the necessity for strong clinical studies, possible interactions between herbs and drugs, and the fact that herbal compositions might vary.

Finally, because of their all-natural composition, ability to address several targets at once, and lack of adverse effects, Herbal remedies play an essential role in the management of inflammation. Herbal medicines including turmeric, boswellia, ginger, and green tea may help with inflammatory problems that last for a long period. Alternate medicine and herbal remedies used together may provide a more holistic approach to inflammation management and general health improvement, however more study is needed to determine standardized doses and formulations.

1.6 PLANT WITH ANTI-INFLAMMATORY ACTIVITY

An inflammatory reaction happens when the body detects or reacts to a threat, such as an infection, an injury, or a toxic substance. Nevertheless, neurological illnesses, cardiovascular diseases, diabetes, and arthritis are all exacerbated by chronic inflammation. The widespread use of synthetic anti-inflammatory medications like corticosteroids and nonsteroidal anti-inflammatory medicines (NSAIDs) comes with a price: serious side effects include kidney damage, gastrointestinal problems, and even cardiovascular dangers. This has prompted scientists to look into more natural solutions, such medicinal herbs, which contain anti-inflammatory qualities and use for a considerable amount of time in conventional medicine. There are bioactive substances found in many plant species that have anti-inflammatory properties. These include polyphenols, flavonoids, alkaloids, terpenoids, and more. A comprehensive review of anti-inflammatory plants, their active ingredients, action mechanisms, and their medicinal uses is presented in this article.

1. Curcuma longa (Turmeric)

Traditional medicine makes extensive use of the spice turmeric, renowned for its potent anti-inflammatory properties. Turmeric contains the polyphenol curcumin, which has potent anti-inflammatory and antioxidant properties. Inflammatory mediators including NF-κB, COX-2, and LOX are inhibited by turmeric. This has the added advantage of decreasing the synthesis of inflammatory cytokines such as TNF-α, IL-6, and IL-1γ. Neuroinflammation, inflammatory bowel disease, arthritis, and other inflammatory illnesses have all shown promising responses to curcumin's medicinal properties. The existing low bioavailability of curcumin might be improved by combining it with piperine, an ingredient in black pepper, or by using nano-formulated curcumin.

2. Zingiber officinale (Ginger)

Traditional medicine has long made use of ginger for its calming and anti-inflammatory effects. The main bioactive chemicals found in ginger are gingerols, shogaols, and paradols. These compounds work by blocking the COX-2 and LOX enzymes, which in turn reduce inflammation. Furthermore, ginger impedes the activation of Reduces while activating NF-κB. Many inflammatory and painful joint disorders, including rheumatoid arthritis and osteoarthritis, may find relief with ginger supplementation, according to clinical trials. Reducing oxidative stress—a factor in chronic inflammation—is another benefit of its antioxidant characteristics.

3. Boswellia serrata (Indian Frankincense)

Inflammatory diseases, such as asthma and arthritis, have traditionally been treated with Boswellia serrata in Ayurvedic therapy. Boswellic acids, the active ingredient, decrease inflammation-related leukotriene production by inhibiting 5-lipoxygenase (5-LOX). Boswellia is a powerful natural treatment for osteoarthritis and inflammatory bowel disease because its boswellic acids inhibit the breakdown of cartilage and regulate immunological responses. It has been shown in clinical trials to effectively alleviate joint pain and increase mobility for those with arthritis.

4. Withania somnifera (Ashwagandha)

There are anti-inflammatory and immunomodulatory effects of the adaptogenic herb ashwagandha. The bioactive components known as withanolides in it have anti-inflammatory actions by lowering levels NF-κB activation and the inhibition of pro-inflammatory cytokines. Additionally, ashwagandha controls the HPA axis and reduces inflammation caused by stress. In the treatment of neuroinflammatory diseases, autoimmune illnesses, and arthritis, it has shown encouraging results.

5. Camellia sinensis (Green Tea)

One of the polyphenolic chemicals found in green tea, epigallocatechin gallate (EGCG), is known to have strong anti-inflammatory effects. Decreased inflammation and tissue damage are outcomes of EGCG's inhibition of COX-2, NF-κB, and matrix metalloproteinases (MMPs). Research on the potential of green tea to ward against chronic inflammatory diseases has focused on its effects on metabolic syndrome, cardiovascular disease, and neurological illnesses. Additionally, it helps the immune system work better and boosts the antioxidant defense systems of cells.

6. Aloe vera

The anti-inflammatory and therapeutic effects of aloe vera are well-known. The anti-inflammatory benefits of the bioactive chemicals found in Aloe vera, such as polysaccharides, anthraquinones, and aloins, are achieved by the inhibition of COX-2 and the reduction of cytokine production. Inflammation of the skin, burns, and the intestines, as shown in inflammatory bowel syndrome (IBS) and ulcerative colitis, are popular areas of use for aloe vera.

7. Ocimum sanctum (Holy Basil)

The inclusion of ursolic acid, eugenol, and rosmarinic acid in holy basil, also known as tulsi, adds to its anti-inflammatory qualities. These chemicals reduce the activity of COX-2 and inflammatory cytokines like IL-6 and TNF-α. Inflammation of the respiratory tract, arthritis, and stress-related inflammatory reactions are some of the traditional uses of holy basil in Ayurvedic medicine.

8. Panax ginseng (Ginseng)

Research has shown that the bioactive ginsenosides found in ginseng may inhibit NF-κB and decrease cytokine production, leading to anti-inflammatory benefits. Researchers have looked into ginseng's potential to protect against metabolic diseases, inflammation in the cardiovascular system, and neuroinflammation. In addition to bolstering immunological regulation, it protects cells against oxidative damage.

9. Nigella sativa (Black Seed)

Kalonji, or black seed, is a medicinal herb whose primary ingredient, thymoquinone, has potent anti-inflammatory properties. Because thymoquinone suppresses inflammatory cytokines, COX-2, and LOX, Nigella sativa is useful in treating metabolic inflammation, arthritis, and asthma. Evidence from clinical trials suggests it may help alleviate the symptoms of inflammatory and autoimmune illnesses.

10. Phyllanthus emblica (Indian Gooseberry/Amla)

The tannins, vitamin C, and flavonoids present in abundance in amla lend it significant anti-inflammatory and antioxidant qualities. In addition to modifying immunological responses, it reduces oxidative stress and pro-inflammatory pathways. In

Ayurvedic medicine, amla is used to treat inflammatory conditions such as diabetes, heart disease, and stomach irritation.

Mechanisms of Action of Herbal Anti-Inflammatory Agents

There are a number of biochemical pathways that medicinal plants use to exert their anti-inflammatory effects, such as:

1. **Inhibition of Inflammatory Enzymes** – There are a number of plant chemicals that reduce via reducing the generation of inflammatory leukotrienes and prostaglandins COX-2, LOX, and 5-LOX.
2. **Suppression of NF-κB Pathway** – Several phytochemicals suppress cytokine production that inhibits NF-κB activation and so has an essential function in controlling inflammation.
3. **Antioxidant Activity** – Polyphenols found in plants serve as antioxidants, preventing the damage that oxidative stress causes by destroying reactive oxygen species (ROS).
4. **Modulation of Immune Responses** – Compounds found in herbs control the activity of immune cells, which in turn lessens overreactions and keeps inflammation at bay.
5. **Cartilage and Tissue Protection** – Arthritis and joint problems may find relief with the help of botanicals like Boswellia and Ginger, which inhibit the breakdown of cartilage.

As an alternative to manmade pharmaceuticals, medicinal plants that have anti-inflammatory actions have the potential to be more beneficial to health while having fewer adverse effects. These plants have a number of bioactive chemicals that help with autoimmune illnesses, neuroinflammation, cardiovascular disease, arthritis, and other inflammatory ailments.

It will need further study, such as large-scale clinical studies and standardization initiatives, before these natural therapies may be completely incorporated into mainstream medicine. Sustainable and holistic healthcare solutions may greatly benefit from herbal anti-inflammatory drugs when traditional knowledge is combined with current scientific confirmation.

1.7 MECHANISM OF INFLAMMATION AND HERBAL MEDICINE INTERVENTION

When viruses, damaged cells, or poisonous substances enter the body, a complicated biological reaction known as inflammation ensues. As a defense mechanism, it triggers the immune system to hunt down and destroy the source of harm, remove any necrotic cells, and start the healing process. In order to bring about a return to equilibrium, a cascade of cellular and molecular processes mediates the inflammatory response. Critical participants in this process include immune cells, cytokines, chemokines, and inflammatory mediators including prostaglandins and leukotrienes. While acute inflammation is transient and disappears once the offending chemical is no longer present, chronic inflammation persists over time and may lead to tissue damage and other illnesses including cancer, cardiovascular issues, and arthritis.

First, an influx of immune cells, including monocytes, macrophages, and neutrophils, rushes to the injured area to begin the inflammatory response. The production of cytokines by these cells, such as TNF-α, IL-1β, and IL-6, attracts more immune cells to the location., which promote inflammation. Vasodilation and increased permeability are vascular changes that cause pain, redness, swelling, and heat. The inflammatory response is intensified even further by the activation of the NF-κB and MAPK pathways. When the body's first reaction to an injury doesn't fix it, chronic inflammation begins, characterized by persistent immune activity and tissue damage caused by macrophages and T cells.

While inflammation lasts for a long time, the immune system stays overactive and releases proteolytic enzymes and reactive oxygen species (ROS), which damage cells. Asthma, IBD, and RA are just a few of the numerous crippling disorders that have chronic inflammation as their basis. Insulin resistance, which occurs when inflammatory cytokines disrupt insulin signaling, is another metabolic condition associated with persistent low-grade inflammation. This includes obesity and diabetes. In order to create tailored treatments to reduce inflammation, it is essential to understand its molecular mechanisms.

The bioactive chemicals found in herbs affect inflammatory pathways, making them an effective tool for those who work in the fields of conventional and alternative medicine to treat inflammatory diseases. There are a variety of medicinal plants that may

to reduce inflammation by blocking important signaling molecules including NF-κB, COX, and LOX. Unlike synthetic medications, which may have unwanted side effects, these natural substances can help decrease inflammation, ease pain, and promote tissue repair.

One popular herbal medicine with strong anti-inflammatory effects is curcumin, which is found in turmeric (Curcuma longa). It decreases the generation of cytokines that promote inflammation by blocking the activation of NF-κB. Through regulating the COX-2 and LOX pathways, curcumin decreases the synthesis of prostaglandins and leukotrienes, which are inflammatory mediators. Curcumin has been shown in several trials to alleviate symptoms of inflammatory bowel disease, neuroinflammatory diseases, arthritis, and other related ailments. Curcumin nanoparticles or a mixture with piperine (from black pepper) improve its absorption and effectiveness because of its low bioavailability.

Another popular herbal medicine with anti-inflammatory effects is ginger, scientifically known as Zingiber officinale. It has bioactive ingredients that reduce the production of pro-inflammatory cytokines and inhibit COX-2, such as gingerols and shogaols. Patients suffering from rheumatoid arthritis and osteoarthritis report less swelling and discomfort after taking ginger extract, according to clinical trials. By removing free radicals that worsen inflammation, ginger's antioxidant qualities add to its medicinal effects.

For ages, Ayurvedic practitioners have relied on Boswellia serrata, more often known as Indian frankincense, to alleviate inflammatory disorders. Boswellic acids, the active ingredient, alter leukotriene synthesis and inhibit 5-lipoxygenase (5-LOX), which in turn reduces inflammation and discomfort. Osteoarthritis, inflammatory bowel disease, and asthma have all been shown to respond well to boswellia extract. This option is safer for long-term usage than NSAIDs since it does not induce gastrointestinal discomfort.

Epigallocatechin gallate (EGCG) is an antioxidant and anti-inflammatory polyphenol found in green tea (Camellia sinensis), which has a high polyphenol concentration. For its effects to be felt, EGCG blocks the activation of NF-κB and reduces the production of inflammatory cytokines. Use of green tea has been associated

with a reduced risk of chronic inflammatory illnesses, including cardiovascular problems, cancer, and neurological diseases like Alzheimer's. Reducing inflammation-induced insulin resistance increases metabolic health, which may be beneficial for diabetics.

The anti-inflammatory and immunomodulatory properties of licorice root's (Glycyrrhiza glabra) component glycyrrhizin are well-documented. Glycerrhizin is able to reduce inflammatory cytokine levels and restrict NF-κB activation. It has a long history of use in the treatment of gastrointestinal and respiratory infections. However, licorice's mineralocorticoid activity may have undesirable side effects, such as hypertension, when taken in excessive amounts.

The potential anti-inflammatory effects of the polyphenol resveratrol, which is found in red wine, berries, and grapes, have just recently attracted attention. It blocks the NF-źB and MAPK pathways, which reduces cytokine production and oxidative damage. Resveratrol has promise in the treatment of inflammatory diseases, including arthritis, cardiovascular disease, and neuroinflammation. Another aspect that enhances its medical potential is its ability to activate sirtuins, which are proteins associated with longevity.

Some other well-known herbal medicines include chamomile (Matricaria chamomilla), which is recognized for its anti-inflammatory flavonoid content, and aloe vera, which contains polysaccharides that influence immune responses. Ashwagandha (Withania somnifera) and holy basil (Ocimum sanctum) are adaptogenic herbs that modulate cortisol levels and cytokine balance, which helps to reduce inflammation that is caused by stress.

By acting on several pathways that contribute to the inflammatory response, herbal medicine presents a potentially useful strategy for inflammation treatment. Herbal medicines provide a more natural and holistic alternative to traditional anti-inflammatory medications, which may have less negative effects on the gastrointestinal, cardiovascular, and renal systems. To determine the best ways to take these herbal substances, how much of them will be bioavailable, and if they are safe to use over the long term, more clinical trials are required. Treatment results for inflammatory illnesses may be improved with supplementing conventional treatment with herbal remedies has the potential to lessen the adverse effects of pharmaceutical drugs. Research into the

molecular processes of herbal components and the development of standardized formulations to optimize their therapeutic potential should be prioritized in the future, especially in light of the increasing interest in natural medicine.

1.8 EVALUATION METHODS FOR ANTI-INFLAMMATORY PROPERTIES OF HERBAL MEDICINES

Inflammation is a multi-step process that occurs when cells in the body react negatively to outside threats including germs, damaged cells, or irritants. Arthritis, cardiovascular disease, and neurological illnesses may all be exacerbated by chronic or severe inflammation, despite the fact that it is a preventive mechanism. Because of its inherent bioactive components, which regulate inflammatory pathways, Inflammation treatment is an area where herbal therapies have been used for quite some time. Herbal medicines undergo a battery of in vitro, in vivo, and clinical tests to ascertain their anti-inflammatory properties and safety.

An important part of screening herbal medications before they are tested on animals or humans is the in vitro assessment of their anti-inflammatory capabilities. Herbal extracts may be tested for their effects on inflammatory indicators in a controlled setting using cell-based assays. Studies of this kind often use macrophages, for example, the RAW 264.7 and J774A.1 cell lines. When these cells encounter pro-inflammatory stimuli like lipopolysaccharides (LPS), they produce various inflammatory mediators, in the form of prostaglandins, nitric oxide (NO), and cytokines as IL-6, IL-1β, and TNF-ι. A possible anti-inflammatory action of herbal extracts is a decrease in levels of these mediators. Many commonly used methods for quantifying treatment-induced mutations and cytokine levels include enzyme-linked immunosorbent assays (ELISA), western blotting, and real-time polymerase chain reactions (RT-PCR). In order to learn how herbal remedies exert their anti-inflammatory effects, scientists have developed enzyme inhibition experiments that focus on cyclooxygenase (COX-1 and COX-2) and 5-lipoxygenase (5-LOX).

Given the tight relationship between inflammation and oxidative stress, assessing antioxidant activity is another crucial in vitro technique. Encouraging the activation of signaling pathways that promote inflammation, reactive oxygen species (ROS) may exacerbate disorders associated with inflammation. The radical scavenging capabilities of herbal extracts including polyphenols, flavonoids, and alkaloids are evaluated using

assays such the DPPH and ABTS measurements. Additional information on the redox potential of plant chemicals may be gleaned from the ferric reducing antioxidant power (FRAP) test. These tests are useful for figuring out if the antioxidant qualities of herbal remedies are responsible for their anti-inflammatory benefits.

Herbal remedies are tested for their pharmacological effectiveness in live creatures via in vivo research once their in vitro evaluations have been successful. Research on inflammation often makes use of rodent models, namely rats and mice. Different inflammatory disease features may be reproduced in vitro by means of various artificially created inflammation models. A common method for evaluating sudden swelling is paw edema model produced by carrageenan. To determine carrageenan's anti-inflammatory effects, scientists inject the herbal extract into the back paws of animals and monitor the swelling over time. The acute anti-inflammatory effects may also be evaluated with the use of models like as paw edema caused by formalin or xylene.

The (CFA)-induced arthritis model is often used for investigations involving chronic inflammation. Chronic joint inflammation and cartilage degeneration are hallmarks of rheumatoid arthritis, which this model attempts to mimic. After administering a herbal remedy, researchers check for changes in histopathology, inflammatory cytokine levels, and clinical symptoms. The fibrotic tissue development frequent in chronic inflammation may be assessed using the cotton pellet-induced granuloma model, which also examines the effects of herbal treatments. This data on the effectiveness of herbal substances in a biological system is crucial, and these in vivo models provide it.

Research using animal models for molecular and biochemical studies can provide light on the action mechanism. Methods like immunohistochemistry, Changes in the levels of certain signaling molecules and inflammatory indicators, such as NF-κB, may be detected using real-time polymerase chain reaction (RT-PCR) and western blotting, MAPKs, and PKA/STAT pathways. Inflammatory illnesses may be amenable to herbal remedies that inhibit certain signaling pathways.

To validate the effects of herbal medicines on human patients, clinical studies are carried out after preclinical research establishes their safety and effectiveness. In randomized controlled trials (RCTs), patients suffering from inflammatory disorders are

given either the herbal remedy or a placebo for the purpose of clinical assessment. To measure how well the medication is working, doctors keep an eye on biomarkers including C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and levels of pro-inflammatory cytokines. Additional information may be gleaned from patient-reported results, such as reductions in pain, enhancements in joint mobility, or reductions in skin inflammation. For reliability in clinical trials, it is essential that standardized herbal formulations undergo extensive testing to guarantee uniformity in quantities of bioactive compounds.

Research into the metabolism, excretion, and absorption of active herbal components may also be aided by pharmacodynamic and pharmacokinetic investigations. Methods like It is possible to identify and quantify bioactive components in plasma and tissue samples by means of liquid chromatography-mass spectrometry (LC-MS) and high-performance liquid chromatography (HPLC). Research like this helps determine the best way to dose herbal medications so that they have the most therapeutic effect with the least amount of side effects.

Safety evaluations are also necessary for the evaluation of herbal medications that are anti-inflammatory. In order to detect any possible side effects, toxicological studies must be conducted by combining in vitro and in vivo methods.Studies on acute and chronic toxicity establish the acceptable dose range, while tests on genotoxicity and hepatotoxicity evaluate the potential dangers of herbal medication in the long run. Herbal formulations continue to be safe and effective for human usage because of quality control and standardization methods, such as Good Manufacturing Practice (GMP) norms.

A thorough strategy that incorporates in vitro, in vivo, and clinical approaches is necessary for assessing the anti-inflammatory effects of herbal remedies. Human clinical studies, animal models, and cell-based tests all contribute to our understanding of the drug's safety, effectiveness, and mechanism of action. We are learning more and more about how herbal medicines influence inflammation thanks to developments in analytical methods, molecular biology, and bioinformatics, and this is opening the door for their incorporation into conventional therapy. Herbal medicines must undergo thorough scientific testing to ensure they are safe and effective alternatives to synthetic anti-inflammatory medications, which are becoming more popular.

1.9 COMMON HERBAL MEDICINES WITH ANTI-INFLAMMATORY PROPERTIES

The immune system's normal reaction to pathogens, injuries, or other potentially dangerous stimuli is inflammation. Arthritis, cardiovascular disease, and autoimmune disorders are only a few of the many problems associated with chronic inflammation, in contrast to acute inflammation's healing-promoting effects. Several herbal medicines have shown their efficacy in managing inflammation for an extended period of time. effective in scientific investigations. Here we take a close look at a few well-known herbal medicines that are known to reduce inflammation.

1. Turmeric (Curcuma longa)

The powerful anti-inflammatory effects of turmeric have made it one of the most studied therapeutic plants. Many inflammatory pathways, such as Turmeric's key ingredient, curcumin, been shown to block the pathways of NF-κB and COX-2. Research on the efficacy of curcumin in the treatment of inflammatory conditions, including neurological illnesses, inflammatory bowel disease (IBD), arthritis, and others. Black pepper contains piperine, a chemical that promotes absorption, and curcumin may be combined with it to increase its bioavailability.

2. Ginger (Zingiber officinale)

For ages, ginger has been a go-to remedy for pain and inflammation in traditional medicine. Some of its bioactive components, such as gingerols and shogaols, reduce inflammation by blocking the production of pain- and swelling-inducing prostaglandins and cytokines. Scientific studies have shown that ginger helps alleviate RA and osteoarthritis symptoms by lowering oxidative stress and inflammatory markers. Ginger, whether in the shape of teabags, powder, or capsules, may effectively reduce inflammation when consumed.

3. Green Tea (Camellia sinensis)

Among the many polyphenols found in green tea, epigallocatechin gallate (EGCG) stands out for its anti-inflammatory and powerful antioxidant properties. Some studies have shown that EGCG may regulate inflammatory responses by preventing the activation of NF-κB and decreasing the generation of pro-inflammatory cytokines. Those who drink green tea on a daily basis are less likely to develop chronic diseases including

diabetes, cancer, and heart disease. One way to help decrease inflammation in the body is to drink green tea every day or use green tea extracts.

4. Boswellia (Boswellia serrata)

Boswellia, or Indian frankincense, is a herb with an Ayurvedic history of use in the management of inflammatory disorders that persist over an extended period of time [1]. The boswellic acids that make it active block an enzyme called 5-lipoxygenase that makes inflammatory leukotrienes. When it comes to addressing inflammatory bowel disease, osteoarthritis, and rheumatoid arthritis, boswellia has shown to be a beneficial remedy. Capsules, resin, and extract are all forms it is accessible in; clinical trials have been encouraging.

5. Willow Bark (Salix alba)

For generations, people have turned to willow bark because of its analgesic and anti-inflammatory effects. Salicin, a derivative of aspirin, helps block the COX enzymes that produce prostaglandins, which in turn reduces inflammation and discomfort. Willow bark has therapeutic effects on a variety of medical issues, including headaches, osteoarthritis, and lower back discomfort, according to studies. Three different versions are available: tea, tincture, and capsule.

6. Ashwagandha (Withania somnifera)

Traditional Indian medicine makes extensive use of the adaptogenic herb ashwagandha because of the ways It lowers inflammation and controls the immunological system. Withanolides are a part of it. which have anti-oxidant and anti-inflammatory effects. Clinical investigations on inflammatory disorders, such as arthritis, have shown the potential of ashwagandha, neuroinflammation, and stress-related inflammation. Its powder, pill, or extract forms are the most popular for consumption.

7. Devil’s Claw (Harpagophytum procumbens)

The anti-inflammatory and analgesic effects of Devil's Claw have made it famous since its native Africa. Harpagosides, its active ingredients, are useful for the management of inflammatory pathways, which contribute to the alleviation of pain associated with arthritis, tendinitis, and muscular strain. According to studies, Maybe Devil's Claw is as effective as nonsteroidal anti-inflammatory drugs (NSAIDs) in

reducing pain. (nonsteroidal anti-inflammatory medicines) while causing much fewer negative effects.

8. Rosemary (Rosmarinus officinalis)

The antioxidant and anti-inflammatory effects of the popular culinary plant rosemary have been extensively studied and confirmed. Carnosic acid and rosmarinic acid are its active ingredients, which provide it antioxidant and anti-inflammatory properties. Inflammatory disorders, including arthritis and neuroinflammation, may find relief from the symptoms caused by rosemary, according to certain studies., and asthma. Various forms of ingestion are possible, including tea, essential oil, and extract.

9. Chamomile (Matricaria chamomilla)

The sedative and anti-inflammatory properties of chamomile have made it a popular herb for centuries. Apigenin and other flavonoids found in it help control inflammatory reactions and lessen oxidative stress. Inflammatory problems, including gastrointestinal issues, skin irritations, and lung inflammation, often find relief with the use of chamomile tea.

10. Glucomannan root, often known as licorice root

Licorice root contains the active ingredient glycyrrhizin, which may modulate pathways and reduce inflammation. Traditional medicine has used it for a long time for a variety of purposes, including the relief of gastritis, sore throats, and inflammation of the respiratory tract. Be wary with licorice since it has adverse effects including elevated blood pressure if taken in large quantities.

11. Echinacea (Echinacea purpurea)

Although echinacea's anti-inflammatory benefits are more well-known, it is also renowned for its ability to enhance the immune system. In addition to lowering inflammation, it regulates the immunological system. via its bioactive components, which include alkamides. Inflammatory skin problems, autoimmune illnesses, and respiratory infections are some of the most prevalent ailments for which echinacea is prescribed.

12. Cloves (Syzygium aromaticum)

The anti-inflammatory and antioxidant eugenol is one of cloves' potent components. Clumps are helpful for inflammatory bowel illness, toothaches, and arthritis because of eugenol's anti-inflammatory and anti-oxidant characteristics. If you're experiencing discomfort, try using clove oil directly. If you prefer to use powdered cloves, you may add them to your meals or tea.

13. (Uncaria tomentosa) Cat's Claw

One of the oldest plants in the Amazon, Cat's Claw, may minimize inflammation by regulating the immunological system. The anti-inflammatory and immune-boosting properties are caused by the polyphenols and alkaloids that are contained therein. Conditions including inflammatory bowel illness and rheumatoid arthritis have shown improvement after using it, according to the research.

An all-natural and efficient method of managing inflammation-related disorders is the use of anti-inflammatory herbal remedies. Despite these plants' long history of usage, new scientific evidence is proving their efficacy. There are many health advantages to incorporating these herbs into your everyday life, whether it's via teas, extracts, supplements, or culinary usage. To make sure herbal remedies are safe and effective, people should talk to their doctor before using them, particularly if they have any kind of preexisting ailment or are already on any kind of drug.

1.10 CHALLENGES IN HERBAL MEDICINE EVALUATION

Traditional treatment systems across the globe, such as Ayurveda, TCM, and Indigenous medicine, have relied on herbal therapy for ages. Herbal medications have become more well-known in contemporary medicine due to the increasing popularity of alternative and natural treatments. Nevertheless, there are substantial obstacles to overcome when evaluating herbal medicines, despite their widespread use. Variability in plant composition, non-standard methodology, regulatory obstacles, and a lack of research all contribute to these problems. The fundamental difficulties of assessing herbal remedies and its consequences for their incorporation into conventional healthcare are discussed in this article.

Variability in Plant Composition

Because of this intrinsic variety in plant composition, assessing herbal medicine is a huge difficulty. Herbal remedies are complex mixes of bioactive chemicals, as

opposed to synthetic pharmaceuticals that are chemically defined and produced in a controlled environment. Several variables may affect the specific chemical make-up of these molecules, such as:

- **Geographical Location**: It is possible to alter the phytochemical composition of a plant by changing its cultivation conditions, soil, and elevation.
- **Harvesting and Storage Conditions**: The amount of active ingredients may change depending on when they are harvested and how they are stored after harvest.
- **Processing Methods**: Potency and effectiveness may vary due to differences in extraction, drying, and formulation techniques.
- **Plant Species and Cultivar Differences**: Various cultivars of the same species may have varying concentrations of bioactive chemicals.

Because of these differences, quality control is quite challenging when it comes to herbal medication formulations.

Lack of Standardization

The term "standardization" describes the steps used to guarantee consistency in the formulation and manufacturing of herbal medicines. There aren't usually established procedures for growing, extracting, or making herbal remedies, in contrast to conventional drugs. Mistakes in dose, effectiveness, and safety may occur due to the absence of standardization. Difficulties with standardization encompass:

- **Difficulty in Identifying Active Ingredients**: It is challenging to determine which components of herbal medicines contribute to therapeutic benefits since many of these treatments include numerous bioactive substances.
- **Batch-to-Batch Variability**: It is difficult to achieve uniformity between batches of herbal medications because of the inherent variances in plant makeup.
- **Lack of Global Standards**: Discrepancies in quality control arise because different nations have different criteria for the manufacture of herbal medicines.

In order to solve these problems, standardized procedures for growing, processing, and making herbal remedies need to be established.

Regulatory and Legal Hurdles

Due to their lack of uniformity under current pharmaceutical frameworks, herbal medications encounter substantial regulatory hurdles. In many parts of the world, herbal medicines are still considered dietary supplements or traditional cures, rather than pharmaceuticals, which are subject to extensive scientific studies before they are approved. Obstacles posed by regulations encompass:

- **Lack of Comprehensive Guidelines**: There is a lack of uniformity in quality assurance and risk evaluations due to the fact that many nations have distinct regulatory frameworks for herbal remedies.
- **Complex Approval Processes**: Herbal medicine makers face the challenge and expense of complying with the regulations that demand costly and time-consuming clinical studies to demonstrate the drug's effectiveness and safety.
- **Adulteration and Contamination Issues**: Herbal medications must undergo rigorous quality inspections to ensure they are free of harmful pollutants including heavy metals, pesticides, and microorganisms.
- **Mislabeling and False Claims**: Both patients and doctors might be misled by the advertising of some herbal remedies due to the use of hyperbolic or unsubstantiated promises.

In order to make sure that herbal medications are safe and effective, there should be standardized worldwide standards for them. This would help with regulatory control.

Limited Scientific Research and Clinical Trials

To be accepted in mainstream healthcare, herbal medications must first be scientifically validated. A significant obstacle, however, is the paucity of research and clinical trials including herbal remedies. Below are some of the reasons:

- **High Cost of Clinical Trials**: Randomized controlled trials (RCTs) on a wide scale are time-consuming and costly to conduct.
- **Complexity of Herbal Formulations**: It is challenging to conduct experiments that separate the effects of individual components in herbal medicines since they generally include numerous bioactive chemicals.

- **Lack of Funding and Interest**: Due to smaller profit margins compared to synthetic pharmaceuticals, pharmaceutical corporations may be hesitant to engage in research on herbal medicines.

- **Traditional Knowledge vs. Scientific Evidence**: Because many herbal medicines rely on anecdotal evidence rather than hard scientific evidence, harmonizing traditional and contemporary medicine is challenging.

To further our scientific knowledge and validate herbal remedies, we need more money and more cooperation between researchers and practitioners of traditional medicine.

Challenges in Pharmacokinetics and Pharmacodynamics Studies

If we want to know if herbal medications are safe and effective, we need to know their pharmacodynamics (how they affect the body) and pharmacokinetics (how they get into the bloodstream). Nevertheless, herbal remedies present distinct obstacles in various domains, such as:

- **Complexity of Herbal Constituents**: It is challenging to ascertain the pharmacokinetic characteristics of herbal medications due to the fact that their many active components could interact in unforeseen ways.

- **Metabolism and Drug Interactions**: Conventional medications and herbal remedies may have opposite effects or lessen the effectiveness of each other.

- **Variability in Bioavailability**: Solubility, digestive enzymes, and gut flora are a few of the elements that might impact the bioavailability of herbal substances.

- **Lack of Biomarkers for Efficacy Assessment**: Indicators of therapeutic effects are not always readily apparent while using herbal remedies, in contrast to conventional medications that have well-established biomarkers for effectiveness.

The pharmacokinetics and pharmacodynamics of herbal medicines may be better understood with the use of modern analytical methods like mass spectrometry and high-performance liquid chromatography (HPLC).

Safety Concerns and Toxicity Issues

Although herbal remedies have a reputation for being harmless, they do include some potential side effects. Important considerations regarding safety include:

- **Adverse Effects and Toxicity**: When used incorrectly, several herbal remedies might be harmful due to the presence of poisonous chemicals.
- **Herb-Drug Interactions**: The effectiveness of pharmaceutical medications may be altered by the presence of some plants.
- **Misidentification and Substitution**: It is possible to cause toxicity by misidentifying therapeutic plants or by using them instead of their intended species.
- **Contamination with Heavy Metals and Pesticides**: Dangerous levels of heavy metals, pesticides, and microbiological contaminants have been found in several herbal remedies.

Quality control, toxicity testing, and customer education about possible dangers are necessary for herbal medications to be safe.

Ethical and Cultural Considerations

When evaluating herbal remedies, it is important to think about cultural and ethical factors, such as:

- **Intellectual Property Rights (IPR)**: The foundation of many herbal treatments is in the wisdom that has been handed down from one generation to another. Ethical questions arise when indigenous populations are not fairly compensated for the utilization of this knowledge.
- **Cultural Beliefs and Practices**: The assessment of traditional medicine must take into account the cultural ideas that underpin it.
- **Informed Consent in Research**: Clinical studies on herbal remedies must adhere to ethical standards by informing participants of all possible hazards and benefits.

To solve these ethical problems, scientists, politicians, and practitioners of traditional medicine must work together.

There are a lot of obstacles to overcome when evaluating herbal medications. These include things like inconsistent plant composition, a lack of standardization, regulatory impediments, a lack of scientific research, complicated pharmacokinetics, safety issues, and ethical considerations. Research in the scientific community, changes to regulations, quality control procedures, and partnerships between conventional and alternative medical systems are all necessary to meet these difficulties head-on. Ensuring the safety, effectiveness, and accessibility of herbal medicines for people worldwide may be achieved by overcoming these hurdles and integrating them more effectively into mainstream healthcare.

1.11 PLANT MATERIALS USED IN THIS STUDY

Ginger (Zingiber officinale)

Ginger is a widely used medicinal rhizome known for its anti-inflammatory, antioxidant, digestive, and antiemetic properties. Traditionally, it has been used in Ayurveda for managing gastrointestinal disorders, nausea, arthritis, and respiratory ailments. Active constituents like gingerols and shogaols contribute to its pharmacological effects, including modulation of inflammatory pathways and improvement of circulation.

Triphala

Triphala is a classical Ayurvedic herbal formulation consisting of three fruits: Amalaki (Emblica officinalis), Haritaki (Terminalia chebula), and Bibhitaki (Terminalia bellirica). It is primarily known for its rejuvenating, digestive, and detoxifying properties. Triphala exhibits antioxidant, immunomodulatory, and mild laxative effects, making it useful in maintaining gastrointestinal health and overall vitality.

Guggulu (Commiphora mukul)

Guggulu is a resin obtained from the tree Commiphora mukul. It is renowned in Ayurveda for its lipid-lowering, anti-inflammatory, and anti-arthritic activities. Guggulu contains active compounds like guggulsterones, which help regulate cholesterol metabolism, reduce inflammation, and support joint health. It is commonly used in the management of obesity, arthritis, and metabolic disorders.

Guduchi (Tinospora cordifolia)

Guduchi is a climbing shrub known for its potent immunomodulatory, adaptogenic, and hepatoprotective properties. It is used in Ayurveda to enhance immunity, combat infections, manage diabetes, and support liver function. Bioactive constituents such as alkaloids, glycosides, and polysaccharides contribute to its antioxidant, anti-inflammatory, and antipyretic effects.

1.12 OBJECTIVES OF THE STUDY

1. To study's pharmacological selection includes many popular herbal remedies and anti-inflammatory medications.
2. To Phytochemical evaluation of the selected herbal remedies.
3. To possibility of pharmacological interactions between herbal remedies and anti-inflammatory medications was examined in vitro.
4. To Finding the dose that affects medication interactions.

1.13 NEED OF THE STUDY

The rising incidence of chronic inflammatory disorders and the shortcomings of current treatment options highlight the future importance of investigating herbal remedies for their potential anti-inflammatory effects. Risks of side effects, such as gastrointestinal difficulties, cardiovascular concerns, and organ damage, will persist with synthetic anti-inflammatory medicines (NSAIDs) and corticosteroids. Consequently, finding natural alternatives that are both safer and more effective will be given increased priority. Investigation into the pharmacological mechanisms, clinical optimization of formulations, and systematic analysis of bioactive chemicals found in medicinal plants will be the primary goals of future research. Herbal anti-inflammatory drugs will be better understood with the use of cutting-edge scientific methods including omics-based methodologies, molecular docking, and high-throughput screening. Also, to make sure that herbal medications are consistent, effective, and safe, quality control and standardization will be a top concern. They will undergo clinical studies to prove their effectiveness, which might lead to regulatory approvals and more general adoption in medicine. As the area of integrative and holistic healthcare continues to grow in popularity globally, there will be an uptick in study into the potential of herbal medicine

to manage inflammation. In order to bridge the gap between traditional knowledge and modern scientific data, future study aims to support the long-term usage of herbal treatments.

1.14 STATEMENT OF AIM

Herbal remedies have long been used in traditional medicine, although there is little proof that they have anti-inflammatory effects. Traditional therapies for chronic inflammation, such nonsteroidal anti-inflammatory drugs (NSAIDs) and corticosteroids, come with serious dangers, including harm to the gastrointestinal tract, kidneys, and the heart. There is a lack of thorough scientific documentation about the efficacy, safety, and action mechanisms of medicinal plants traditionally used to treat inflammatory diseases. Their incorporation into conventional medicine is further hindered by the absence of standardized formulations, consistent dosages, and regulatory authorization. The fact that different plant species, cultivation methods, and extraction processes result in bioactive chemical concentrations that might vary greatly makes it difficult to rely on them as a treatment agent. The complete efficacy of herbal remedies cannot be known unless thorough pharmacological assessments and rigorous clinical studies are conducted. So, finding, isolating, and validating the anti-inflammatory components in herbal remedies is an immediate and pressing need for systematic study. By tackling these obstacles, we can bring traditional medicine and contemporary science closer together, which will speed up the process of creating standardized herbal anti-inflammatory medicines that are safe, effective, and can replace synthetic pharmaceuticals.

Chapter 2

REVIEW OF LITERATURE

Rajapaksha, R M H K K et al., (2024) For both acute and chronic medical conditions, phytochemicals continue to serve as a solid foundation for the development of new medicines. Reducing inflammation with minimal side effects requires the development of novel therapeutic drugs. Inflammation is the immune system's reaction to potentially harmful stimuli. In this study, we will use molecular docking to screen the plant's phytochemicals for possible anti-inflammatory effects against cyclooxygenase-2 (COX-2), and we will use heat-induced egg albumin denaturation as an in vitro method to test the anti-inflammatory activity of different Horsfieldia iryaghedhi plant extracts. Cold maceration in a combination of distilled water and 99.9 percent methanol was used to extract all of the fresh, completely expanded bark and leaves of H. iryaghedhi. After that, a focus sequence was made. To study the anti-inflammatory efficacy, the heat-induced denaturation of egg albumin was used. As a positive control, diclofenac sodium was used. In addition, we used autodock vina for site-specific molecular docking to assess the binding energies, pharmacokinetic and toxicological characteristics, and enzyme selectivity of a set of phytochemicals for COX-2 (PDB ID: 5IKR). Research indicates that the anti-inflammatory properties of the water and methanol extracts vary with concentration, as seen by their IC50 values of 116.4 μg/ml when tested against the reference medication Diclofenac sodium. The methanol bark extract was more effective than the other extracts in reducing inflammation, with an IC50 of 293 μg/ml. In addition, a strong relationship ($p<0.05$, $R2 \approx 1$) was seen between concentration and % inhibition in both the water and methanol extracts. Molecular docking studies have shown that phytochemicals found in the plant may suppress COX-2 activity. The druggability, favorable toxicological and pharmacokinetic properties, and medicinal use of N, N-Dimethyl-5-methoxy tryptamine and methyl 2,4-dihydroxy-6-methylbenzoate led to their selection for this investigation. Researchers have discovered that extracting the bark of Horsfieldia iryaghedhi using methanol significantly reduces inflammation in both animals and humans. The findings suggest that the bark and leaves of Horsfieldia iryaghedhi contain compounds with anti-inflammatory properties. To confirm the results,

nevertheless, more in vivo testing and molecular dynamics investigations may be required.

Fah, Lauris et al., (2024) Public health officials are still quite worried about the treatment of inflammatory diseases due to the negative effects associated with conventional anti-inflammatory drugs. Another option is researching medicinal plants for new anti-inflammatory medications. Hemostatic and antibacterial, Jatropha multifida is a popular traditional medicinal herb in the Euphorbiaceae family. Few details exist about its anti-inflammatory properties. The research examined if Jatropha multifida stem sap was immunomodulatory or anti-inflammatory. Anti-inflammatory and anti-hemolytic effects of stem sap were tested in vitro using the same procedures. To accomplish this, the in vivo rat paw edema test was employed. TNFα, a chemical mediator of inflammation, was used to assess immunomodulation potential. The DPPH technique assessed its antioxidant properties. This study's anti-hemolytic effect was 66.21% higher than Diclofenac (24.94%) and Ibuprofen (40%), compared to non-toxic Jatropha multifida sap. The LC50 was 0.604 mg/mL. DPPH inhibition is strong at 0.5 mg/mL, like vitamin C. This sap has anti-inflammatory and immunomodulatory properties, reducing paw inflammation to a level comparable to diclofenac at 800 mg/kg and reducing TNFα (286.15) more than normal control rats, making it acceptable for traditional medical usage.

Venkatraman, Thirumalai et al., (2024) Numerous medical conditions, including as asthma, arthritis, allergies, cancer, and other respiratory ailments, are largely influenced by the immune system's inflammatory response. It has been well-documented that novel anti-inflammatory drugs made from medicinal plants may be able to avoid the harmful side effects of current ones. Edible plants such as Solanum xanthocarpum, Sida cardifolia, and Psidium guajava were extensively used by indigenous communities to treat a variety of ailments. In the case of S. xanthocarpum, the ratio of fruits to leaves was 2:1:1, whereas in the case of S. cardifolia, the ratio was 1:1:1. In order to make the extract, the herbal mixture was cold macerated in a solution of ethanol (Eth) and water (Aq). Polyherbal formulations (PHF) were given the following names: Aq1:1:1, Aq2:1:1, Eth1:1:1, and Eth2:1:1. We measured the anti-inflammatory efficacy by inhibiting protein denaturation and stabilizing the SRBC membrane using various approaches, as

well as by assessing the total flavonoid content (TFC) and total phenolic content (TPC) using a biochemical methodology. When it came time for statistical analysis, we fired out the Bonferroni post hoc test and the ANOVA. The 89.34 mg GAE/100g of Dry ext and 59.58 mg QE/100g of Dry ext levels, respectively, of TPC and TFC, were found to be greatest in the Eth2:1:1 PHF mix. The SRBC membrane stabilization (66.7±1.2) and protein denaturation inhibitory (60.9±1.7) tests showed that Eth2:1:1 had the best anti-inflammatory capabilities when compared to other PHF forms. The current study confirms that the novel PHF containing the 2:1:1 ethanolic extract is more effective in reducing inflammation. There are a number of inflammatory diseases, some of which may be deadly, and this finding may lead to a new drug to treat them.

Pradubyat, Nalineeet al., (2024) The use of medicinal plants as dietary supplements has the potential to alleviate a multitude of health concerns, such as inflammation, cancer, metabolic problems, and chronic diseases. Traditional medicines are promising areas for pharmaceutical research due to their therapeutic properties. Aims of the Research Safflower seed oil and five medicinal Thai plants—Citrus aurantifolia, Cannabis sativa, Tiliacora triandra, Alpinia galanga, and Piper nigrum—come together to form Belog Plus (BP), a polyherbal preparation. The primary goal of this research was to assess the product's effectiveness. Two important indicators of herbal products that impact their therapeutic properties—total flavonoid content (TFC) and total phenolic content (TPC)—were quantified in this research. This study sheds light on the efficacy of BP as it examined the molecular mechanisms behind the anti-inflammatory impact of the plant extracts in addition to their antioxidant and anti-inflammatory capacities. To assess the antioxidant capabilities of the BP ethanolic extract and its constituents, we used DPPH, FRAP, and H2O2-induced oxidative stress. The mechanisms were uncovered by analysis of messenger RNA and protein expression, and the anti-inflammatory impact was assessed using the Griess reaction test. An aluminum chloride colorimetric assay was used to estimate total flavonoid content (TFC), and the Folin-Ciocalteu (F-C) test was used to assess total phenolic content (TPC). Herbal biomarkers were uncovered by the LC-MS/MS study. Conclusion BP's ethanolic extract successfully decreased inflammation by regulating nitric oxide synthesis (IC50 24.4 μg/ml) and notably lowering levels of inflammatory genes such iNOS, COX-2, IL-6, and TNF-α. In addition, at doses ranging from 6.25 to 25 μg/ml, it considerably decreased the synthesis

of the inflammatory proteins iNOS and COX-2. C. aurantifolia, A. galanga, and P. nigrum exhibited significant anti-inflammatory effects among the individual components, with IC50 values of 35.7, 6.5, and 23.3 µg/ml, respectively. The TPC and TFC included trace amounts of phenolic (800.6 µg GAE/mg) and flavonoid (47.4 µg catechin/mg) components, according to phytochemical analysis. The LC-MS/MS analysis also uncovered a few bioactive chemicals with anti-inflammatory characteristics. Our results indicate that BP, when taken orally, may help reduce the risk of chronic inflammatory disorders. A substantial reduction in iNOS and COX-2 protein production is seen in the ethanolic extract of BP, which contains bioactive phenolic and flavonoid components.

Ullah, Md et al., (2023) By "herbal medicine," we mean the method of treating or preventing illness via the use of plants that possess medicinal qualities. A lot of area is covered by this idea, from the widespread and consistent usage of traditional treatments throughout cultures to the process of standardizing and tritating plant extracts. The analgesic and anti-inflammatory effects of Ficus racemosa were investigated in this research by giving rats an extract of the plant. In order to study the analgesic and anti-inflammatory effects, researchers used carrageenan to generate acute inflammation. Along with the approach described in S. Asian Res. 170 by Lima et al., methods like the tail flick and acetic acid writhing were also used. There were no significant differences in anti-inflammatory activity across the groups, according to the statistical analysis. Only when contrasted with the positive control group with a high dose of 1000 mg/kg did the acetic acid writhing technique's analgesic efficacy become statistically significant ($p<0.05$). In the tail flick test, the extremely high dosage of 1000 mg/kg was the only dose that showed statistically significant effects ($p <0.05$) across all groups. Our extract may not be effective at moderate or low dosages due to variations in the extraction process or seasonal effects. Gathering the plant at various times of the year and using different extraction processes might make determining its analgesic and anti-inflammatory properties easier.

Peiris, D S H S et al., (2023) Extracts from the tuberous roots of Mirabilis jalapa L. will be tested in vitro for their antibacterial and anti-inflammatory properties. Hexane, dichloromethane, and methanol are the organic solvents that are used in this experiment. The anti-inflammatory activity was assessed in vitro using a heat-induced egg albumin

denaturation inhibition test and hypotonicity-induced membrane stabilization of HRBCs. To test the antibacterial properties in vitro, the disc diffusion and well diffusion techniques were used. The participants utilized for the tests were three typical types of wound infections. The particular bacterial varieties in question are Pseudomonas aeruginosa (ATCC 27853), Staphylococcus aureus (ATCC 25923), and Escherichia coli (ATCC 25922). The end result In the experiment to prevent heat-induced denaturation of egg albumin, the methanolic extract of M. jalapa showed the strongest anti-inflammatory properties, with an IC 50 value of 137.9 µg/ml. Using the HRBC membrane stabilization method with the aqueous extract of M. jalapa, on the other hand, demonstrated the most anti-inflammatory effects (IC 50 = 197.4 µg/ml). None of the four extracts had any kind of antibacterial action. The S. aureus experiment that used the well diffusion approach did, however, reveal a few of inhibitory zones. The dichloromethane extract showed the highest inhibitory zone of 15.33 ± 0.33 mm when tested against S. aureus at a dose of 400 mg/mL, while the hexane extract showed an inhibitory zone of 14.00 ± 2.08 mm. At 200 mg/mL, the dichloromethane extract had an inhibitory zone of 11.00 ± 0.58 mm. Findings indicate that tuberous roots of M. jalapa are anti-inflammatory rather than antibacterial.

Akhtar, Most. Afia. (2022). One of the biggest threats to human health, according to the international community, are inflammatory diseases. There is a long tradition of using medicinal plants in traditional medicine in Bangladesh to treat a variety of illnesses, particularly those involving inflammation. The declared purpose of this project is to document the current level of knowledge on the anti-inflammatory characteristics of medicinal plants with a rich history of use in traditional medicine of Bangladesh. Several preclinical studies with these plants have previously been conducted or are now in the planning stages. The data reported in this research refers to medicinal plants and was gathered via searches of Google Scholar, PubMed, Scopus, Web of Science, and ScienceDirect. The search was limited to papers pertaining to plants that have been researched for their anti-inflammatory qualities and will continue until December 2020. Plant samples were collected in Bangladesh, according to the report. Basic search phrases used were "anti-inflammatory," "Bangladeshi," and "medicinal plants." If a plant fulfilled any one of these three requirements, it was evaluated for inclusion: have been used for a long time to treat inflammatory disorders, including

inflammation itself; 2) shown substantial anti-inflammatory benefits in at least two independent trials; or 3) shown similar or distinct effects in at least two separate investigations. Data on 48 different medicinal plant species used in traditional medicine in Bangladesh for the treatment of inflammatory disorders were gathered in this research. Experimental models that assessed the anti-inflammatory effects of plant samples in vitro and in vivo had their molecular pathways explained. Additional information was provided for a subset of the plants that were evaluated including environmental characteristics, anti-inflammatory studies conducted in countries other than Bangladesh, and, if applicable, active components isolated from these plants. Bangladeshi medicinal plants have strong anti-inflammatory characteristics, which bode well for the development of novel treatments for diseases associated with inflammation. There is still a considerable distance to go before we can create safe and effective pharmaceutical drugs using these discoveries, even if this paper did discuss some initial plant screening. We need to find active compounds, figure out how they work, and test them thoroughly for safety and effectiveness.

Ekarika et al., (2022) The inflammatory response has been associated with a number of diseases. Medications that reduce inflammation are essential for the management and prevention of certain conditions. We need new and stronger anti-inflammatory medications. pharmaceuticals, since the current medicines often result in ineffective therapy or severe adverse effects. For their anti-inflammatory activities, methanol extracts of ten plants—A. conyzoides, A. indica, M. oleifera, A. vera, T. fruticosum, Z. officinale, O. gratissimum, V. amygdalina, C. papaya, and A. sativum—were investigated. The plants were locally obtained.

Niyanta, Sailor et al., (2022) Curcuma longa, a member of the Zingiberaceae family, is the plant from which turmeric is derived. Because of its anti-inflammatory and skin-protective properties, curcumin has gained a lot of fame. For centuries, curcumin has been used by herbalists as a remedy for skin issues and inflammation. The eventual goal of this project is to create a turmeric-based topical anti-inflammatory cream. The herbal cream was manufactured using the primary emulsion procedure. Numerous physiochemical investigations were carried out on the turmeric cream, including investigations into its anti-inflammatory action, homogeneity, spreadability, appearance,

grittiness, viscosity, and pH measurement. Consistent with commercially available turmeric cream, the study's examinations of the physicochemical properties yielded satisfactory findings. Taking everything into account, the data was appropriate and in line with the product description.

Neve, Vrushali et al., (2023) The severe side effects of the available medications meant that many individuals still suffered from inflammation and discomfort even after treatments were available. Ancient healers made extensive use of the wide variety of herbal remedies available today due to their analgesic and anti-inflammatory properties. One of these herbs, Momordica Dioica, has a history of traditional use, although scientific data to support these claims is lacking. This study set out to determine if methanolic extracts of Momordica Dioica fruit exhibited any analgesic or anti-inflammatory effects. Forced to blow away Methanol is used to extract the Momordica Dioica fruit in compliance with OECD guideline version 18. Also, studies on the Momordica Dioica extract's acute oral toxicity in methanol were carried out. The activity-causing active component was found using high-performance thin-layer chromatography (HPTLC). The hot plate method was used to assess the efficacy of analgesia mediated centrally. To assess the ability to reduce inflammation, a carrageenan-induced paw oedema test was used. Momordica dioica's methanolic extract mitigates the ceiling effect that some exercisers experience. The hot plate approach demonstrated a significant analgesic effect (p 0.0001) for the Methanolic Extract of Momordica dioica (MEMD) extract at 100 mg/kg and in all combinations with the standard. The anti-inflammatory effects of the extract were most pronounced two to four hours after carrageenan induction, and they were consistent across all doses tested (p 0.0001, p 0.001). The extract contains a pentacyclic terpenoid known as Ursolic acid, which supports the long-held belief that it possesses anti-inflammatory and analgesic properties.

Riaz, Tahreem et al., (2023) Traditional medicine has long relied on plant extracts, seeds, oils, and fruits to treat a wide range of ailments. Inflammation is a pathogenic process that involves a myriad of cytological and chemical events that cause damage or destruction of tissues. Because of their capacity to suppress inflammatory pathways, enzymes, and cells, medicinal herbs possess anti-inflammatory capabilities.

Evening primrose, Ribesnigrum, Oleaeuropea, Herpagophytum, Elaeagnusangustifolia, Rosa canina, Zingiber officinale, salvia officinale, Borago officinale, Rosmarinus officinale, and cassia fistula are just a few of the plants whose anti-inflammatory mechanisms are researched in this research. Our goal in doing this research was to provide a comprehensive medical strategy for inflammation, one that makes use of anti-inflammatory herbs in addition to modifications in diet and exercise, because there is no known cure for this condition.

Sankararajan, Umadevi et al., (2023) Traditional medicine relies heavily on herbal medicines. Herbal combinations often use botanical components to promote therapeutic alignment. An anti-inflammatory ointment made from Ficus religiosa tree bark using a novel HPTLC technology is the goal of this work. The flavonoid component of the hydroalcoholic extract was separated by means of column chromatography. The mobile phase was made by combining toluene, ethyl acetate, and methanol at a ratio of 4:14:02. When a basic ointment was made from this separation using the fusion procedure, the physicochemical properties of the formulation were found to be within acceptable limits. In the HPTLC investigation, the mobile phase consisted of toluene, ethyl acetate, formic acid, and methanol in the following ratios: 3:3:0.8:0.2. The wavelength of the mobile phase was 280 nm. To test its anti-inflammatory effects, the Carrageenan-induced paw edema method was used to albino mice. An Rf value of 0.89 was recorded for standard quercetin, 0.88 for fractionate quercetin, and 0.86 for simple ointment. The HPTLC method was validated and all parameters were determined to be within acceptable ranges in accordance with the standards set by the ICH. Swelling may be alleviated with only a little of the homemade ointment. The topical formulation successfully decreased inflammation in carrageenan-induced paw edema, in contrast to nonsteroidal anti-inflammatory medications (NSAIDS).

Akhlaq, Muhammad et al., (2023) Inflammation, the result of an immune system reaction, is actually considered a positive phenomenon. The four main symptoms of inflammation are redness, swelling, heat, and pain. For a wide range of medical conditions, people throughout the world rely on herbal remedies. Approximately 7,500 types of plants are used for medicinal purposes; they include variants of over 17,000 species of blooming plants. Despite the continued success of synthetic chemistry, modern

medicine's dependence on natural substances is unparalleled. Several nonsteroidal anti-inflammatory drugs (NSAIDs) block the arachidonic acid-digesting isoform of the cyclooxygenase enzyme, which in turn reduces prostaglandin production and inflammation. Nonsteroidal anti-inflammatory drugs (NSAIDs) have harmful adverse effects. However, certain medicinal herbs contain pharmacological properties that reduce inflammation and are safe to use. This study provides valuable information for aspiring researchers and practitioners looking for anti-inflammatory therapeutic herbs.

Patel, Jaya et al., (2023) Nonsteroidal anti-inflammatory drugs (NSAIDs) are now the go-to for inflammation treatment. One negative aspect of these drugs is the increased risk of blood clots, heart attacks, and strokes. This is why studies are still being conducted to see if natural components can be used to make effective anti-inflammatory drugs. Medications made from plants have the potential to alleviate inflammation and a host of linked health problems. Traditional anti-inflammatory medications now available have a laundry list of side effects. This is why it's critical to look for newer drugs with fewer or no side effects at all. Using carbopol 934 and propylene glycol, this research aimed to generate a polyherbal gel that included hydroalcoholic extracts of three herbs: Berberis aristata root, Rubia cordifolia root, and Boswellia serrata gum. The 32-factorial design of the experiment was repeated nine times. The independent variables included the concentration of carbopol 934 and the propylene glycol penetration enhancer. The dependent variables were viscosity (m.Pas), percentages of in vitro release of berberine, rubiadin, and AKBA, and AKBA itself. By integrating an overlay plot with a desirability technique, a design expert chose the optimal gel. An optimal gel with a viscosity of 39568 m.Pas included 0.48 mg of berberine, 0.42 mg of rubiadin, and 0.51 mg of AKBA. The gel considerably decreased inflammation, according to histopathology and in vivo investigations.

Preeja, R. et al., (2021) The purpose of my study is to identify any anti-inflammatory properties of herbal formulations using mint and green tea. Greetings from everyone around! Green tea, being a "non-fermented" kind, has more catechins than both black and oolong teas. By controlling the expression of their genes and proteins, epigallocatechin 3-gallate and green tea reduce the synthesis of inflammatory enzymes and cytokines. Mint demonstrated potent anti-inflammatory properties in a mouse model

of ear edema produced by croton oil. Steps and Components: Making a medicinal plant remedy: One hundred milliliters of distilled water is mixed with one gram of powdered mint and one gram of tea leaves. The mixture was filtered through filter paper after being heated for around fifteen to twenty minutes. Once again, the mixture was heated until the volume was reduced from 70 ml to 20 ml. The findings demonstrate a 60% inhibition at 20 µl and a 90% inhibition with 50 µl, in contrast to the standard's 40% inhibition. For this reason, the anti-inflammatory effects of the extract are dose-dependent. One important takeaway from this study is that it confirms what many suspected: mint and green tea greatly decrease inflammation. Compared to the 40% inhibition seen with diclofenac sodium, the gold standard, an anti-inhibitory zone of 90-100 degrees is much larger.

Shingala, Zuli et al., (2021) People have been employing plants for a variety of medical issues ever since they were discovered, making them one of the most major sources of medications. Pharmaceuticals produced from traditional medicinal plants have found widespread usage in modern medicine. Inflammation begins as soon as the immune system recognizes a threat. Inflammation is shown primarily by four symptoms: redness, warmth, pain, and swelling. The anti-inflammatory marker chemicals found in medicinal plants are thoroughly reviewed in this paper. To determine if medicinal plants, plant extracts, or pure chemicals are effective in reducing inflammation, it uses in-vitro and in-vivo study models.

Shahrajabian, M. Hesam. (2021). Many illnesses are influenced by an inflammatory response that is not well controlled. Alkaloids, flavonoids, polyphenols, proanthocyanidins, terpenoids, and steroids are the main components of medicinal plants and herbs that have anti-inflammatory activities. Several plants with anti-inflammatory properties are included in this paper. Our primary goal is to provide an explanation of the mechanisms by which the natural components of plants used in traditional Iranian and Chinese herbal therapy may alleviate and even prevent inflammatory disorders. In order to compile this exhaustive literature analysis, we searched databases like and others for studies that discuss the benefits of anti-inflammatory medicinal plants and natural remedies. Herbal treatment uses a broad range of plant components, or a combination of them, to cure sickness, enhance health, and prevent illness completely. Additional study

and clinical trials are necessary to fully understand the role of medicinal plants in the treatment and prevention of inflammatory disorders.

GIRI, MAHENDRA et al., (2019) This study will make and evaluate an anti-inflammatory gel from methanolic extracts of Emblica officinalis and Aegle marmelos fruit. Methods: The gels were made using the following ingredients in the amounts given: distilled water, carbopol 934, methylparaben, propylene glycol 400, MEEOF, and MEAMF. Gradual use of triethanolamine was the next step in maintaining a skin pH in the 6.8 to 7.0 range. The formulations were tested for skin irritation, homogeneity, spreadability, and pH using a rabbit model. To further investigate their anti-inflammatory properties, we used a carrageenan-induced rat paw edema model that utilizes albino Wistar rats weighing 150-200 g, regardless of sex. By measuring the change in edema volume in the backpaw of the rat, we were able to determine the inhibition percentage. To conduct stability evaluations, we referred to the rules established by the ICH. Results showed that the gel was visually appealing, very homogenous, and simple to work with. Viscosity ranges from 4200 to 4500 centipoises. Results from animal studies demonstrated that all of the formulations were gentle on the skin. After 3 hours, formulations F4 and F5 decreased inflammation by 66.66% and 61.66%, respectively, compared to the reference treatment. After 4 hours, the percentage dropped to 59.21% and 63.15%. When kept according to conventional protocols, the material remained stable when applied topically and did not irritate the skin. F4 and F5 were determined to have anti-inflammatory properties that were on par with the gold standard.

Singh, Harjeet et al., (2019) In this work, a herbal gel is prepared and its anti-inflammatory activity is evaluated in vitro using extracts from the stem bark of Mesua ferrea Linn. To make the gels, scientists employed a wide range of polymers and ethanolic extracts. The physiochemical parameters of the formulations were also evaluated, including their spreadability, pH, viscosity, and so on. The presence of alkaloids, flavonoids, and phenols, among others, was discovered via phytochemical study. The ethanolic extracts had a much stronger anti-inflammatory effect than the standard medicine. Developing anti-inflammatory compositions using Mesua ferrea Linn bark extract is a promising area of research.

Malhotra, Hitesh et al., (2019) The purpose of this study was to identify any anti-inflammatory or anti-arthritic characteristics of Eclipta prostrata Linn fractions. Method used: Four components were isolated from the hydro-alcoholic extract: n-butanol, alcohols, chloroform, and n-hexane. After the fractions were tested in vitro, they were tested in vivo using a carrageenan-induced paw edema model, which is a tool for assessing anti-inflammatory effects. The anti-arthritic effect of two active fractions was also assessed using a model of arthritis generated by formaldehyde. Results showed that both the chloroform and ethyl acetate fractions had anti-inflammatory effects at 100 and 200 mg/kg, with the former showing the greatest promise. Consequently, their anti-arthritic potential is being investigated further, and the findings are encouraging. According to the results, the chloroform and ethyl acetate fractions possess significant anti-arthritic characteristics.

Yatoo, Dr. Mohammad (2018) There has been a significant uptick in the incidence of illnesses with an inflammatory origin. Drugs used to treat inflammatory illnesses not only alleviate symptoms, but they also prevent potentially lethal consequences. Not to mention that they aren't exactly inexpensive and aren't always easy to come by. Here is where a new century has been ushered in for the treatment and prevention of inflammatory disorders via the area of medicinal herb research and development. Bringing focus to the anti-inflammatory therapy options available, including both natural and manufactured drugs, as well as their components, action mechanisms, benefits, and potential drawbacks. Improving health care for all people, regardless of their socioeconomic condition, should be the fundamental priority. There has been encouraging evidence that herbs may reduce inflammatory responses, which can lead to major systemic abnormalities. It is crucial to intervene early on to bring inflammation under control, since it may cause pathological effects if left unchecked or untreated. Inflammation is a defensive response to injury or infection. Beneficial aspects of medicinal plants or their constituents include being more accessible, less costly, having fewer or no negative effects, being safer, and more efficient than synthetic equivalents. In order to avoid inflammation and its negative impacts, it is helpful to consume medicinal plants that contain phytoconstituents that have anti-inflammatory and anti-inflammatory characteristics. Phytoconstituents extracted from these plants may include glycosides, flavonoids, alkaloids, polysaccharides, terpenoids, cannabinoids,

fatty acids, and steroid hormones. The anti-inflammatory activities of these active compounds have been investigated via several areas of investigation. Lipooxygenases, cyclooxygenases, interleukins, prostaglandins, nitric oxide, mitogen-activated protein, nuclear factor, and countless more are just a few of the inflammatory factors and proteins that they may work in tandem with or against. In light of the above, more investigation into the molecular and cellular levels is necessary to comprehend the whole mechanism. You may find anti-inflammatory characteristics in many common herbal plants, such as Curcuma longa, Zingiber officinale, Rosmarinus officinalis, Borago officinalis, Urtica dioica, Uncaria tomentosa, Vaccinium myrtillus, Olea europaea, and countless more. Some people think they're a better way to manage inflammatory crises than chemical or synthetic steroids, nonsteroid anti-inflammatory medicines, immunosuppressants, and related therapies. They may be used safely and effectively in inflammatory situations after a thorough phytochemical, pharmacological, and physiological trial. Alternative herbal remedies and anti-inflammatory medications are now being considered for patenting. In terms of lowering inflammation, plant-based herbal medicines outperform synthetic counterparts and are safer to use. Because of their comparable mechanism of action, phytoconstituents are just as effective as synthetic chemicals. The many medicinal uses of these plants for various disorders need more investigation into the molecular processes behind them. Recent patents relevant to anti-inflammatory medications and medicinal plants are examined in this article to provide insight into the present and future of this field.

Seervi, Kishan et al., (2018) Herbal remedies are more popular than synthetic ones because of the widespread belief that they are safer and have fewer negative effects. A growing number of individuals are seeking out natural cures. Various rheumatic diseases account for the vast majority of inflammatory illnesses experienced by people of working age across the globe. It has been called the "King of human misery" by certain descriptions. This research focuses on a poly-herbal anti-inflammatory formulation that includes alcoholic extracts of Vinex negundo leaves, Boswellia serrata, Berberis aristata, and wintergreen oil. Distilled water, propylene glycol 400, triethanolamine, propyl paraben, and methyl paraben were all added to the mixture at a concentration of 1% w/v to create the gel. Variations in extract content were used for the three formulations (F1–F3). The efficacy of the anti-inflammatory was evaluated by means of the carageenan-

induced paw edema model in rats. consistency, color, pH, and spreadability of the three formulations (F1-F3). It was found that the F3 formulation has all of the ideal parameters.

Ghasemian, Mona et al., (2016) Herbal supplements made from plants with therapeutic secondary metabolites are helping with more and more medical issues. Inflammation is a pathologic condition that is associated with many diseases and health problems. This includes a wide range of conditions, such as autoimmune diseases, diabetes, cardiovascular accidents, rheumatic problems, and many more. Below, we provide the results of clinical and experimental studies that evaluated the anti-inflammatory characteristics of several plants. This review presents a variety of medicinal plants, including evening primrose, Devil's claw, Zingiber officinale, Rosmarinus officinalis, Borago officinalis, and Curcuma longa, among others. This research examines several methods for reducing inflammation, including lifestyle modifications and herbal medications, as there is currently no one-size-fits-all solution.

Perumal, Rajalakshmi et al., (2016) A variety of herbs have been used in Siddha formulations, such as cardamom, ginger, arrowroot, yew leaves, pepper, clove, Indian rose chestnut, and Abies webbiana (D. Don) Spach. Herbal treatments such as these helped with a wide variety of symptoms, including lack of appetite, indigestion, gastric reflex, hiccups, flatulence, itching, scabies, cold, cough, headache, and joint difficulties. Although these herbal treatments are used to treating arthritis, there is a dearth of scientific data about how they work. The present study aimed to assess the antioxidant and anti-inflammatory properties of many herbal drugs in vitro in order to give scientific evidence for their anti-arthritic impact. In 2016, the International Journal of Pharmacognosy and Phytochemical Research published this work.

Thelingwani, Roslyn et al., (2015) Concerns over the safety and effectiveness of herbal therapy are particularly prevalent in underdeveloped countries. The World Health Organization reports that a significant portion of Africa's population uses herbal remedies to treat various medical issues. When there's a good chance of combining herbal and conventional therapies, it's crucial to do basic safety assessments for each. Even if antiretrovirals are becoming increasingly efficient in treating HIV/AIDS, this is particularly important in an area where herbal treatments are often used, such as Africa.

Research and development of herbal therapies may be approached in a similar manner to that of conventional pharmaceuticals. These evaluations will increase the worth of herbal remedies by assisting doctors and patients in making better informed judgments on the combination of herbal remedies with pharmaceuticals. Government agencies responsible for monitoring drug usage, such as the Food and Drug Administration (FDA) and the European Medicines Agency (EMA), may also utilize this information to set guidelines. When assessing herbal medicines for potential drug-drug interactions (DDIs), the standards established by the FDA and EMA for DDIs might equally apply to DHIs, which concern the adverse drug and medical effect (ADME) of pharmaceuticals. We present the present status of DHI and propose future research options that may lead to safer utilization of herbal medicines in this review.

Shaikh, Dr. Rafik et al., (2015) Using in vitro and in vivo models, the researchers in this study aimed to investigate the efficacy of several herbs used in traditional Indian medicine in lowering inflammation. Using water, ethanol, and hexane as solvents, the antioxidant and COX-1 and 2 inhibitory activities of plant samples from Terminalia bellarica, Cissus quadrangularis, Plumbago zeylanica, and Terminalia chebula were evaluated in vitro. A mouse model of edema generated by carrageenan and phorbol myristate acetate (PMA) was used to investigate the in vivo anti-inflammatory effects of samples that showed promise in inhibiting COX-2. The majority of plants inhibited COX-2 rather than COX-1, according to the findings. Extracts from T.bellarica (73.34%) and T.chebula (74.81%) showed significantly higher levels of COX-2 specific inhibition compared to the other samples. The chosen plants' ethanol fractions were able to neutralize DPPH, OH, and superoxide radicals with remarkable effectiveness. An in vivo anti-inflammatory investigation revealed that both T.bellarica and T.chebulla significantly reduced the production of edema. The ethanolic percentage of the chosen medicinal plants did not impact cell viability in cytotoxicity assays. An HPTLC fingerprint of the flavonoids was also developed to guarantee the good quality of the samples. Efforts to standardize the selected botanicals could benefit from the results. Furthermore, the selected plants may hold the key to developing novel COX-2 suppressing anti-inflammatory medications.

Shaikh, Dr. Rafik et al., (2014) Aiming to identify any anti-inflammatory, antioxidant, or anti-cancer characteristics in several medicinal plants used in traditional Indian medicine was the primary objective of this research. There was an in vitro evaluation of the antioxidant and anticancer characteristics of botanical extracts from various families. The Miliaceae family's Soymida fembrifuga (Roxb.) A. Juss., the Menispermaceae family's Tinospora cordifolia, the Lamiaceae family's Lavandula bipinnata, and the Sterculiaceae family's Helicteres isora were involved. The results indicated that the chosen cancer cells, including HeLa-B75 (34.21 ± 0.24%), HL-60 (30.25 ± 1.36%), HEP-3B (25.36 ± 1.78%), and PN-15 (29.21 ± 0.52%), were significantly affected by the cytotoxic effects of H. isora. The most notable enzyme associated with inflammation, cyclooxygenase-1 (COX-1), was not inhibited by the chosen botanicals; instead, they specifically inhibited cyclooxygenase-2 (COX-2). There was an inhibitory range of 3.93–19.61% for COX-1 and 19.66–49.52% for COX-2. Research on antioxidants indicated that the chosen plants were effective in neutralizing hydroxyl (OH), superoxide (SOR), and 1,1-diphenyl-2-picrylhydrazyl (DPPH) radicals. Flavonoid fingerprinting utilizing high-performance thin-layer chromatography (HPTLC) was used to control the quality of selected plant samples. New antioxidant, anti-inflammatory, and anticancer medications may be discovered using the selected plants, according to the present results.

Amutha, Arul et al., (2014) So that we may learn more about Foeniculum vulgare's analgesic and anti-inflammatory effects. Doses of 50, 100, and 200 mg/kg of an ethanolic extract of Foeniculum vulgare were tested in Swiss Albino mice and Wistar rats to determine its analgesic and anti-inflammatory properties. Albino rats and albino mice were studied to determine the effects of analgesia using the formalin test and the writhing test, respectively. By inducing edema in the hind paws of rats using carrageenan, we examined the anti-inflammatory effects of the ethanolic Foeniculum vulgare extract. A substantial decrease in the pain response to acetic acid and formalin tests was seen when 50, 100, and 200 mgm/kg of the ethanolic extract of Foeniculum vulgare was administered intraperitoneally ($p<0.001$). Foeniculum vulgare demonstrated a dose-dependent inhibition of edema production in inflammation produced by carrageenan, indicating a substantial anti-inflammatory effect ($P < 0.001$). The efficacy of the ethanolic Foeniculum vulgare extract was comparable to that of the most effective

pharmaceuticals. The ethanolic extract of Foeniculum vulgare may have anti-inflammatory and analgesic properties, according to this study. Both cerebral and peripheral routes may have an impact on these outcomes. The results suggest that the extract might be useful in the treatment of inflammatory and painful diseases.

Murugesan, Dharuna et al., (2014) In order to find new medicines, it is necessary to investigate medicinal plants. People seek healing from a wide range of medical conditions by using medicinal herbs. Worldwide, there is a great deal of interest in the search for new, safe phytochemical compound medicines. A small number of medicinal plants have shown promise in scientific trials. Nonsteroidal anti-inflammatory drugs (NSAIDs) and similar treatments alleviate inflammation-related swelling and pain. The liver, the gastrointestinal tract, and other human biological systems are vulnerable to the long-term effects of nonsteroidal anti-inflammatory drugs (NSAIDs). Multiple medicinal plants have shown anti-inflammatory properties. This study examined the anti-inflammatory effects of several medicinal herbs.

Nagarkar, Bhagyashri et al., (2013) There is a long tradition of using medicinal plants to treat a variety of illnesses, particularly those associated with inflammation. The species listed below are all part of this category: The following species are mentioned by the writers: This is due to the fact that each of these plants serves a distinct function in the treatment of various ailments. We opted to examine these herbs since nobody has previously looked at their anti-inflammatory properties together and just a few of them have been studied individually. We used the in vivo Carrageenan produced rat paw edema paradigm to successfully administer root water decoctions orally. Their actions may be responsible for Dashamoola's ability to reduce inflammation.

Chandra, Sangita et al., (2012) Ashwagandha, whose scientific name is Withania somnifera, has a long and storied history of use in traditional Indian medicine. So, we decided to see whether ashwagandha hydroalcoholic extract might stop in vitro protein denaturation and inflammation. The test extract was tested for its absorbance and viscosity after being incubated with egg albumin at various concentrations in a controlled laboratory environment to assess its anti-inflammatory capabilities. Diclofenac sodium was the medication used as a benchmark. Conclusion: The present results demonstrated

that the ashwagandha extract's ability to inhibit protein denaturation was concentration dependant. Diclofenac sodium was shown to be less effective than the test extract. These findings provide further evidence that ashwagandha inhibits inflammation-induced protein denaturation in vitro. The effects were probably caused by the ashwagandha's alkaloids and withanolides.

Agbaje, E et al., (2012) Although other mediators also showed significant inhibitory effects, the serotonin model had the lowest proportion at 42.8%. The phytochemical analysis uncovered cardiac glycosides, flavonoids, anthraquinones, and tannins. Zinc, copper, manganese, lead, and chromium are among of the elemental components that have been linked to anti-inflammatory properties in the water-based SPH extract. Although 2 g/kg of SPH administered orally did not result in mortality, the median lethal dose administered intravenously was 39.81 mg/kg, with lead presumably playing a role in the observed toxicity. A pH of 6.7 was measured for the herbal remedy. Our findings provide support to the local use of SPH for the treatment of acute and subacute inflammatory illnesses, and they also point to possible pathways via which SPH exerts its anti-inflammatory effects. Last but not least, be careful while taking the herbal cure since it might have harmful side effects. Importance in the context of business: Traditional medicine has a long tradition of using herbal treatments. utilized to treat inflammatory reactions among many other diseases. These alleged benefits are due to the phytoconstituents that are present in natural medications. As a result of this study, the pharmaceutical industry will be able to create new anti-inflammatory drugs that are more widely available, cheaper, and safer than existing ones.

Usmanghani, Khan et al., (2011) When it comes to treating RA, this research contrasted the efficacy of Methotrexate with that of Arthritin, a coded herbal medicine. Half of the RA patients in each group were chosen at random to take part. In contrast to the test group, which received Arthritin, the control group received Methotrexate. Before and after patients began taking the two drugs, we examined their impact on RA. There were significant differences between the test and control groups when the physicians' data for these parameters were compared ($p<0.05$). Arthritin, the medicine that was tested, has a better efficacy, and the p-value is a pitiful 0.03. Methotrexate is less effective than Arthritin in treating rheumatoid arthritis.

Yousif, Miriam et al., (2011) We developed, described, and conducted phytochemical and biological evaluations of two herbal gels with the hope that they would have a topical anti-inflammatory effect. Qarad, a tannin extract from Acacia nilotica Del. fruits, and G, a tannin extract from Quercus infectoria Oliv. galls, were chosen as the active components. Powdered medication total polyphenol content was evaluated using colorimetric methods. The samples that were studied were each given a 50% aqueous methanol extract and then added to PVA hydrogels at concentrations ranging from 0.5 to 2 mg/ml. In order to standardize the extracts using HPLC and determine the drug concentration in the hydrogels, gallic acid was used as a marker. The inhibitory impact of the hydrogels and extracts on xylene-induced ear edema in mice was used to determine the anti-inflammatory effectiveness.

Umar, Muhammad et al., (2010) The article summarizes current research on the topic of herbal extracts' anti-inflammatory properties, focusing on the many experimental paradigms that are often used to evaluate the anti-inflammatory effects of herbal ingredients in living organisms. The anti-nociceptive potential of plant extracts is often evaluated using the hot plate method and the formalin or acetic acid induced writhing test. It is common practice to use oedema, granuloma, and arthritis models to assess the anti-inflammatory efficacy of these extracts. The very efficient adjuvant-induced and collagen-induced arthritis models have not been extensively used to assess the anti-inflammatory effects of herbs. A double-positive reference model should contain steroids and non-steroidal anti-inflammatory drugs (NSAIDs) to avoid bias.

Sen, Saikat et al., (2010) Research into therapeutic plants via traditional medicine practices has lately attracted a great deal of attention from researchers throughout the globe. Our earth is blessed with an abundance of medicinal plants. These plants have been revered for centuries as a valuable resource for treating and preventing various illnesses. Inflammation is a complicated biological reaction of vascular tissue to many damaging stimuli, and pain is a signal of discomfort that may accompany inflammation as a consequence of current or prospective damage to the body. Diseases such as rheumatism, encephalitis, pneumonia, oesophagitis, cancer, heart issues, fibrosis, and many more are linked to inflammation and discomfort. Opioid analgesics and nonsteroidal anti-inflammatory medications are often prescribed to alleviate pain and

inflammation, but they come with a laundry list of side effects. Consequently, herbal medications may provide an alternative. Every year, a large number of plants with potential anti-inflammatory or analgesic properties undergo clinical trials; yet, only a small fraction of these plants really make it into mainstream medicine. Research based on natural sources should thus take center stage. We need to learn more about active phytoconstituents, apply them to targeted treatments, identify any side effects, and ultimately harness their therapeutic potential.

Mohammed, Asad et al., (2007) The origins of rheumatoid arthritis, a chronic illness affecting several systems, remain a mystery. Unpredictably, it strikes healthy adults, mainly those in their twenties and thirties. Ayurvedic practitioners use sudard to alleviate the swelling and discomfort of inflammatory conditions including osteoarthritis, rheumatoid arthritis, frozen shoulder, sciatica, ankylosing spondylitis, and chronic backache. We set out to determine sudard's efficacy using a variety of animal models, including those that induce acute inflammation with formalin (2% v/v), polyarthritis with carrageen (1% v/v), Subacute inflammation, arthritis brought on by adjuvants, sponge implantation, and Eddy's hot plate approach for analgesia. The animal models that were studied showed promising analgesic, anti-inflammatory, and anti-arthritic effects for the sudard formulation.

RESEARCH GAP

Despite the growing interest in herbal medicines for their anti-inflammatory properties, significant research gaps remain in their scientific validation, mechanisms of action, and clinical efficacy. Many traditional herbal remedies have been used for centuries based on empirical knowledge, but there is limited high-quality clinical evidence to support their widespread medical use. The bioactive compounds responsible for anti-inflammatory effects in many herbs are not fully characterized, and their interactions with cellular pathways require further investigation. Additionally, variations in plant species, extraction methods, and dosages create inconsistencies in efficacy and safety profiles. Moreover, potential herb-drug interactions and long-term safety concerns are not well understood, posing risks for patients using herbal remedies alongside conventional treatments. Standardization and regulatory approval of herbal medicines also present challenges due to the lack of uniform guidelines across different countries.

Addressing these research gaps through rigorous pharmacological studies, well-designed clinical trials, and regulatory frameworks is essential to ensure the safe and effective integration of herbal medicines into modern healthcare for managing inflammation-related conditions.

Chapter 3

MATERIALS AND METHODS

3.1 MATERIALS

3.1.1 Equipment's and glass wares

The glassware used was entirely composed of borosil. The glassware washed with water and rinsed with distilled water after being soaked in a 1% soap solution for 30 minutes before to use in the research. Sterilization of glassware was performed in accordance with standard operating procedure.

We used EDTA tubes, syringes from Dispo Van, centrifuge tubes from Tarson, micro pipettes from Ependorf with capacities of 2-20 µL, 10-100 µL, and 100-1000 µL, as well as 15 mL and 50 mL tubes.

3.1.2 Chemicals

Himedia Laboratories supplied the dextrose, sodium citrate, citric acid, and sodium chloride. Analytical grade methanol and diethyl ether were sourced from Renchem in India.

Nectar Drugs Pvt. Ltd. of Mumbai and Alembic Pharmaceuticals of Vadodara provided the diclofenac sodium and etodolac, respectively, as free samples. We sourced carrageenan from Mumbai-based HiMedia Laboratories Pvt. Ltd.

3.1.3 Instrumentations

Rotary Evaporater ((RV 10 auto V, IKA, Germany)

Centrifuge (REMI; R-8C, India)

Water bath (REMI, India)

Cooling Centrifuge (Centrifuge 5424 R, Eppendrof, Germany)

Sonicator (Equitron)

Analytical balance (shimadzu,Japan)

Microscope (LEICA DM1000 LED, Germany)

UV- Visible Spectrophotometer (UV 1800, Simadzu Corp., Japan)

Gas chromatography–mass spectrometry (GC–MS/MS) System, Version 4, Shimadzu, Japan; High Performance Thin Layer Chromatography (HPTLC) (Camag, Switzerland, Wincats software).

Deep freez (-20°c) (Remi, India)

3.1.4. Plant Materials

The powders of Ginger, Triphala, Guggulu, and Guduchi were procured from the Ayurvedic shop Dhanvantri in Indore. The ginger rhizomes were sourced from Lakshmi Nagar Local Market, Indore.

3.2 CHEMICALS

Carrageenan, Standard drug Etodolac, Diclofenac sodium

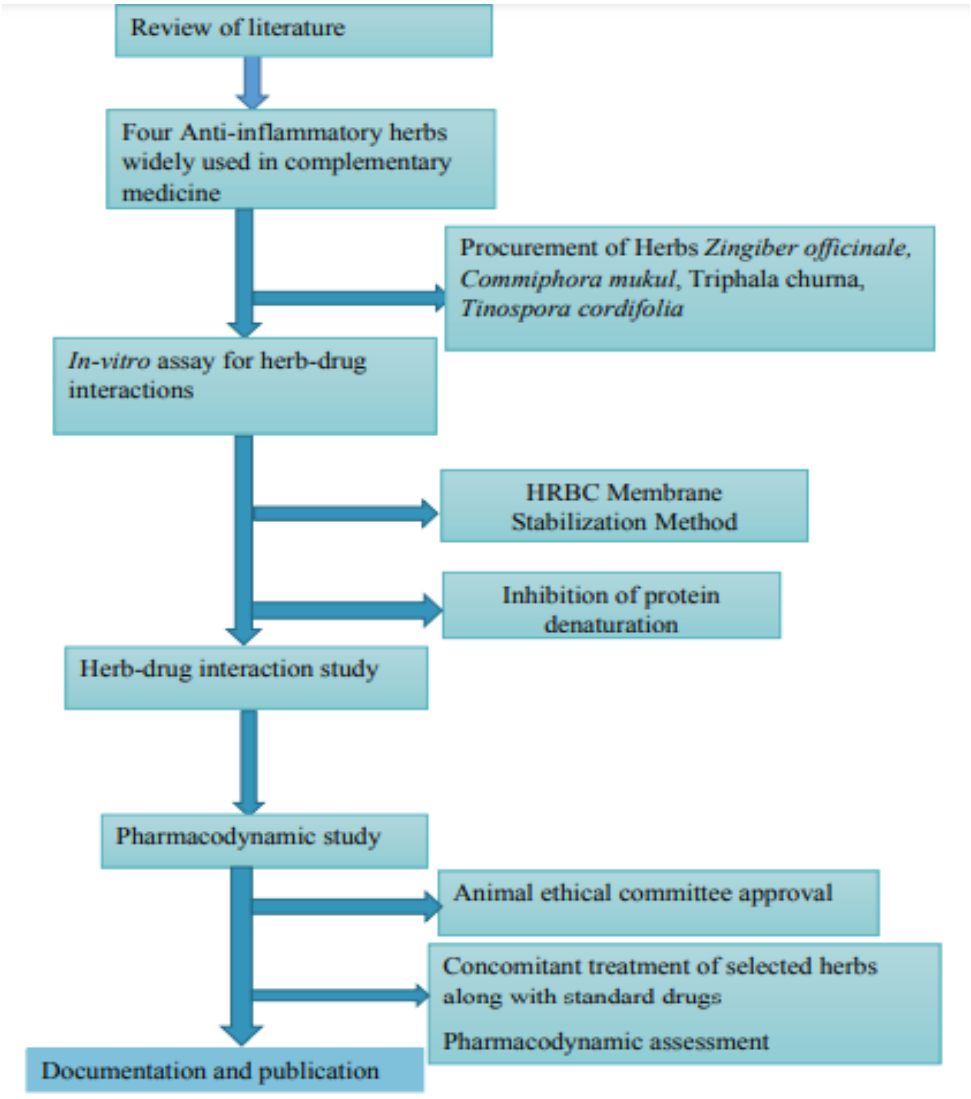


FIGURE 3. 1 Flow chart of overall experimental study design.

3.3 STANDARDIZATION OF HERBS:

3.3.1 Organoleptic evaluation:

Color Determination

We took the untreated medication part and looked at its color in the daylight.

Identification of the Odor

A little bit of the drug was swallowed, and the air containing it was breathed slowly and again as the odor was noted.

Determination of Taste

The medicine's taste was evaluated by placing a little bit on the tongue.

The following factors are being considered: sum of ash, ash insoluble in acids, water and alcohol solubility, and extractive values.

3.3.2 Powder microscopy:

To identify the starch grains in the sample, we created an unstained slide and an iodine-stained slide after treating the drug powder with phloroglucinol and adding a drop of strong hydrochloric acid (1:1) to stain the lignified components.

3.3.3 Physicochemical parameters

Determination of Ash

When anything is burnt, what's left behind are the ash particles. There are three methods to find out how much ash—total ash, acid-insoluble ash, and water-soluble ash—remains after burning herbs.

Looking at the ash value of crude medicine is one way to establish its grade and purity. The existence of impurities including silicate, carbonate, and oxalate is suggested. It is possible to approximate the concentration of inorganic compounds in pharmaceuticals by using the water-soluble ash. Indicative of contamination with earth material, the acid insoluble ash is mostly composed of silica.

To prevent the formation of microorganisms including yeast, bacterium, and fungus, pharmaceuticals should have a very low moisture content while stored. One way to find out how much active ingredient is in a certain quantity of plant material when

extracted with a specific solvent is to estimate the extractive values. It also shows if the raw medicine is running low (Bele A et al., 2011). The following parameters were measured: total ash, soluble ash in water, insoluble ash in acid, sulphated ash, and loss on drying, in accordance with the procedure prescribed in the Indian Pharmacopoeia. (Anonymous, 1966;1985;1996;2007 and WHO.).

Determination of Total Ash:

In a previously fired and weighed silica crucible, about 2 grams of the medicinal plants were precisely measured. A thin, uniform coating of the medication powder was distributed over the base of the crucible. The crucible was burned at a temperature of no more than 450°C until it was carbon-free. To acquire the constant weight, the technique was repeated. The figures are shown in (Table-1) as a percentage of the total ash, with regard to the air-dried medication.

Determination of Water-Soluble Ash:

The ash was collected and blended with 25 cc of water using the procedure for estimating total ash. A further five minutes were spent heating the mixture. The ash-free filter paper was rinsed with hot water to remove the insoluble material. After transferring the insoluble ash to a weighted silica crucible, it was burnt for 15 minutes at a temperature that could not go over 450°C.

The procedure was carried out again and again until the weight did not change. There was a reduction in the overall ash weight after the removal of insoluble components. As the ash's solubility in water was specified, the mass difference was calculated. By consulting the air-dried medication (Table-1), the quantity of water-soluble ash was ascertained.

Finding Acid-Insoluble Ash:

To get 25 milliliters of 2M hydrochloric acid, boil it for 5 minutes with the ash you got using the whole ash method. The insoluble ash was gently transferred onto filter paper that did not contain any ash after a thorough rinsing with hot water.

The previously measured silica crucible was filled with the insoluble ash before it was burnt. Once it had cooled in a desiccator, the weight was taken. The method was repeated until the weight remained constant. Using the air-dried medicine as a reference,

the percentage of acid insoluble ash was calculated, and the findings are shown in Table-1.

3.4 EXTRACTIVE VALUE

When the drug's ingredient cannot be easily assessed by conventional methods, extractive plant material value is beneficial for assessment. The chemical components and type of the substances contained in the crude medication are indicated by these numbers, which are also indicative of their approximate measures. It is possible to dissolve significant amounts of the target material in the solvent used for extraction.

- Ethanol soluble extractive
- Methanol soluble extractive
- Water soluble extractive

3.4.1 Ethanol soluble extractive:

Five grams of coarsely crushed herbs were macerated in one hundred milliliters of ethanol in a sealed flask for twenty-four hours while being shaken frequently for six hours. The next step was to let the mixture sit for 18 hours.

During the rapid filtering procedure, great care was taken to avoid solvent loss. The filtrate was dried at 105˚C after a quarter of a milliliter had evaporated in a shallow dish with a tarred bottom until it attained a constant weight. Table 2 shows the proportion of the air-dried medication that is soluble in petroleum ether.

3.4.2 Water-Soluble Extractive:

After being air-dried and finely powdered, a 5g sample of the medicine was macerated in a sealed flask containing 100 mL of chloroform water for a duration of 24 hours. After 6 hours of frequent shaking, the flask was left to stand for another 18 hours. It was filtered quickly to prevent solvent loss.

3.5 LOSS ON DRYING

Finding the relative humidity is what it's designed for. On an air-dried basis, the proportion of active chemical components in crude medications is given. Knowing and controlling the drug's moisture content is, hence, essential.

In order to keep crude pharmaceuticals from breaking down owing to chemical changes or microbiological contamination, it is important to keep their moisture content to a minimum.

Two grams of herb powder was put on a tarred dish and dried for one hour in an oven set at 105°C.

It underwent a second weighing after being dried in a desiccator. Table 2 shows the values of the drying loss as a function of the amount of air-dried medication.

3.6 PRELIMINARY PHYTOCHEMICAL ANALYSIS

The purpose of its design is to determine the relative humidity. The percentage of active chemical components in crude pharmaceuticals is provided on an air-dried basis. Therefore, it is crucial to know and regulate the drug's moisture content. Reducing the moisture content of crude medicines is crucial to prevent their degradation due to chemical changes or microbiological contamination.

Two grams of herb powder was put on a tarred dish and dried for one hour in an oven set at 105°C. It underwent a second weighing after being dried in a desiccator. Table 2 shows the values of the drying loss as a function of the amount of air-dried medication.

3.7 PREPARATION OF PLANT EXTRACTS:

Using a rotary shaker set to 100 RPM, 100 g of dry powder from each crude drug was macerated for 20 hours with intermittent shaking. Then, 100 g of powder was macerated for 6 hours with methanol : water (70 : 30) using the same procedure. Using the same solvent, this procedure was carried out three times.

After filtration, the hydro-methanolic and methanolic extracts were mixed, and the solvent was removed by means of a vacuum-operated rotating evaporator. We kept the dried extracts at 4 degrees Celsius.

3.7.1 Qualitative Phytochemical screening of methanolic extract of Plants

A battery of qualitative chemical tests was run on all of the macerated extracts to determine the presence of several phytochemicals, including alkaloids, carbohydrates, phenolics, tannins, steroids, flavonoids, saponins, and resins.

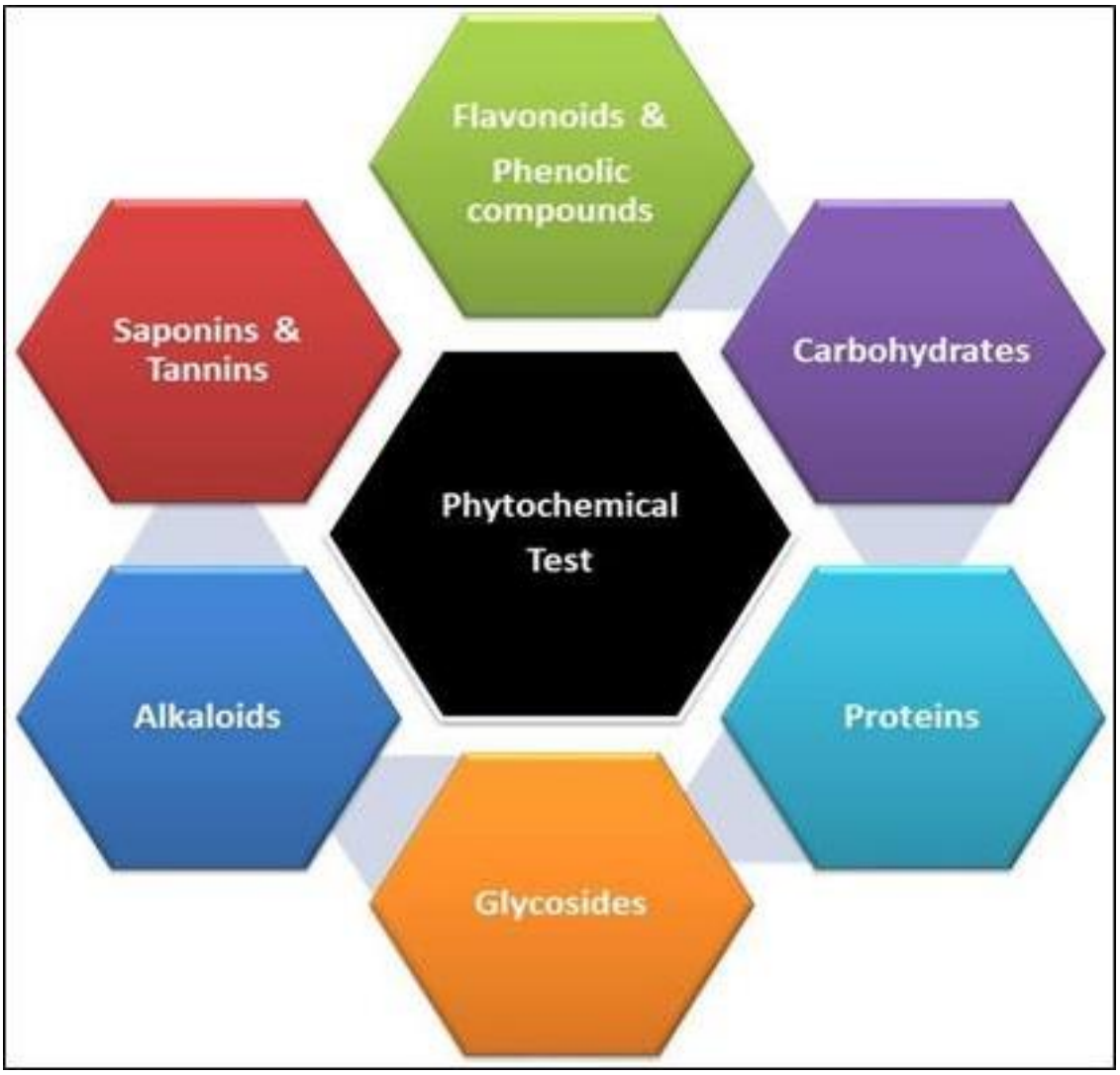


FIGURE 3. 2 List of phytochemical tests

Test For Carbohydrates

Molisch's test (General test)

Before adding concentrated H2SO4 from the edges of the tube, the extracts were combined with 2-3 mL of the test tube, stirred, and a few drops of alcoholic α-naphthol. At the point where the two liquids met, a violet ring could be seen.

Fehling's Test:

One milliliter of MeOH extract, one milliliter of Fehling's A solution, and one milliliter of Fehling's B solution were combined in a test tube and subjected to a 10-minute heating in a water bath. The presence of reducing sugar is indicated by the formation of red precipitate.

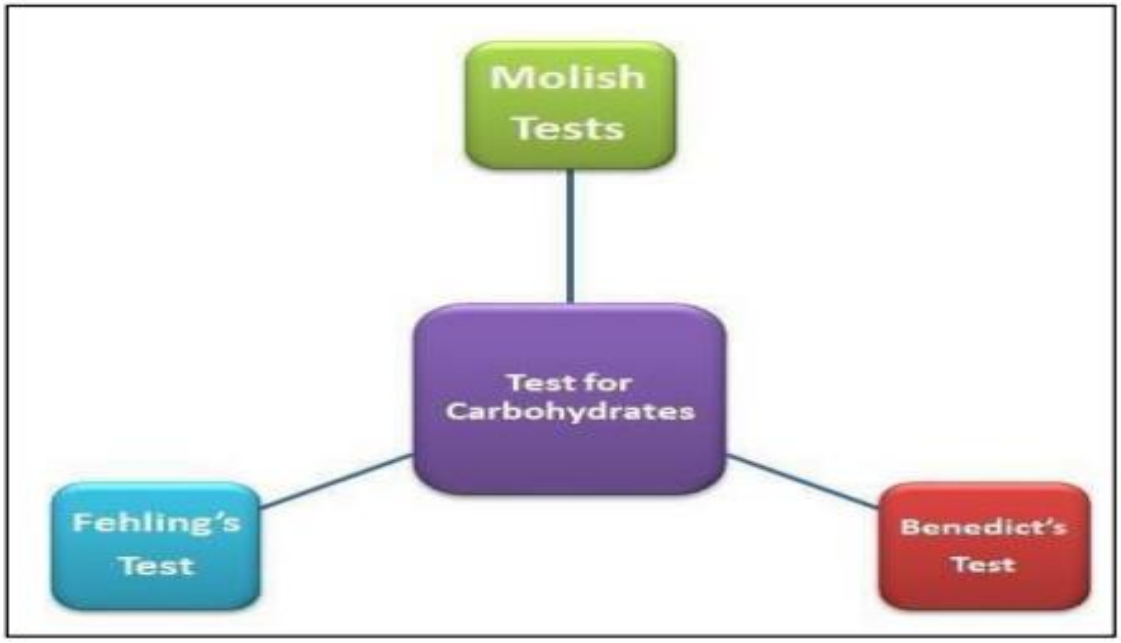


FIGURE 3. 3 Identify carbs

Benedict's test:

After the extract and Benedict's reagent were combined in equal amounts in a test tube, the mixture was heated in a water bath for 5-10 minutes. The quantity of reducing sugar in the test solution determines its hue, which might be green, yellow, or red.

Tests For Phytosterols Salkowski Test

After being treated with chloroform, the extracts were filtered. The filtrate was then mixed with 2 milliliters of highly concentrated H2SO4. Steroids were detected by shake-well analysis with a red chloroform layer and a greenish yellow acid layer fluorescence.

Libermann-Burchard test

After being treated with chloroform, the extracts were filtered. To the filtrate, add 1-2 milliliters of strong hydrochloric acid and 2 drops of acetic anhydride.

As you work your way down the test tube, you should see the color shift from red to blue to green.

Tests For Alkaloids Dragendroff's test

A solution of potassium bismuth iodide, known as Dragendorff's reagent, was added to the filtrates. When an orange precipitate formed, it meant that alkaloids were present.

Mayer's test

The extracts underwent treatment with potassium mercuric iodide, often known as Mayer's reagent. The existence of an alkaloid was confirmed by the production of a cream-colored precipitate.

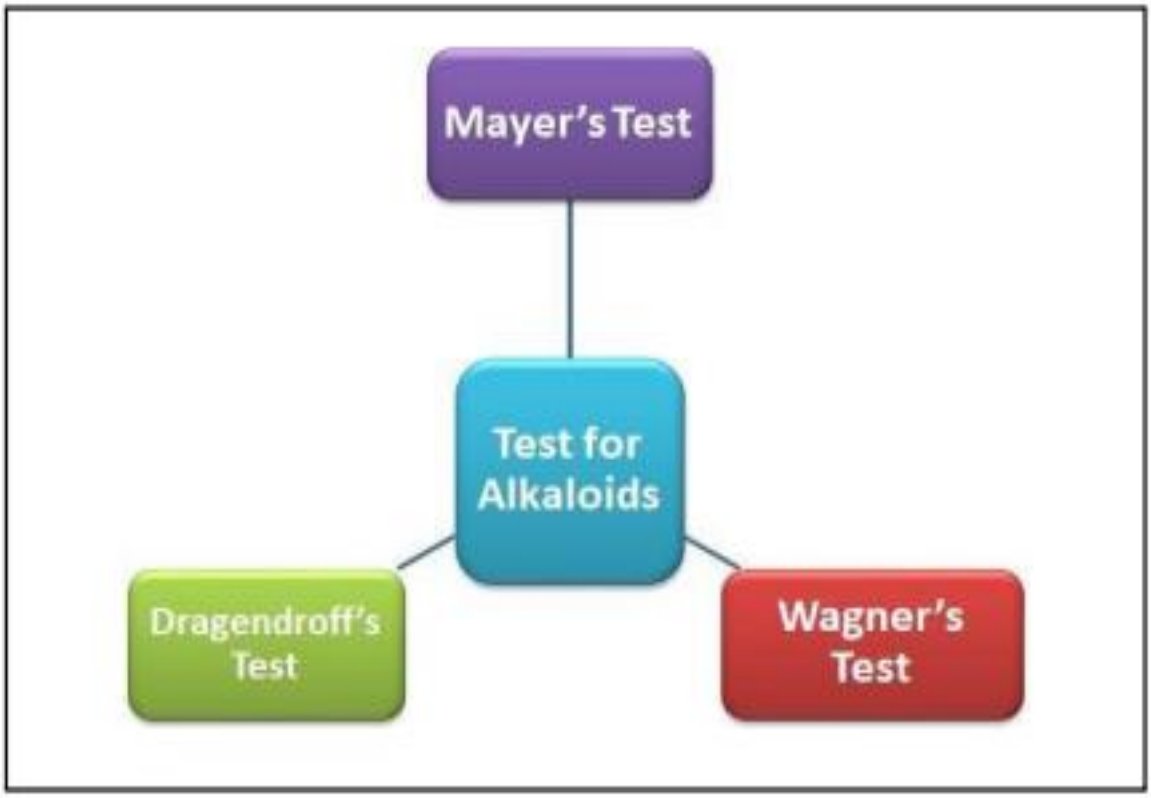


FIGURE 3. 4 Test for Alkaloids

Wagner's test:

In a test tube, about 2-3 milliliters of filtrate were combined with a few drops of Wagner's reagent. The presence of a reddish-brown precipitate is a telltale sign of alkaloids.

Tests For Phenolic Compounds and Tannins Ferric Chloride Test

The extract was supplemented with a little quantity of a ferric chloride solution that was neutral and had a concentration of 5%. It was determined that phenolic nucleus was present when a blue black coloration was formed.

Gelatin solution Test

An 1% sodium chloride gelatin solution was added to the extract. The presence of tannins was confirmed by the production of a white precipitate.

Lead Acetate test

A little quantity of distilled water was used to dissolve the extract. A little quantity of lead acetate solution was added to this mixture. Phenolic compounds are present when a white precipitate occurs.

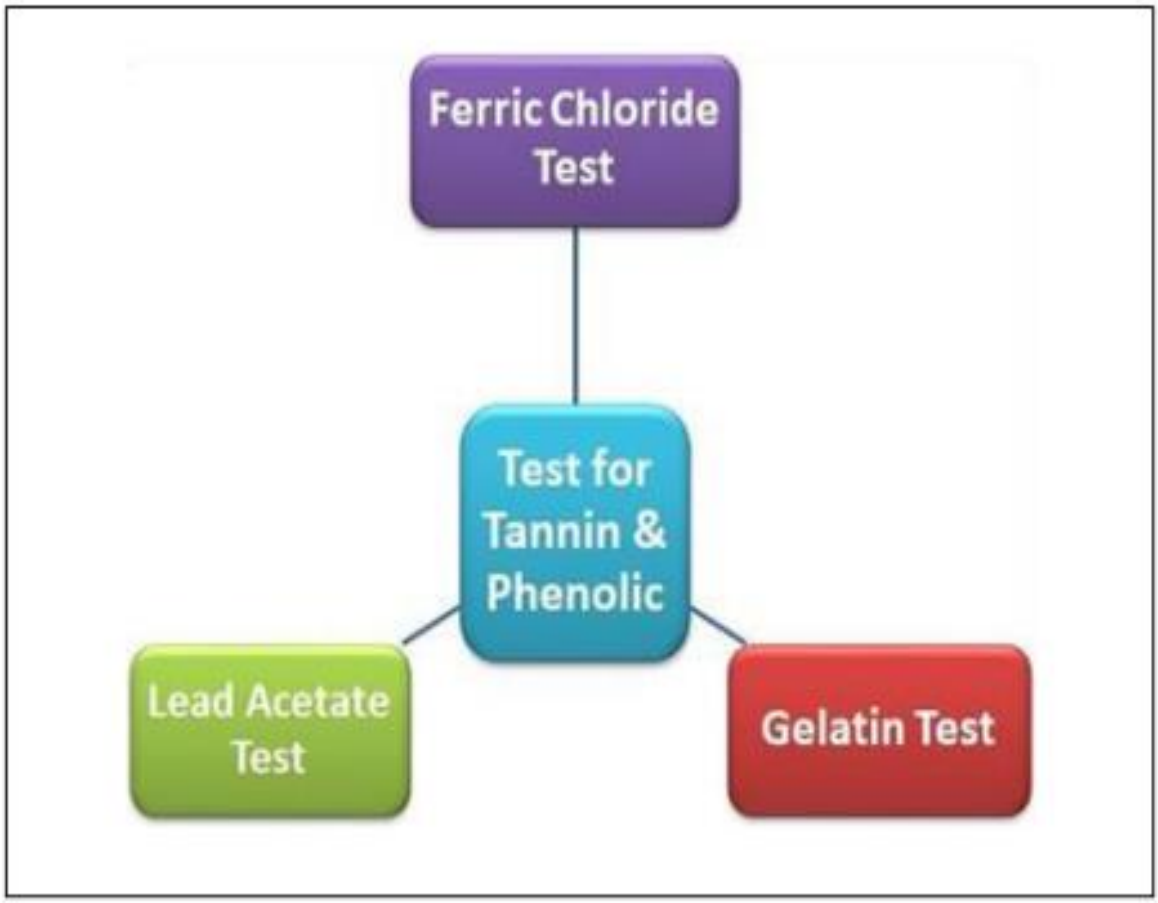


FIGURE 3. 5 Analysis for phenolic and tannin compounds

Saponin Glycoside Testing

As a foam test, the extracts were mixed with water and shaken forcefully. Foam that did not disappear was noted

Tests For Flavonoids Shinoda Test

A little amount of magnesium metal particles was added to the extracts before they were subjected to a slow but steady treatment with strong hydrochloric acid. The presence of flavonoids was confirmed by the creation of a magenta-pink tint.

Lead acetate: combine a little amount of 10% lead acetate with a few drops of the test solution. A white precipitate is produced.

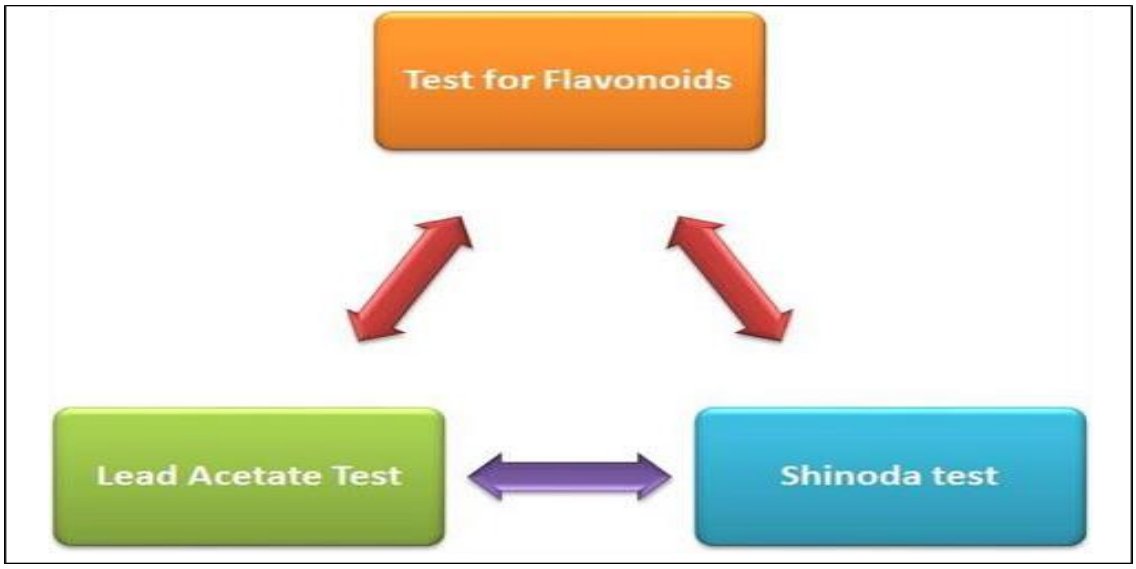


FIGURE 3. 6 Test for flavonoids

Test for Glycosides Borntrager's test

After boiling the medicine with diluted sulfuric acid, it was filtered. Then, benzene was added to the filtrate, and everything was vigorously agitated. With great care, the organic layer was removed, and a solution of ammonia was applied in stages. The lack of pink color in the ammoniacal layer indicated the presence of anthraquinone glycosides.

The legal test used one milliliter of a pyridine-dissolved test solution. A sodium nitropruside solution of 1 milliliter was made alkaline by adding 10% sodium hydroxide to it. The presence of cardiac glycosides is signaled by a shift in hue from pink to blood red.

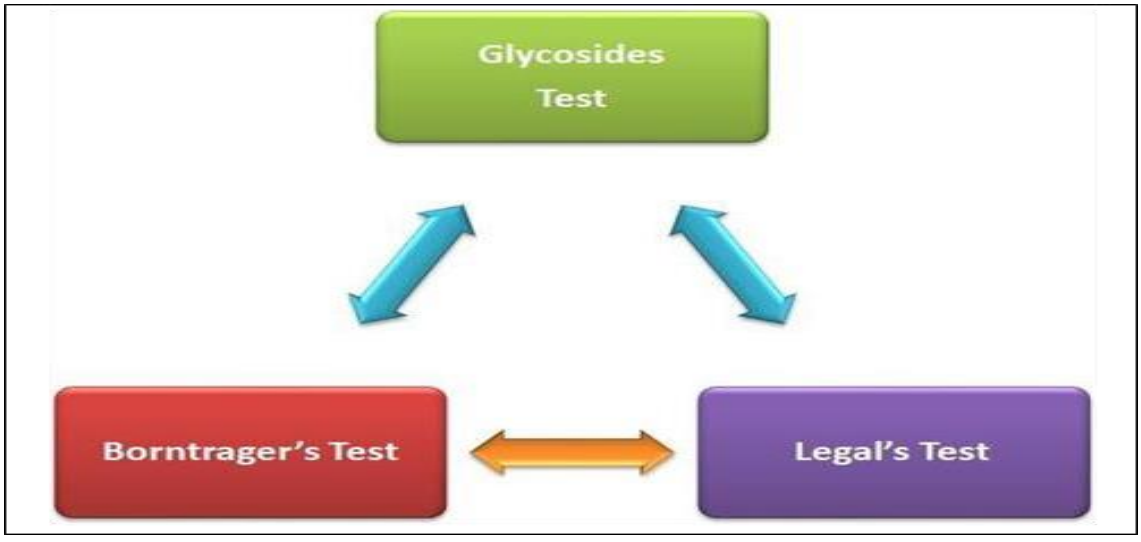


FIGURE 3. 7 Test for Glycosides

Detection of Terpenoids Salkowski test

Add 3 milliliters of strong sulfuric acid to make a layer after thoroughly mixing 2 milliliters of chloroform to extract the solution. A reddish-brown coloration of the interface was indicative of terpenoids.

Libermann-Burchard's Test:

The extract was treated with chloroform. This solution was heated and cooled after adding a few drops of acetic anhydride. The test tube was inserted into a solution of concentrated sulphuric acid via its sides.

Steroids are present when the top layer becomes green at the layer junction; triterpenoids are present when it turns deep red. Additionally, a brown ring will be seen at the layer junction.

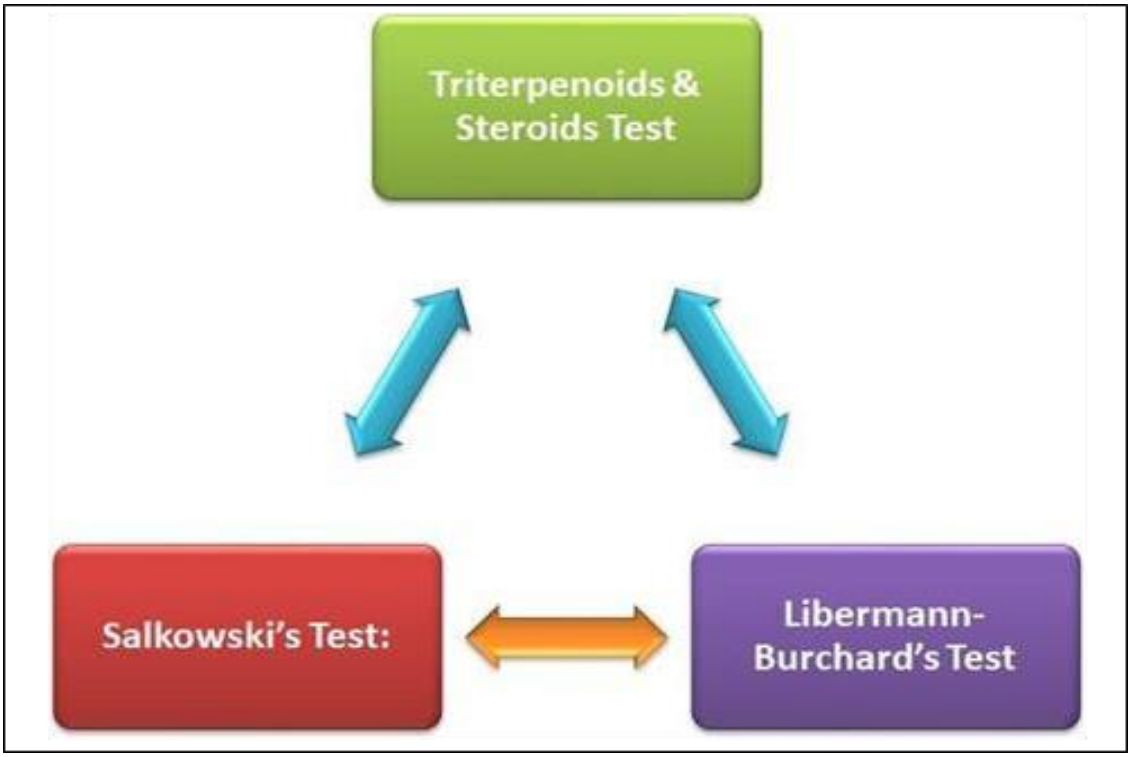


FIGURE 3. 8 Test for triterpenoids and steroids

Detection of resins:

A greenish hue will appear at the tube junction as a result of the presence of sterols when 2 milliliters of guggul MeOH extract and 1 milliliter of boiling acetic anhydride are combined with 2 milliliters of H2SO4.

Assay for amino acids and proteins:

Biuret's Test:

One milliliter of a 10% sodium hydroxide solution was added to the extract in a test tube before heating it. To the aforesaid combination, a drop of a copper sulfate solution with a concentration of 0.7% was added. Proteins are present when a violet or pink color develops.

Ninhydrin test:

Three milliliters of the test solution were subjected to a water bath for ten minutes while three The next step was to add a 5% Ninhydrin solution using droppers. The presence of amino acids is indicated by the formation of a blue tint.

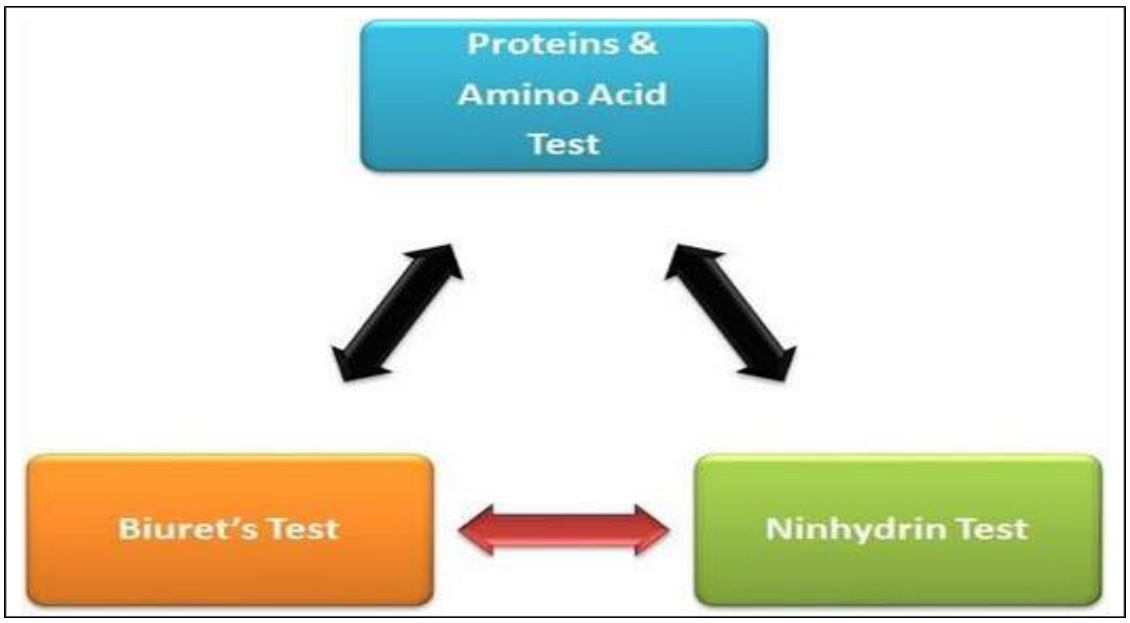


FIGURE 3. 9 Test for protein and amino acids

Quantitative phytochemical screening of Methanolic extract of TPH churna

Total phenolic content

A methanolic extract of TPH was tested for total phenolics using the Folin-Ciocalteau reagent.

Principle

Included in the class of compounds known as total phenolics are coumarins, stilbenes, hydrolyzable tannins, phenolic acids (including derivatives of benzoic and cinnamic acid), lignans, and lignins. The polyphenols found in plant extracts create a

blue complex when they combine with certain redox reagents, such as Folin-Ciocalteu reagent. The alkaline state and concentration of phenolic compounds determine the maximal absorption of the chromophores in the process that generates a phosphotungstic-phosphomolybdenum blue complex.

A 1000 µg/mL stock standard solution of gallic acid was made for the calibration curve by dissolving 10 milligrams of gallic acid in 10 milliliters of methanol. Various concentrations of the standard were created by diluting it in distilled water, ranging from 10-100 µg/mL.

Test Concentration: 30 µg/mL solutions of TPH extract was prepared.

Experimental Protocol

A 1:1 water-to-reagent ratio was used to dilute the Folins-phenol reagent by 500 εL, and 1 mL of the test or standard was also added, along with 2.5 mL of 20% sodium carbonate. The reaction was carried out by letting the mixture sit at room temperature in darkness for 40 minutes after a good agitation. Following incubation, the absorbance was measured at a wavelength of 725 nm.

A gallic acid calibration curve was developed using the outcomes of linearity tests conducted within the 10-100 µg/mL range. Both the METPH and MEGU extracts had their total phenolic content measured in milligrams of gallic acid equivalent (mg GAE/g extract) according to the standard curve.

Total tannin content

The tannins were measured using a slightly modified Folin-denis technique..

Principle

A combination of phosphomolybdate and phosphotungstate, the Folin-denis reagent allows for the colorimetric determination of polyphenols and phenols. A blue complex consisting of a phosphotungstic-phosphomolybdenum combination is formed during the process.

The calibration curve was made by dissolving 10 milligrams of gallic acid in 10 milliliters of methanol to form a stock standard solution with a concentration of 1000 µg/mL. Various concentrations of the standard were created by diluting it in distilled water, ranging from 10-100 µg/mL.

The test concentration was brought down from 300 mg/mL by diluting a stock solution of methanolic Triphala extract.

Experimental Protocol

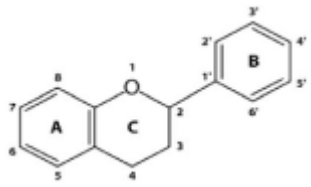
An initial volumetric flask of 10 mL was filled with 1 mL of the test or standard, 0.5 mL of Folin-Ciocalteu phenol reagent in a water-to-sodium carbonate ratio of 1:1, and 1 mL of a 35% sodium carbonate solution (or saturated sodium carbonate solution) before being diluted with distilled water to a final volume of 10 mL. We shook the ingredients well and then set them aside to rest for 30 minutes at room temperature. The absorbance of the test and standard solutions were measured at 725 nm using a UV/Visible spectrophotometer, in contrast to the blank.

The total tannin content (TTC) was determined using three separate techniques. A linearity range of 20-100 µg/mL was used for the purpose of creating a gallic acid calibration curve. In milligrams per milliliter, the sample's tannic acid content was determined.

Total Flavonoid content

According to Jamuna et al. (2014), the flavonoid-aluminum chloride (AlCl3) complexation the total flavanoids content of MEGL+GU was determined using a method.

Principle



Flavones and flavonols have acid stable complexes formed when aluminum chloride reacts with their C-4 keto groups and C-3 or C-5 hydroxyl groups. Complexes containing aluminum chloride and the orthodihydroxyl groups attached to flavonoids' A- or B-rings may be acid labile. A spectrophotometer set at 415 nm may be used to detect the yellowing of the solution caused by the presence of flavonoids in plant extracts.

Concentration to standard: By dissolving 10 mg of Quercetin in methanol, a stock standard of 1000 µg/mL of Quercetin was created in 10 ml volumetric flasks. The

standard was diluted in methanol to create solutions between 150 and 800 µg/mL in concentration.

The concentration of the test was determined by first preparing a 1000 µg/mL stock solution of all extracts and then diluting it to 500 µg/mL.

Experimental Protocol

Separately, 1 milliliter of plant extract or standard was added to 300 microliters of a 5% aqueous sodium nitrite solution. We incubated the mixture for 5 minutes before pouring in 300 µL of an aqueous aluminum chloride solution that is 10% and allowing it to sit for about six minutes. A 4% aqueous sodium hydroxide solution and 5 mL of distilled water were also added to it. After everything is well combined, the mixture is left to incubate for fifteen minutes at room temperature. The absorbance was observed at 510 nm.

The presence of flavonoids was indicated by the pinkish hue. Upon achieving linearity within the 150-800 µg/mL range, a quercetin calibration curve was generated. We calculated the amount of total flavonoid concentration (in milligrams of QE) per gram of dry weight extract using the standard curve.

3.8 TLC study of plant extracts

Using a ready-made TLC plate and a variety of mobile solvents selected for the polarity of the elute, we analyzed the methanolic extracts of GN, TPH, GL, and GU. Depending on the elute's polarity, the TLC plate uses a different mobile phase. Both the UV 365 nm and UV 254 nm wavelengths were used to view the produced chromatogram.

3.9 GC-MS study to check solvent effect in prepared extracts

The identification and detection of unknown chemicals in extracts is made possible by the widely used gas chromatography-mass spectroscopy (GC-MS) technique. In this case, the solvent effect in various extract powders was examined using the GC-MS method.

Sample preparation:

The GC-MS Head Space Solid Sampler was injected with powdered extracts of GN, GL, TPH, and GU.

TABLE 3. 1 GC–MS analysis methodology

Instrument	Gas Chromatograph: Mass Spectrometer/ Mass Spectrometer (GC-MS/MS) with Head Space TQ8040 (Schimadzu)
Column	Capillary column; SH-Rxi-5Sil, (30 m in length 0.25 mm internal diameter and 0.25µm thickness)
Carrier gas	Helium gas
Gas Chromatography condition	Oven temperature programmed as initial temperature 50°C (held time 5 min), ramped to 150°C at the value of 4°C/min and at 260°C at the value of 30°C/min (held for 5 min). Pressure: 112.1 kPa, Total Flow :96.9 mL/min, Column Flow :1.90 mL/min, Linear Velocity :50.0 cm/sec, Purge Flow :0.0 mL/min
Mass spectroscopy condition	Ion source temperature: 200°C, Interface Temp.: 270°C, Detector Gain: 0.80 kV +0.00 kV, with Q3 scan with scan speed 3333.
Run time	42 min
Library	GC-MS library: NIST17.lib

3.10 PROTOCOL FOR IN-VITRO STUDY

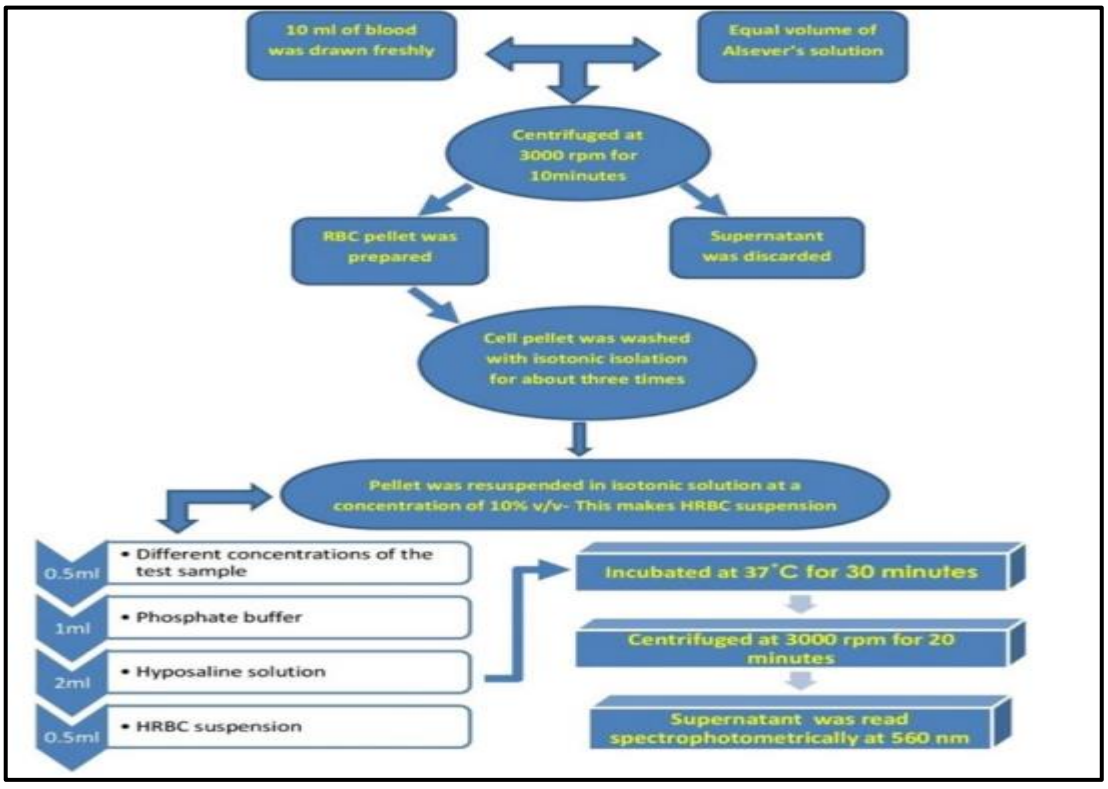


FIGURE 3. 10 Technique for stabilizing HRBC membranes

3.10.1 Technique for stabilizing HRBC membranes:

Samat S et al. (2010) outlined the steps for preparing a red blood cell (RBC) suspension. The blood for the research was donated by an individual in good health who voluntarily stopped using any nonsteroidal anti-inflammatory drugs (NSAIDs) two weeks before to the procedure. Three washes with one-to-one normal saline were performed after the blood sample had been spun at 3000 rpm for 10 minutes. After the blood sample was taken, it was reconstituted using a 10% v/v solution of normal saline. According to Gandhi et al. (1991), the HRBC membrane stabilization method was used to evaluate the anti-inflammatory activity. The obtained blood was mixed with sterile Alsever medium, which included 2% (weight/volume) dextrose, 0.8% sodium citrate, 0.5% citric acid, and 0.42% sodium chloride in water. The blood was then centrifuged at a higher speed of 3000 rpm for an additional 10 minutes. Rinsing the packed cells with isosaline (0.85%, pH 7.2) allowed for the preparation of a 10% (v/v) solution. An experimental mixture was prepared using the plant extract's secondary metabolite, 1 milliliter of phosphate buffer (0.15 M, pH 7.4), 2 milliliters of hyposaline (0.36%), and 0.5 milliliters of HRBC solution. As a baseline, we used diclofenac.

For the control, milliliters of distilled water were used instead of hyposaline. Following 30 minutes of incubation at 37 °C and 10 minutes of centrifugation at 3000 rpm, the test mixes were prepared. The quantity of haemoglobin in the supernatant was measured using a UV-Visible spectrophotometer set at 560 nm.

We used this calculation to determine the percentage: Rate of blood loss The hemolyzation rate is 100 times the ratio of the test sample's optical density to the control's optical density. The protective value is 100, which is the result of dividing the control sample's optical density by the test sample's optical density. One hundred a solution of bovine serum albumin and distilled water. The proteins needed to be denaturized by heating the mixture to 70°C for 10 minutes in a water bath. Activity at 660 nm was measured as each combination cooled to room temperature. The exam was repeated three times for each participant. The following formula was used to obtain the inhibition percentage:

% inhibition = Absorbance of control- Absorbance of sample/Absorbance of control*100

3.11 STATISTICAL ANALYSIS

In order to demonstrate the outcomes, the three independent trials' means and standard deviations were used. Using Microsoft Excel (Inc. 2007), the researchers calculated the linear regression coefficient (R2) and performed statistical analysis (mean ± SD) on the tannin and phenolic content.

Using a two-way analysis of variance (ANOVA) and a Bonferroni multiple comparison test, the in-vitro investigation compared the standards and plant extracts test subjects. The tool used to establish the statistical significance criteria were GraphPad Prism, with *p ≤0.05, **p ≤0.01, and ***p ≤0.001.

A two-way ANOVA and a Bonferroni multiple comparison test were included in the GraphPad Prism program, which compared the standards and plant extracts. The significance levels were established at *p ≤0.05, **p ≤0.01, and ***p ≤0.001.

Chapter 4

RESULTS AND DISCUSSION

4.1 RESULTS AND DISCUSSION

4.1.1 Organoleptic evaluation

Ginger:



Figure 4. 1 Ginger Powder

Color: Slightly brown powder

Odour: Aromatic

Taste: Agreeable & Pungent

Triphala Powder:



Figure 4. 2 Triphala powder

Color: Greenish-brown powder

Odour: Astringent

Taste: Astringent

Guggul powder:



Figure 4. 3 Guggul powder

Color: Brown powder

Odour: Aromatic

Taste: Bitter

Guduchi:



Figure 4. 4 Guduchi Powder

Color: Cream to slight yellow powder

Odour: Bitter

Taste: Bitter

4.2 POWDER MICROSCOPY: GINGER

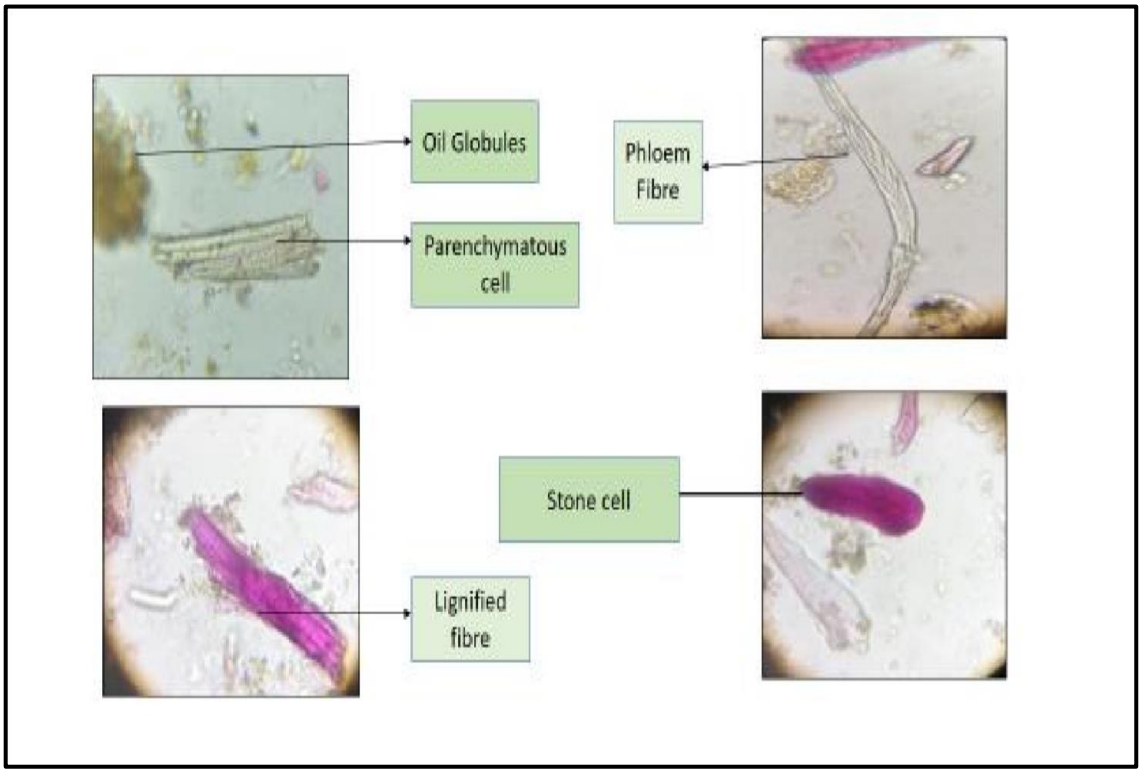


Figure 4. 5 Powder Microscopy of Ginger in 10 X Triphala churna

Triphala churna

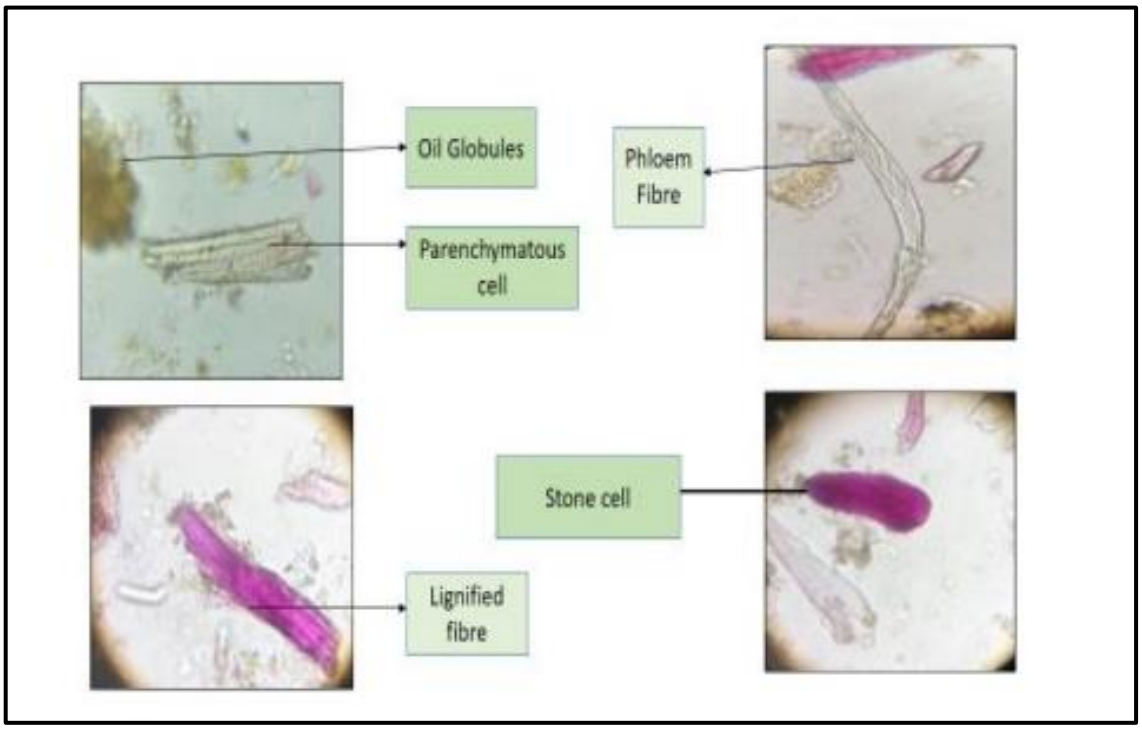


Figure 4. 6 Powder Microscopy of Triphala in 10 X Guduchi

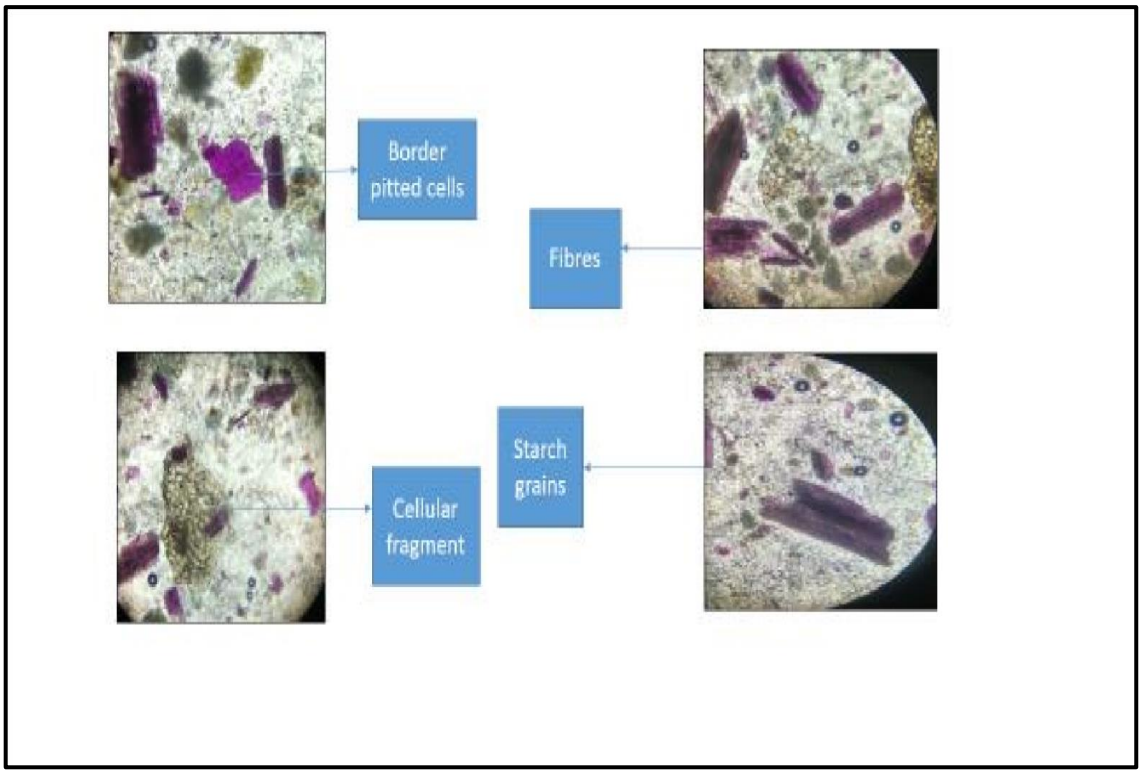


Figure 4. 7 Powder Microscopy of Guduchi in 10 X

4.3 STANDARDIZATION PARAMETERS:

4.3.1 Proximate Analysis:

The results of proximate analysis of Ginger powder are shown in Table 4.1

TABLE 4. 1 Proximate analysis of Ginger powder

Parameters	Value (% W/W)
Total ash	5.5
Acid-insoluble ash	0.90
Water-soluble ash	1.3
Alcohol soluble extractive	6.25%
Water soluble extractive	14%
Loss on drying	3

The results of proximate analysis of TPH powder are shown in Table 4.2

TABLE 4. 2 Proximate analysis of TPH powder

Parameters	Value (% W/W)
Total ash	3
Acid-insoluble ash	1
Water-soluble ash	2
Alcohol soluble extractive	27.25%
Water soluble extractive	36.25%
Loss on drying 4	Loss on drying 4

The results of proximate analysis of Guggulu powder are shown in Table 4.3

TABLE 4. 3 Proximate analysis of Guggulu powder

Parameters	Value (% W/W)
Total ash	5.36
Acid-insoluble ash	0.96
Water-soluble ash	4.51
Alcohol soluble extractive	37.3
Water soluble extractive	31.54
Loss on drying	3.88

The results of proximate analysis of Guduchi powder are shown in Table 4.4

TABLE 4. 4 Proximate analysis of Guduchi powder

Parameters	Value (% W/W)
Total ash	7.5
Acid-insoluble ash	0.62
Water-soluble ash	12.05
Alcohol soluble extractive	7.27
Water soluble extractive	13.05
Loss on drying	4.2%

4.3.2 Physicochemical Evaluation:

Various analytical parameters were measured for the powdered ginger, triphala churna, guggul, and guduchi, including total ash, ash that is water-soluble and acid-insoluble, extractive value in water and alcohol, and so on. Powder medications may be physicochemically examined to detect adulteration, poor quality, or improper management of herbs. Plants that are used medicinally have had some kind of processing done to them throughout their growth and harvest.

Plant parts are susceptible to contamination from a wide variety of sources, including but not limited to: molds, insects, animal waste, stone, dirt, metal, dust, etc.; inactive plant parts from the same plant or another plant; and other pollutants. It need to be within predetermined limits, according to the World Health Organization (WHO).

The extractive values of the chemical components of powdered pharmaceuticals are used for evaluation; these values also help in identifying which chemical components are soluble in a particular solvent. It was found that water had the highest extractive value of various plant powders, followed by alcohol.

High extractive values for alcohol and water solubility showed polar components such as tannins, glycosides, phenols, flavonoids, and volatile oils. When testing pharmaceuticals for impurities like silica and other inorganic substances, ash value is an essential metric to look for. A modest percentage change in the weight of ash in certain drugs indicates a change in quality, whereas a large shift indicates a change in formulation. Tables 4.1, 4.2, 4.3, and 4.4 show the results for the percentages of total ash, water-soluble ash, and acid-insoluble ash, respectively.

4.4 PRELIMINARY SCREENING OF EXTRACTS:

The powdered herbs GN, TPH, GL, and GU were extracted using a mixture of methanol and water, which served as the solvents. Based on their solubility, different polarity solvents are used to separate and concentrate different secondary metabolites.

In comparison to the hydro-methanolic extract, the yield percentages of the methanol extracts of all the chosen plants were higher. The findings demonstrate that a multitude of secondary metabolites were concentrated and extracted using methanol.

4.4.1 Prepared Extracts:



Figure 4. 8 Preparation of extracts of GN, TPH, GL, GU by using solvent methanol

TABLE 4. 5 Different selected herbs and their consistency in solvents

Sr.no.	Plant name	Colour of extract		Consistency	
		Hydro-methanolic	Methanol	Hydro-methanolic	Methanol
1	Ginger Powder	Brown	Reddish brown	Sticky	Sticky
2	Guggul powder	Black	Black	Sticky	Sticky
3	Guggul+Guduchi powder	Blackish brown	Blackish brown	Semi-solid	Semi solid
4	Triphala powder	Blackish brown	Blackish brown	Solid	Solid

4.5 EXTRACT QUALITY ASESSMENT FOR PHYTOCHEMICAL CONTAINS:

Many plant tissues include chemical components called secondary metabolites that provide medicinal plants their therapeutic advantages. Flavonoids, alkaloids, glycosides, gums, resins, tannins, volatile oils, and other chemicals fall under this category of very valuable compounds. Depending on the plant, they might accumulate

everywhere or only in certain spots. They may be widespread or limited to certain regions of the plant. The phytoconstituents of a medicinal plant are responsible for its medicinal effects. All four of these plants' methanolic extracts—GN, TPH, GL, and GU—were tested for the presence of several phytoconstituents; the results are shown in Table 4.6 below.

TABLE 4. 6 Phytochemical tests for GN powder

Phytochemical test	Ginger Powder
Alkaloids	+ve
Glycosides	-ve
Saponins	+ve
Tannins	+ve
Carbohydrates	+ve
Gum and mucilage	-ve
Phytosterols	+ve
Resins	-ve

Where,

-ve=not present,

+ve= present

Phytochemical analysis of GN powder revealed the presence of carbohydrates, tannins, and saponins but the absence of resins, gum, mucilage, and glycosides.

4.5.2 Phytochemical tests for Triphala

TABLE 4. 7 Phytochemical tests for TPH powder

Phytochemical test	TPH Powder
Alkaloids	+ve
Glycosides	-ve
Saponins	-ve
Tannins	+ve
Carbohydrates	-ve
Gum and mucilage	-ve
Phytosterols	+ve
Resins	-ve

Where,

-ve=not present,

+ve= present

The results of the phytochemical tests conducted on TPH powder, gum, mucilage, and glycosides showed that there were no carbohydrates or saponins, but that there were tannins, alkaloids, and phytosterols..

4.5.3 Phtyochemical tests for Guggul

TABLE 4. 8 Phytochemical tests for GL powder

Phytochemical test	GL Powder
Resins	+ve
Glycosides	-ve
Saponins	-ve
Tannins	-ve
Carbohydrates	+ve
Gum and mucilage	+ve
Phytosterols	+ve
Alkaloids	-ve

Where,

-ve = not present,

+ve= present

By performing phytochemical tests of GL powder Resins, Gum & mucilage and carbohydrates, were found to be present and tannins, alkaloids, glycosides were found to be absent.

4.5.4 Phytochemical tests for Guduchi

TABLE 4. 9 Phytochemical tests for GL powder

Phytochemical test	GL Powder
Alkaloids	+ve
Glycosides	+ve
Saponins	+ve
Tannins	-ve
Carbohydrates	+ve
Gum and mucilage	-ve
Flavanoids	+ve
Resins	-ve

Where,

-ve = not present,

+ve= present

Results from phytochemical analyses of GU powder showed the presence of carbohydrates, tannins, alkaloids, glycosides, and flavonoids but the absence of gum, mucilage, and tannins.

The results of the qualitative chemical tests demonstrated that the extraction process made good use of phytochemical separation. A variety of pharmacological actions are controlled by commonly occurring, potent phytochemicals known as secondary metabolites. An earlier investigation shown that glycosides, flavonoids, and polyphenols have anti-inflammatory, antioxidant, and antiulcer characteristics. Both the plant selection process and the phytochemical correlation may be aided by these resources.

4.6 THIN LAYER CHROMATOGRAPHY

Plant components found in the MEGN, METPH, MEGL, and MEGU extracts were separated, isolated, and identified using the thin-layer chromatography method.

Transdermal light chromatography (TLC) is an essential analytical technique for the separation, recognition, and evaluation of many classes of natural chemicals. Applying TLC to the methanolic GN, TPH, GL, and GU extracts improved component separation.

The presence of secondary metabolites such tannins, phenolic compounds, alkaloids, flavonoids, glycosides, and resins was shown by the TLC examination of several extracts.

TABLE 4. 10 Different extracts GN, TPH, GL, GU TLC with mobile phase

Name of Metabolite	Mobile phase	Visualization	Color of spot	Rf values	Rf values
MEGN	Toluene: Ethyl acetate (7:3)	-	Blue, Yellow,	0.48	0.53
METPH	Toluene: ethyl acetate: formic acid (2:5:1.5)	-	Black	0.34	0.45
MEGL	Toluene:acetone (9.1)	-	Blue	0.25	0.31
MEGU	Chloroform:Methanol (9:1)	Anisaldehyde sulphuric acid	Blue, Dark blue	0.55	0.69

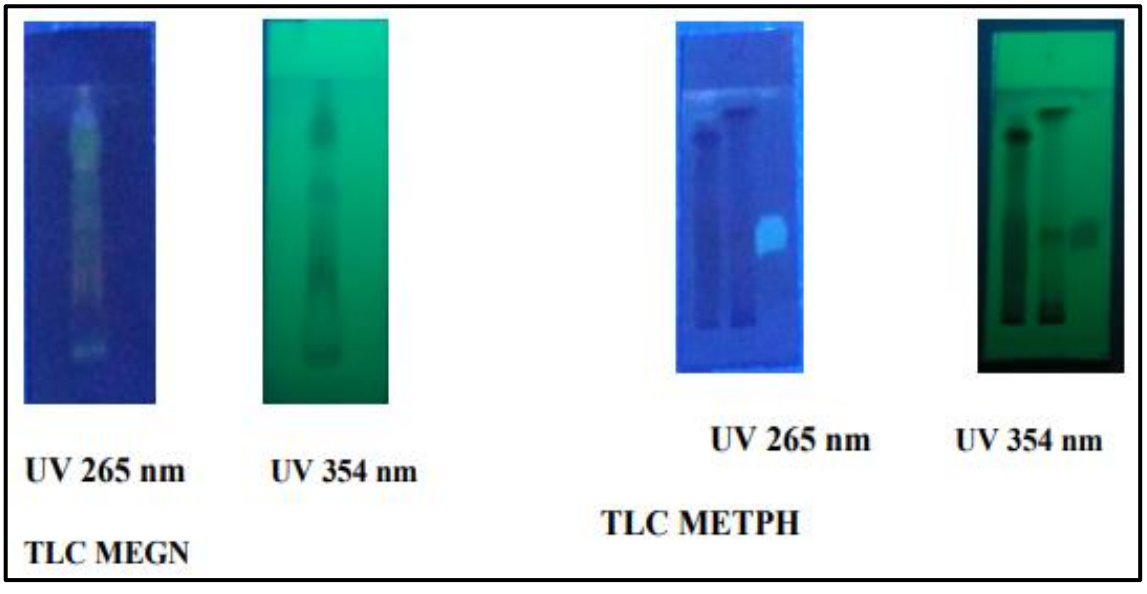


Figure 4. 9 Images of TLC of MEGN, METPH, MEGL, MEGU

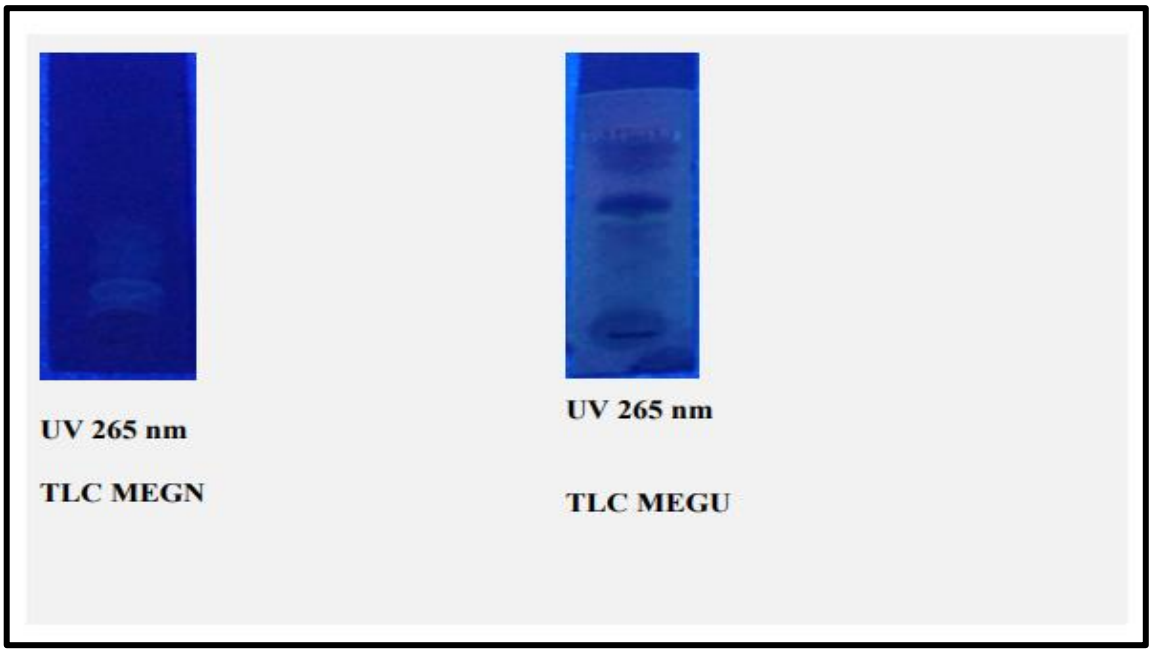


Figure 4. 10 Images of TLC of MEGN, METPH, MEGL, MEGU

It has been determined from a review of the phytochemical literature and the aforementioned findings that the MEGN METPH MEGL MEGU include tannins, flavonoids, steroids, a combination, and phenolics. In terms of their many known pharmacological actions, including anti-inflammatory activity, which phytochemicals are seen to be the most promising.

4.7 GC-MS/MS STUDY

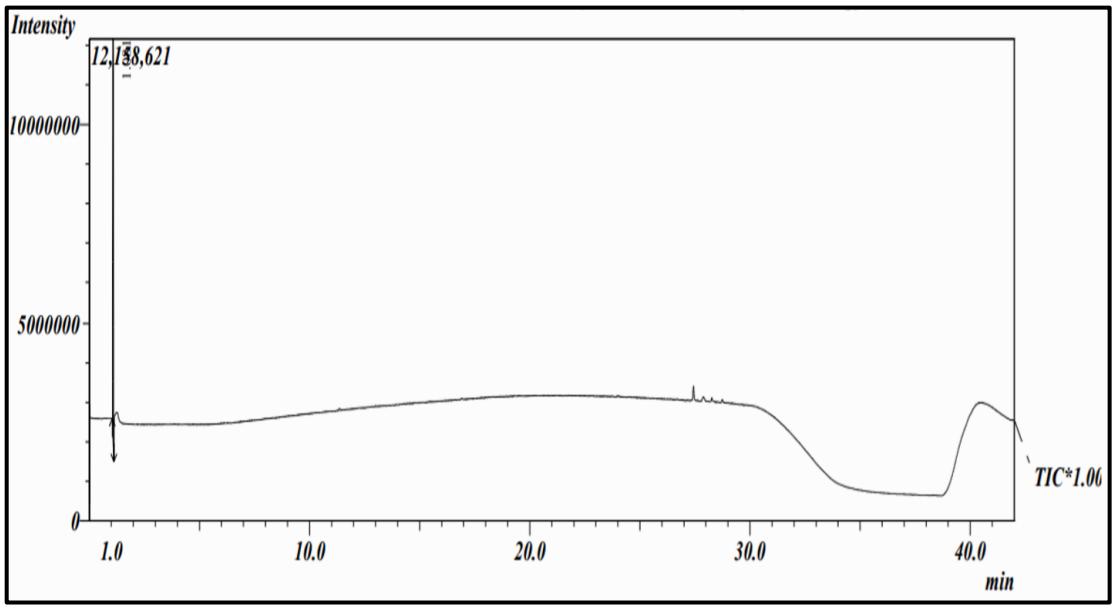


Figure 4. 11 Chromatogram of Ginger Extract

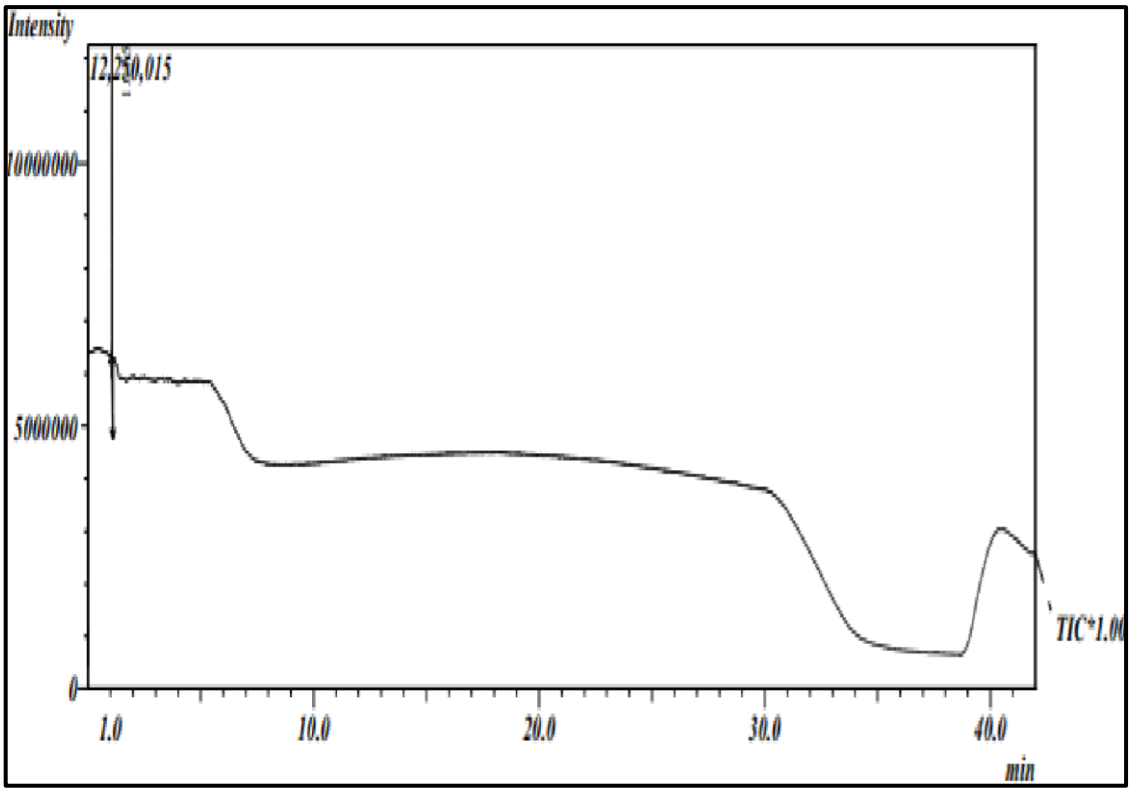


Figure 4. 12 Chromatogram of Triphala Extract

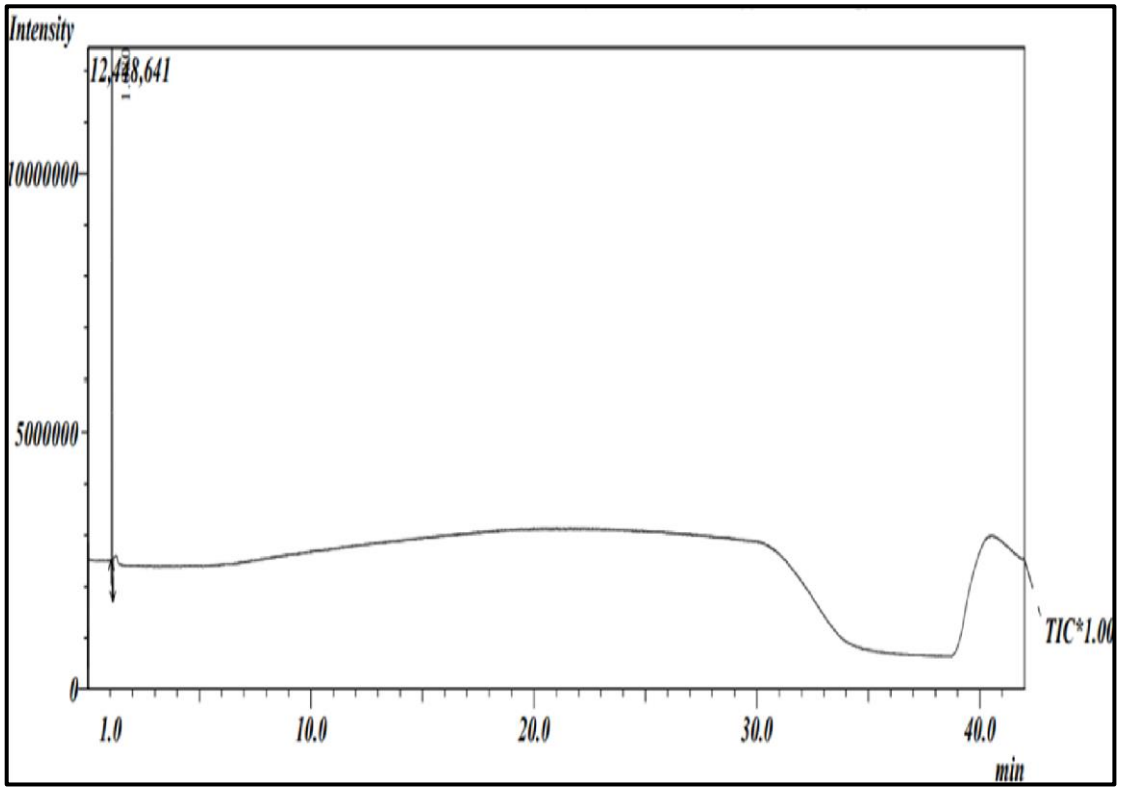


Figure 4. 13 Chromatogram of Guggul Extract

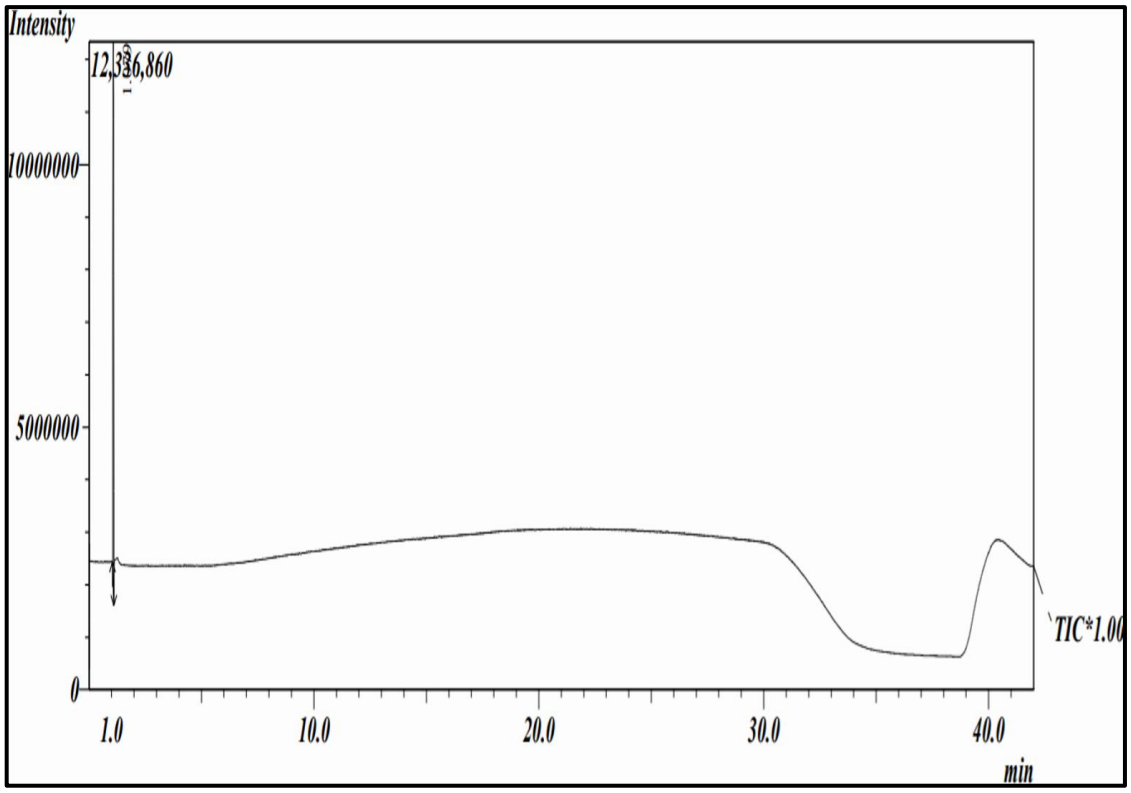


Figure 4. 14 Chromatogram of Guggul +Guduchi Extract

4.7 GC-MS/MS

A GC-MS analytical investigation was conducted on all four MEGN, METPH, MEGL, and MEGL+GU samples to evaluate the solvent impact. The lack of a peak in any of the four samples examined by GC/MS suggests that the solvent effect was not present in the extracts of these samples.

4.8 QUANTITATIVE PHYTOCHEMICAL SCREENING:

4.8.1 Total tannin content:

Milligrams of tannic acid equivalent per gram of METPH extract was used to evaluate its total tannin concentration. In the detection range, the linear relationship was satisfactory, according to the tannic acid standard curve (Figure 4.8).

The mean±standard deviation of the results are shown for a sample size of 3.

4.8.2 Total phenolic contents

Here we may see the gallic acid standard curve, and the total phenolic content of each extract is shown graphically. The METPH extract was found to have 224.67±1.17 mg GAE/g of total phenolic content.

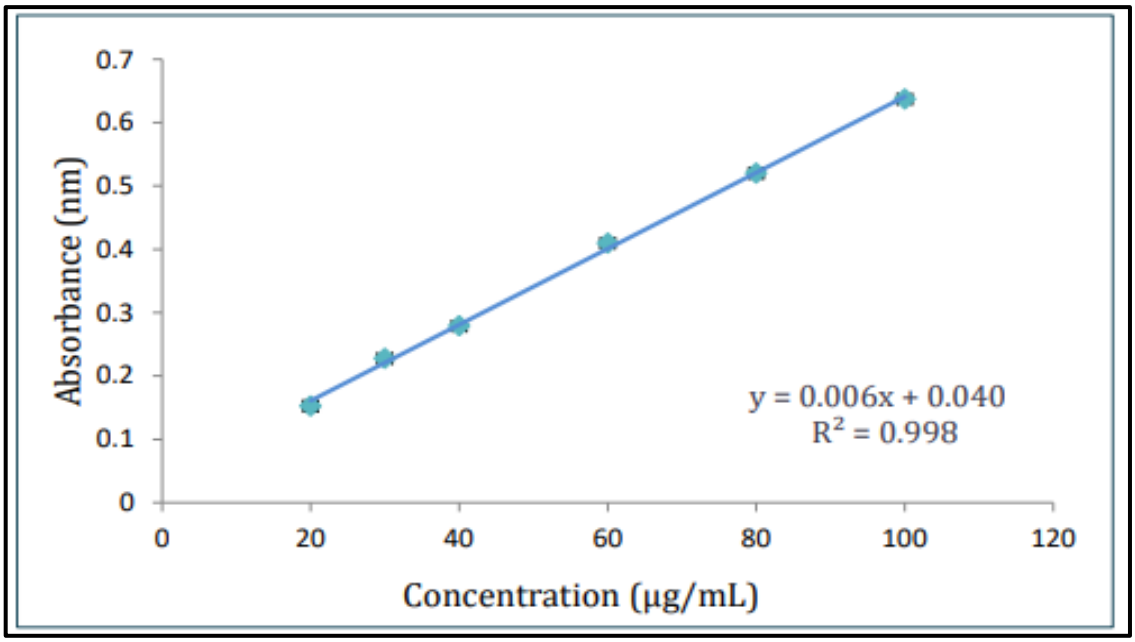


Figure 4. 15 Standard curve of tannic acid for total tannin estimation.

4.8.3 Total Flavanoid content

A quercetin equivalent per milligram of extracts was used to assess the total flavonoid content of MEGU. Figure displays the quercetin standard curve.

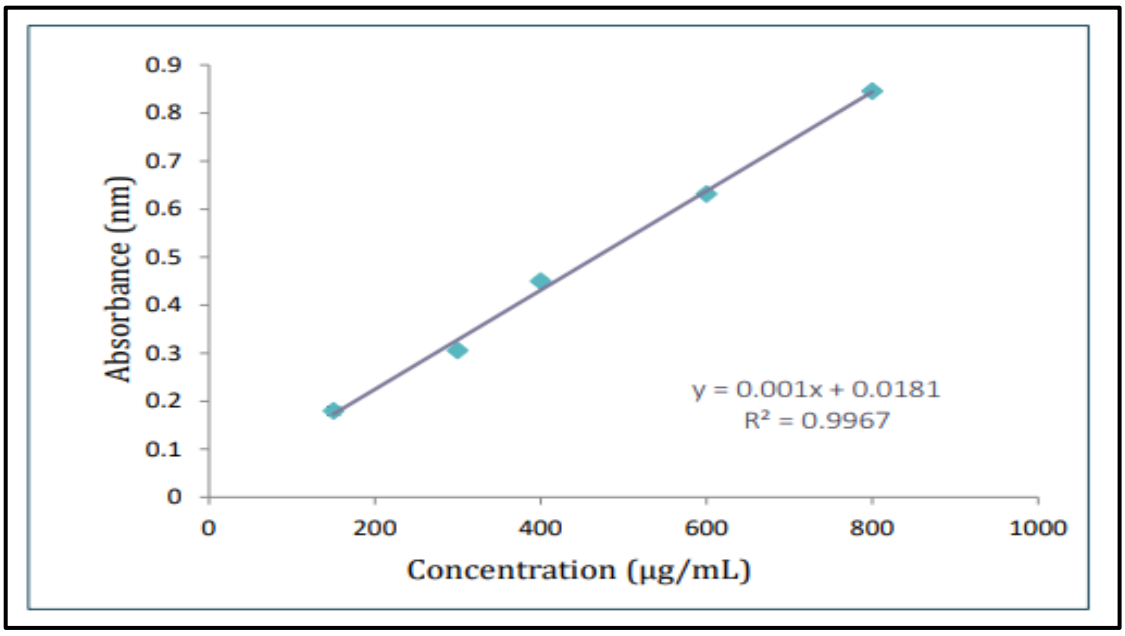


Figure 4. 16 Standard curve of quercetin for total flavonoid estimation.

4.9 SPECTRAL ANALYSIS

The FTIR spectroscopy was carried out on the Diclofenac sodium and Etodolac standards that were used in the research.

4.9.1 Spectral analysis of Etodolac standard

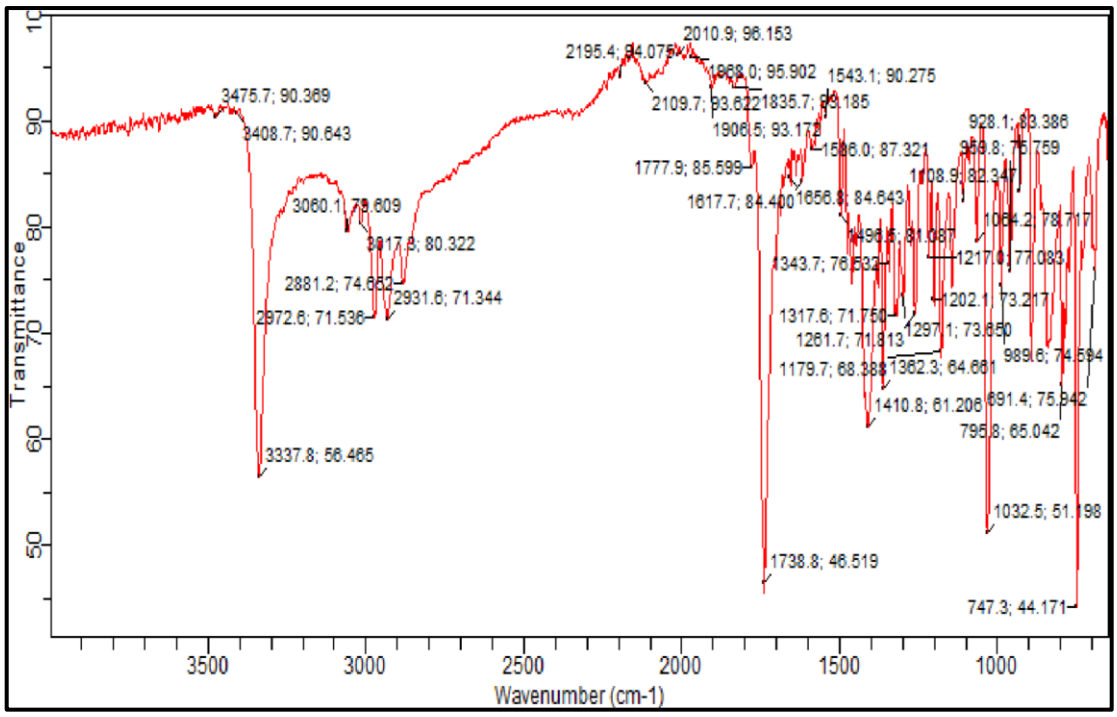
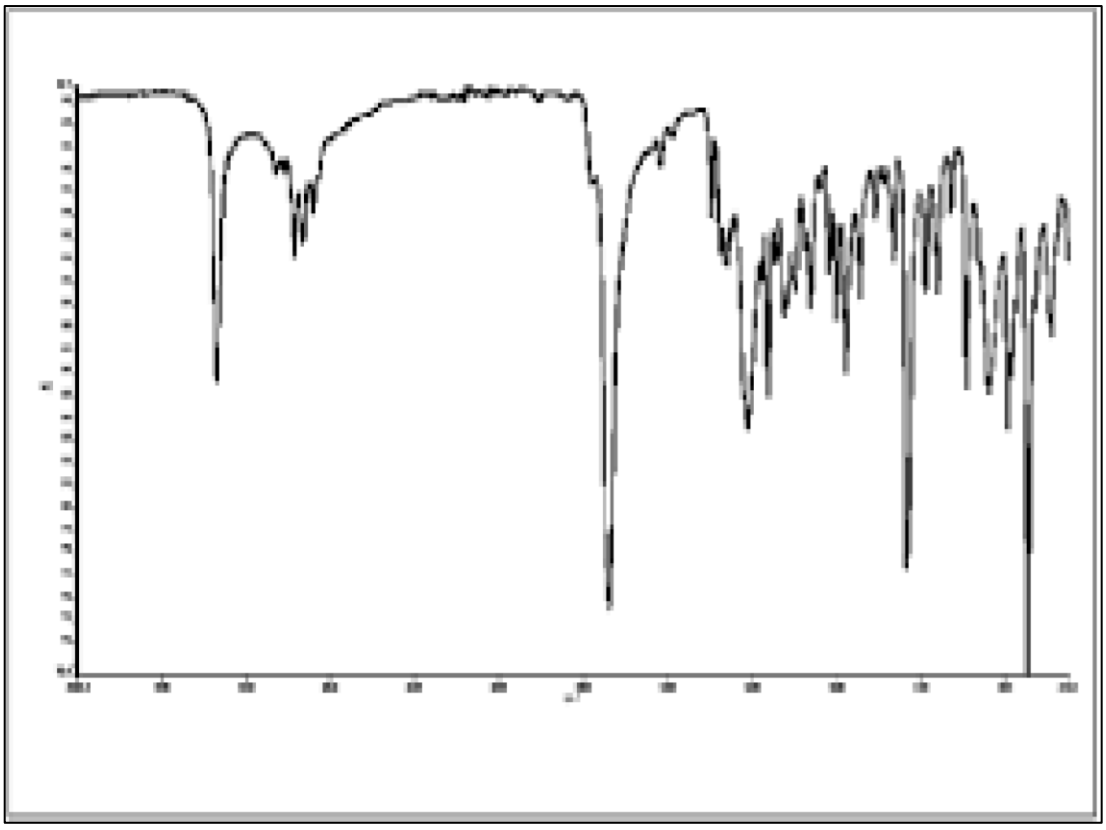


Figure 4. 17 FTIR spectra of Etodolac sample

4.9.2 Spectral ana*l*ysis of Diclofenac sodium standard



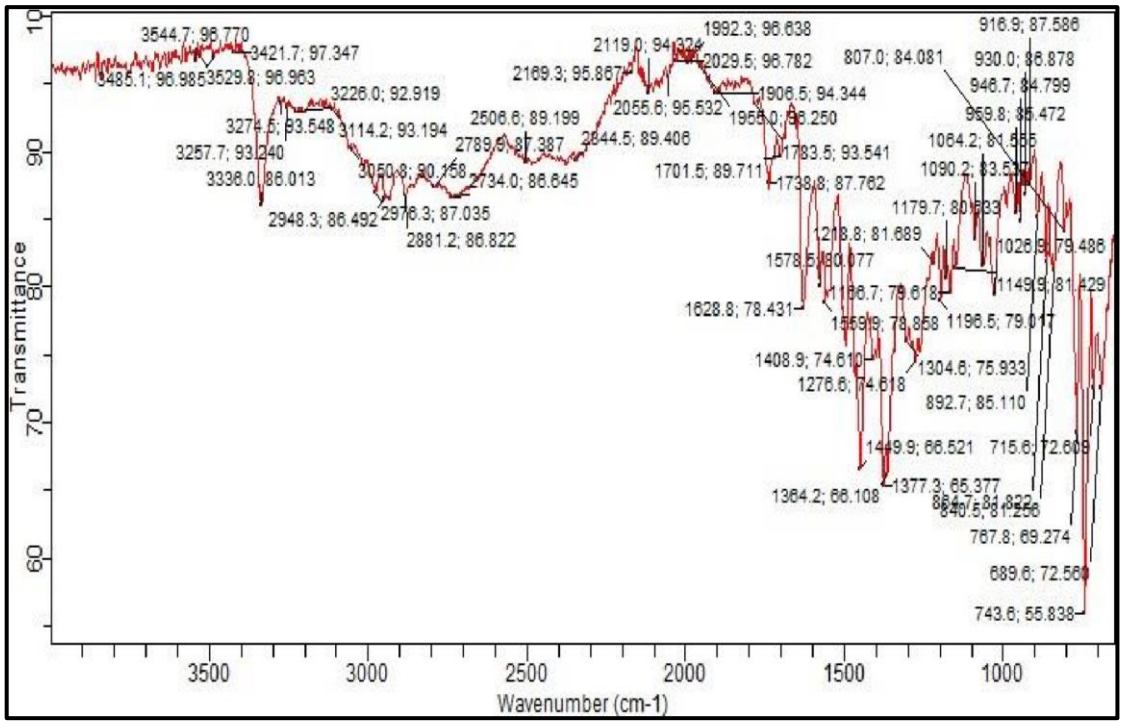


Figure 4. 18 FTIR spectra of Diclofenac sodium sample

4.10 IN-VITRO STUDY

4.10.1 HRBC Method for MEGN, METPH, MEGL, MEGL+GU with standard Diclofenac sodium

TABLE 4. 11 Effect of MEGN, Diclo and Diclo + MEGN on HRBC membrane protection

Groups	% Protection				
	50(µg/ml)	**100(µg/ml)**	**200(µg/ml)**	**250(µg/ml)**	**500(µg/ml)**
Group–I MEGN(25mg/10ml)	0.165±0.009	0.197±0.0045	0.286±0.002	0.463±0.0055	0.568±0.012
Group-II Diclo (25 mg/10 ml)	0.141±0.007	0.197±0.007	0.275±0.008	0.434±0.026	0.474±0.005
Group III Diclo+MEGN(12.5 mg+12.5mg=25 mg/10ml)	0.602±0.005	0.508±0.006	0.503±0.006	0.384±0.0077	0.186±0.0073

In Table 4.11, we can see the impact of MEGN, Diclo, and Diclo + MEGN on the protection of the HRBC membrane. Data are presented as the mean ± SD, and each group consisted of three individuals. Our statistical investigation included a Bonferroni multiple comparison test and a two-way analysis of variance (ANOVA) conducted in GraphPad Prism. A p-value of less than 0.05, 0.01, and 0.001 were used to compare the results to the inflammatory control group, respectively.

TABLE 4. 12 Effect of METPH, Diclo and Diclo+METPH on HRBC membrane protection

Groups	% Protection				
	50(µg/ml)	**100(µg/ml)**	**200(µg/ml)**	**250(µg/ml)**	**500(µg/ml)**
Group–I METPH (25mg/10ml)	0.153 ±0.005	0.281± 0.016	0.524± 0.029	0.638± 0.016	0.754± 0.0081
Group III Diclo+METPH(12.5 mg+12.5mg=25 mg/10ml)	0.176± 0.007	0.321± 0.021	0.586± 0.007	0.684± 0.007	0.884± 0.007

Table 4.12 shows the results of the HRBC membrane protection tests conducted with METPH, Diclo, and Diclo+METPH.

The values are shown as the mean ± SD, and there Each group had three members. The GraphPad Prism software was used to do the statistical analysis. "The findings were statistically significant (**P < 0.01, ***P < 0.001) when compared to the inflammatory control group.

TABLE 4.13 Effect of MEGL, Diclo and Diclo+ GL on HRBC membrane protection

Groups	% Protection				
	50(µg/ml)	**100(µg/ml)**	**200(µg/ml)**	**250(µg/ml)**	**500(µg/ml)**
Group–I MEGL (25mg/10ml)	0.176± 0.007	0.321± 0.021	0.486± 0.007	0.584± 0.007	0.784± 0.007
Group-II Diclo (25 mg/10 ml)	0.141± 0.007	0.197± 0.007	0.275± 0.008	0.434± 0.026	0.667± 0.036
Group III Diclo+MEGL (12.5mg+12.5mg=25 mg/10ml)	0.186± 0.007	0.384± 0.007	0.603± 0.006	0.708± 0.006	0.893± 0.005

Table 4.13 Effect of MEGL, Diclo and Diclo+ GL on HRBC membrane protection; Results are presented as the average plus or minus the standard deviation, with three participants in each group. GraphPad Prism software was used for statistical analysis, yielding significant results when contrasted with the inflammatory management (*P < 0.05, **P < 0.01 and ***P < 0.001).

Groups	**% Protection**				
	50(µg/ml)	**100(µg/ml)**	**200(µg/ml)**	**250(µg/ml)**	**500(µg/ml)**
Group–I MEGL+GU (25mg/10ml)	0.165±0.009	0.197±0.004	0.286±0.002	0.463±0.005	0.568±0.012
Group-II Diclofenac (25 mg/10 ml)	0.141±0.007	0.197±0.007	0.275±0.008	0.434±0.002	0.474±0.005
GroupIII Diclo					
+MEGL+GU (12.5mg+12.5 mg=25 mg/10ml)	0.186±0.007	0.384±0.007	0.503±0.006	0.508±0.006	0.602±0.005

TABLE 4. 13 Effect of MEGL+GU, Diclo and Diclo+GL+GU on HRBC membrane protection

Groups	% Protection				
	50(µg/ml)	100(µg/ml)	200(µg/ml)	250(µg/ml)	500(µg/ml)
Group–I MEGL+GU (25mg/10ml)	0.165± 0.009	0.197± 0.004	0.286± 0.002	0.463± 0.005	0.568± 0.012
Group-II Diclofenac (25 mg/10 ml)	0.141± 0.007	0.197± 0.007	0.275± 0.008	0.434± 0.002	0.474± 0.005
GroupIII Diclo					
+MEGL+GU (12.5mg+12.5 mg=25 mg/10ml)	0.186± 0.007	0.384± 0.007	0.503 ±0.006	0.508± 0.006	0.602± 0.005

The effect of MEGL+GU, Diclo, and Diclo+GL+GU on the protection of the HRBC membrane is shown in Table 4.14. Results are presented as the average plus or minus the standard deviation, with three participants in each group. The statistical analysis was conducted using GraphPad Prism software, with comparisons to the inflammatory control set at *P < 0.05, **P < 0.01 and ***P < 0.001.

A measure of the anti-inflammatory action was the suppression of hypotonicity-induced HRBC lysis, or the stability of the HRBC membrane. We determined the percentage of membrane stability at concentrations of 50, 100, and 200 εM. 200, 250, and 500 mcg/ml for MEGN, METPH, MEGL, and MEGL+GU (test), diclofenac sodium (standard), and a combination of these four substances (test). The most efficacious solutions were those containing 50 mcg/ml of methanolic ginger extract or a combination of ginger and diclofenac sodium (Table 4.11). When using Diclofenac sodium alone, the percentage of membrane protection increased with increasing concentration; however, when combined with MEGN, the percentage of protection decreased at a concentration of 500 mcg/ml, indicating that the combination was having a negative impact. The combination of Diclo+ METPH, Diclo+MEGL, and Diclo+MEGL+GN all shows synergistic effects at a concentration of 500 mcg/ml or above, increasing the percentage of protection. In response to harm, biological tissues launch an inflammatory response.

A rapid and temporary drop in the number of lymphocytes in the peripheral circulation might affect the response over the long run, and steroidal anti-inflammatory drugs can facilitate this process via lysis and the reassignment of cells.

The findings indicate that the anti-inflammatory properties of MEGN, METPH, MEGL, and MEGL+GL+GU will be seen at different concentrations. Any of the chosen extracts may be a powerful medicine for relieving acute inflammation.

By preventing the lysis of the erythrocyte membrane caused by hypotonicity, all of the herbs utilized in this research showed a stabilizing impact on the cell membrane. Since lysosomal membranes are comparable to erythrocyte membranes, it stands to reason that the extract may be able to stabilize both types of membranes (Kumar V. et. al, 2011). The release of active neutrophil lysosomal components, including protease and bacterial enzymes, is crucial for stabilizing the lysosomal membrane and preventing extracellular inflammation and damage (Yurugasan N. et. al., 1981).

Hypotonicity may produce hemolysis due to cell contraction caused by osmotic loss of fluid components and intracellular electrolytes; however, the exact method by which the extract stabilizes the membrane is yet unknown. According to Vasivu R et al. (2008), the extract has the potential to block processes that might increase or improve the outflow of these components from inside cells. In vitro research indicated that MEGN, METPH, MEGL, and MEGL+GU had strong anti-inflammatory effects.

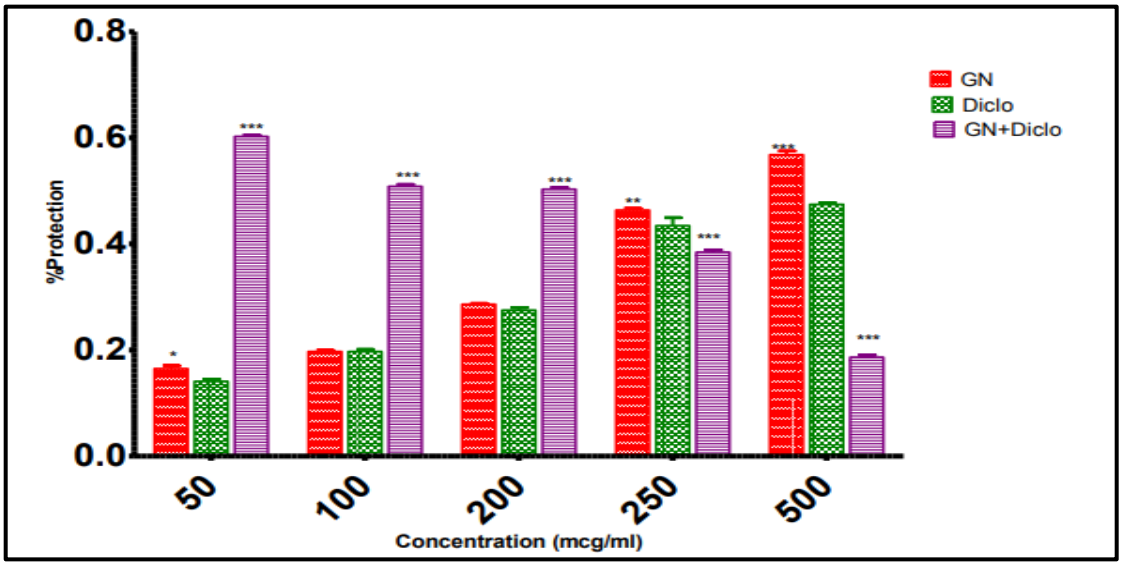


Figure 4. 19 % protection of HRBC membrane by MEGN, Diclo, Diclo+MEGN

Results show that MEGN, Diclo, and Diclo+MEGN all protected the HRBC membrane by 4.18 percent. There were three participants in each group, and the data was analyzed using GraphPad Prism software using a two-way ANOVA and a Bonferroni multiple comparison test. When compared to the inflammatory control, the significant thresholds were *P < 0.05, **P < 0.01 and ***P < 0.001.

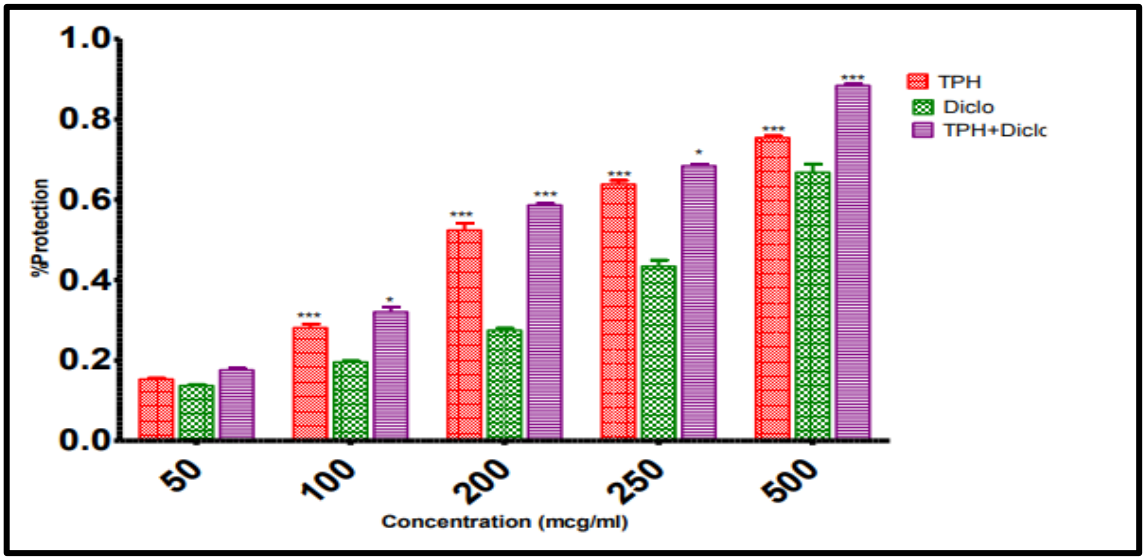


Figure 4. 20 % protection of HRBC membrane by METPH, Diclo, Diclo+METPH

Figure 4.19% shows the HRBC membrane's protection by METPH, Diclo, and Diclo+METPH. The values are presented as the mean ± SD, and there were three groups in each. *P < 0.05, **P < 0.01, and ***P < 0.001 were used to compare the results to the inflammatory control in the statistical analysis conducted using GraphPad Prism program.

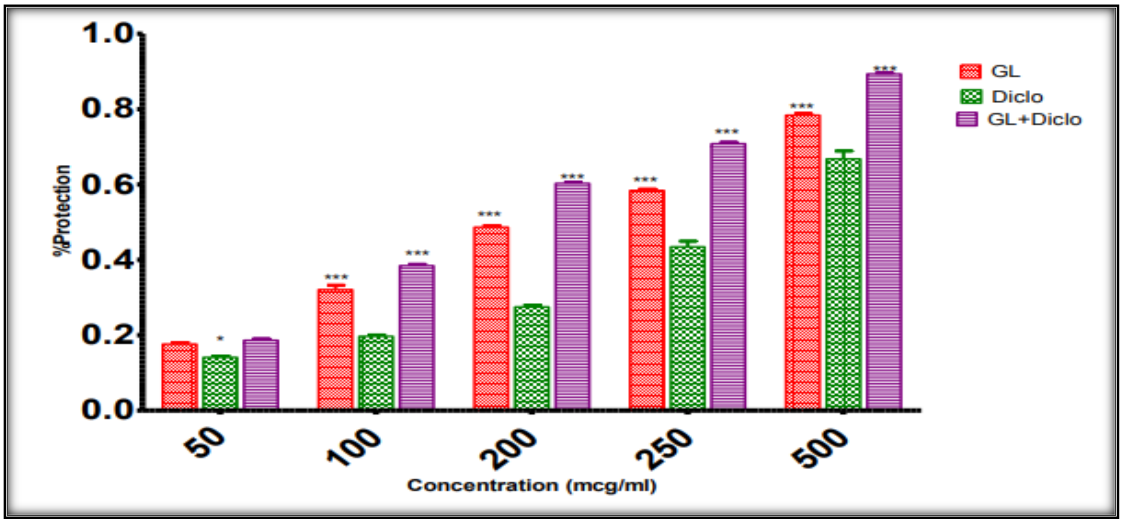


Figure 4. 21 % protection of HRBC membrane by MEGL, Diclo, Diclo+MEGL

Figure 4.20 shows the percentage of HRBC membrane protection provided by MEGL, Diclo, and Diclo+MEGL. The values are presented as the mean ± SD, and there were three groups in each. The data was analyzed statistically in comparison to the inflammatory control, as measured by GraphPad Prism software.

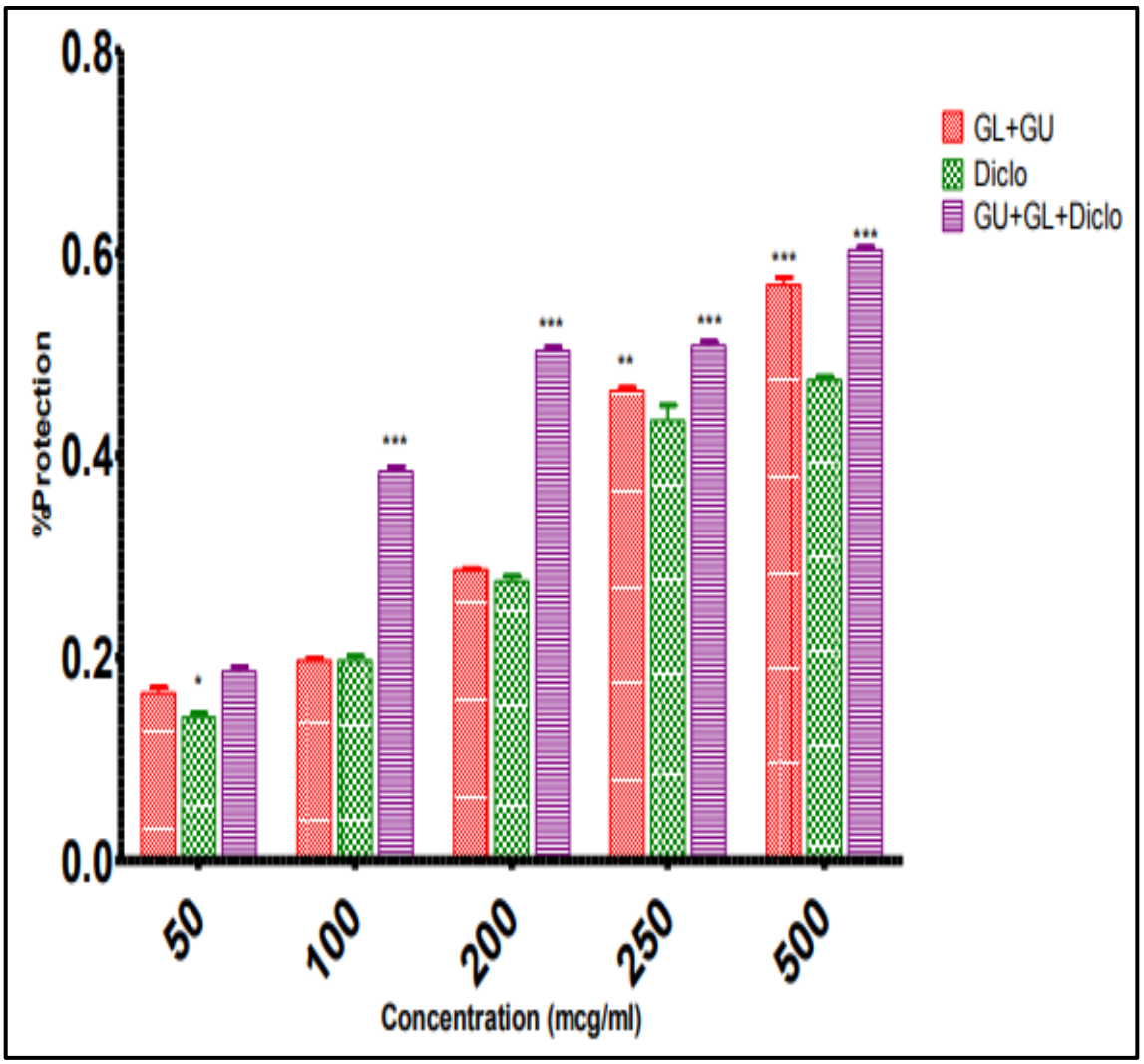


Figure 4. 22 % protection of HRBC membrane by MEGL+GU, Diclo, Diclo+MEGL+GU

The figure shows the 4.21% protection of the HRBC membrane by MEGL+GU, Diclo, and Diclo+MEGL+GU. The values are presented as the mean ± SD, and there are three groups in each group. For the statistical examination of the data, GraphPad Prism was used, along with a Bonferroni multiple comparison test and a two-way analysis of variance (ANOVA). A significance level of *P < 0.05, **P < 0.01 and ***P < 0.001 was used to denote statistical significance in comparison to the inflammatory control.

4.11 IN-VITRO STUDY:

TABLE 4.14 HRBC Method for MEGN, METPH, MEGL, MEGL+GU using Etodolac standard

Groups	% Protection				
	50(µg/ml)	100(µg/ml)	200(µg/ml)	250(µg/ml)	500(µg/ml)
Group –I MEGN (25mg/10ml)	0.150± 0.007	0.168± 0.005	0.286± 0.002	0.463± 0.005	0.568± 0.012
Group-II Eto (25 mg/10 ml)	0.139± 0.004	0.197± 0.007	0.208± 0.010	0.434± 0.026	0.474± 0.005
Group III Eto+MEGN 12.5mg+12.5mg=25 mg/10ml)	0.178± 0.004	0.216± 0.005	0.317± 0.005	0.503± 0.006	0.604± 0.007

The protection of the HRBC membrane was examined in Table 4.15 by comparing the effects of MEGN, ETO, and Eto+MEGN. Data are presented as the mean ± SD, and each group consisted of three individuals. ***P < 0.001 was, **P < 0.01, and *P < 0.05 was also used to compare the results to the inflammatory control in the statistical analysis conducted using GraphPad Prism program.

TABLE 4. 15 Effect of METPH, Eto and Eto+METPH on HRBC membrane protection

Groups	% Protection				
	50(µg/ml)	100(µg/ml)	200(µg/ml)	250(µg/ml)	500(µg/ml)
Group –I METPH (25mg/10ml)	0.153± 0.005	0.269± 0.008	0.510± 0.007	0.578± 0.045	0.654± 0.008
Group-II Eto (25 mg/10 ml)	0.137± 0.005	0.195± 0.005	0.275± 0.008	0.434± 0.026	0.667± 0.03
Group III Eto+METPH (12.5mg+12.5mg=25 mg/10ml)	0.176± 0.007	0.321± 0.02	0.586± 0.007	0.684± 0.007	0.884± 0.007

The mean ± SD is shown for each group's findings, and the GraphPad Prism tool was used for statistical analysis. *P < 0.05, **P < 0.01 and ***P < 0.001 were the significant thresholds when contrasted with the inflammatory control. Table 4.16 shows the effects of METPH, Eto, and Eto+METPH on the protection of the HRBC membrane.

TABLE 4.16 Effect of MEGL, Eto and Eto+MEGL on HRBC membrane protection

Groups	% Protection				
	50(µg/ml)	100(µg/ml)	200(µg/ml)	250(µg/ml)	500(µg/ml)
Group –I MEGL (25mg/10ml)	0.150± 0.007	0.168± 0.005	0.286± 0.002	0.463± 0.005	0.568± 0.01
Group-II Eto (25 mg/10 ml)	0.139± 0.004	0.197± 0.007	0.208± 0.01	0.434± 0.026	0.474± 0.005
Group III Eto+MEGL (12.5mg+12.5mg=25 mg/10ml)	0.604± 0.007	0.503± 0.006	0.317± 0.005	0.216± 0.005	0.178± 0.004

The impact of MEGL, Eto, and Eto+MEGL on the protection of the HRBC membrane is shown in Table 4.17. The results are presented as the mean ± SD, and there were three groups in each. The data was analyzed statistically using GraphPad Prism software.

TABLE 4. 17 Effect of MEGL+GU, Eto and Eto+MEGL+GU on HRBC membrane protection

Groups	% Protection				
	50(µg/ml)	100(µg/ml)	200(µg/ml)	250(µg/ml)	500(µg/ml)
Group–I MEGL+GU (25mg/10ml)	0.176± 0.007	0.321± 0.021	0.486± 0.007	0.584± 0.007	0.784± 0.007
Group-II Eto (25 mg/10 ml)	0.139± 0.004	0.197± 0.007	0.208± 0.010	0.434± 0.0263	0.474± 0.005
Group-III Eto+MEGL+GU (12.5 mg+12.5mg =25 mg/10ml)	0.604± 0.007	0.503± 0.006	0.317± 0.005	0.216± 0.0055	0.178± 0.004

Table 4.18 Effect of MEGL+GU, Eto and Eto+MEGL+GU on HRBC membrane protection; Results are presented as the average plus or minus the standard deviation, with three participants in each group. With significance levels of *P < 0.05, **P < 0.01 and ***P < 0.001, the findings were compared to the inflammatory control in the statistical analysis that was carried out using GraphPad Prism software.

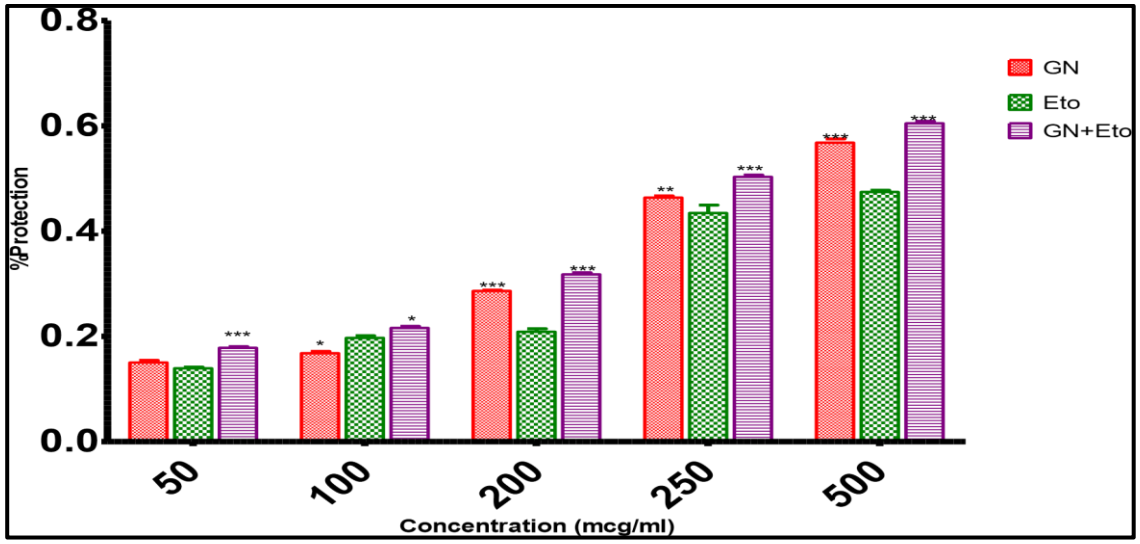


Figure 4. 23 % protection of HRBC membrane by MEGN, Eto, ETO+MEGN

The figure shows the 4.22% protection of the HRBC membrane by MEGN, Eto, and ETO+MEGN. The data is shown as the average plus or minus the standard deviation, and every group has three categories. In comparison to the inflammatory control research, the data was statistically examined using GraphPad Prism software, with significance levels of *P < 0.05, **P < 0.01, and ***P < 0.001.

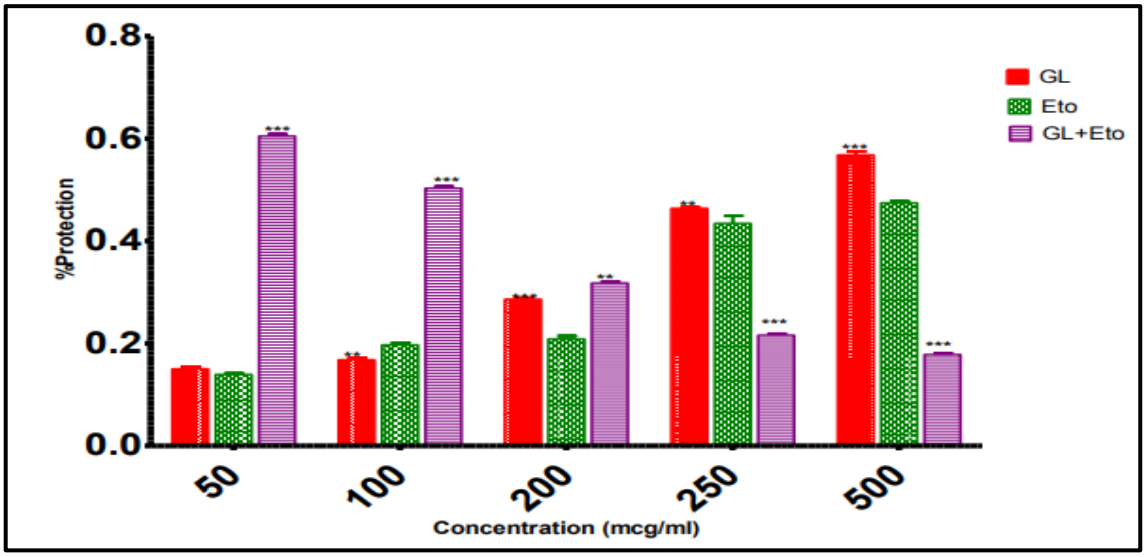


Figure 4. 24 % protection of HRBC membrane by MEGL, ETO, ETO+MEGL

Results show that MEGL, ETO, and ETO+MEGL protected the HRBC membrane by 4.23%. Each group had three subjects, and the data was analyzed statistically using GraphPad Prism software with a two-way ANOVA and Bonferroni multiple were the significant thresholds when contrasted with the inflammatory control.

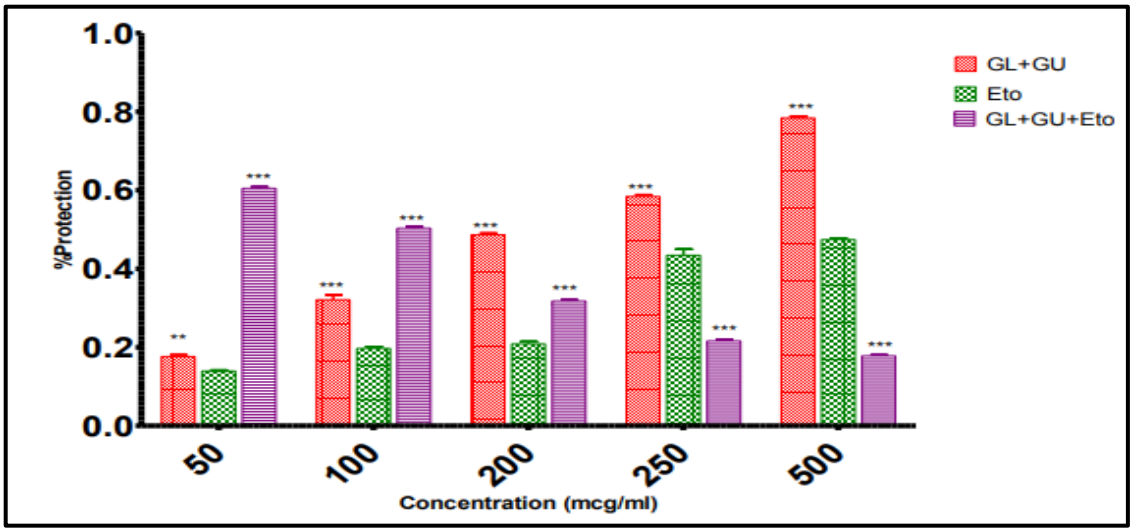


Figure 4.25 % protection of HRBC membrane by MEGL+GU, ETO, ETO+MEGL+GU

The HRBC membrane was protected by MEGL+GU, ETO, and ETO+MEGL+GU to a degree of 4.24%. The data are shown as means ± SD, and there were three groups in each. The statistical analysis was conducted in GraphPad Prism using a two-way analysis of variance (ANOVA) and a Bonferroni multiple comparison test. "The findings were statistically significant (**P < 0.01, ***P < 0.001) when compared to the inflammatory control group.

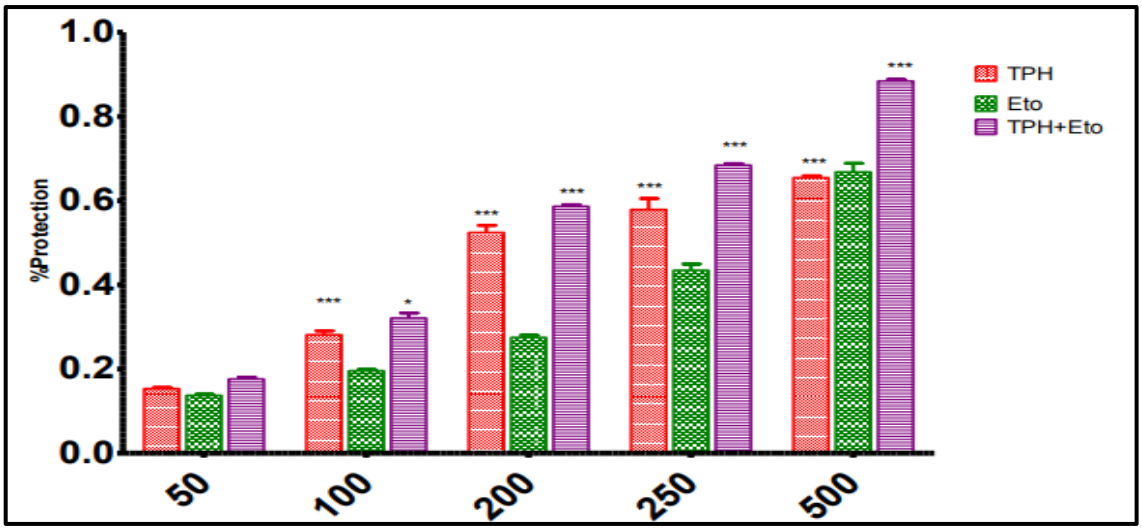


Figure 4. 26 % protection of HRBC membrane by METPH, ETO, ETO+METPH

The HRBC membrane is protected by METPH, ETO, and ETO+METPH to a 25% extent (Figure 4.25) with three samples per group (n=3). *P < 0.05, **P < 0.01, and ***P < 0.001 were used to compare the results to the inflammatory control in the statistical analysis conducted using GraphPad Prism program.

4.12 INHIBITION OF PROTEINASE ACTIVITY WITH STANDARD DICLOFENAC SODIUM

TABLE 4.19 Inhibition of protein (albumin) denaturation by MEGN, Diclo, MEGN+Diclo

Groups	% Protection				
	200 (µg/ml)	**400 (µg/ml)**	**600 (µg/ml)**	**800 (µg/ml)**	**1000 (µg/ml)**
Group-II Diclo (25 mg/10 ml)	23.270± 5.26	26.100 ±1.46	43.450 ±2.41	58.560± 2.53	63.370± 2.78
Group III Diclo+MEGN (12.5mg+12.5mg=25 mg/10ml)	59.62± 0.731	55.650 ±2.34	44.150 ±1.78	31.510 ±1.33	28.230 ±3.14

Results show that MEGN, Diclo, and MEGN+Diclo inhibited albumin denaturation. Each group had three subjects, GraphPad Prism, together with two-way ANOVA and the Bonferroni multiple comparison test, was used to statistically analyze the data. When compared to the inflammatory control, the significant thresholds were *P < 0.05, **P < 0.01 and ***P < 0.001.

TABLE 4. 18 Inhibition of protein (albumin) denaturation by METPH, Diclo, METPH+Diclo

Groups	% Protection				
	200 (µg/ml)	400 (µg/ml)	600 (µg/ml)	800 (µg/ml)	1000 (µg/ml)
Group –I METPH (25mg/10ml)	36.180± 2.09	42.1± 1.82	47.420± 1.94	51.66± 1.15	53.68± 1.23
Group-II Diclo (25 mg/10 ml)	31.93± 1.27	36.43± 2.27	40.450± 0.59	43.560± 1.29	47.70± 1.61
Group-III Diclo+METPH (12.5mg+12.5mg=25 mg/10ml)	40.29± 1.04	43.650± 0.88	46.483± 0.77	51.17± 1.20	55.56± 1.39

Inhibition of protein denaturation by METPH, Diclo, and METPH+Diclo is shown in Table 4.20. Values are presented as mean ± SD, and there are three groups in each. For statistical analysis, GraphPad Prism was used.

TABLE 4.19 Inhibition of protein (albumin) denaturation by MEGL, Diclo, MEGL+Diclo

Groups	% Protection				
	200 (µg/ml)	400 (µg/ml)	600 (µg/ml)	800 (µg/ml)	1000 (µg/ml)
Group –I MEGL (25mg/10ml)	2.84± 1.62	36.78± 1.83	41.75± 1.45	45.330± 1.01	49.01± 1.71
Group-II Diclo (25mg/10 ml)	31.93± 1.27	36.43± 2.27	40.450± 0.59	43.560± 1.29	47.70± 1.61
Group-III Diclo+MEGL (12.5mg+12.5mg=25 mg/10ml)	40.29± 1.04	43.650± 0.88	46.48± 0.77	49.510± 0.67	53.230± 0.86

The protein denaturation inhibition by MEGL, Diclo, and MEGL+Diclo is shown in Table 4.21. The values are presented as the mean ± SD, and there are three groups in

each. *P < 0.05, **P < 0.01, and ***P < 0.001 were used to compare the results to the inflammatory control in the statistical analysis conducted using GraphPad Prism program.

TABLE 4. 20 Inhibition of protein (albumin) denaturation by MEGL+GU, Diclo, MEGL+GU+Diclo

Groups	% Protection				
	200 (µg/ml)	400 (µg/ml)	600 (µg/ml)	800 (µg/ml)	1000 (µg/ml)
Group –I MEGL+GU (25mg/10ml)	30.18± 1.10	32.44± 1.30	35.420± 0.94	38.330± 1.01	41.68± 1.23
Group-II Diclo (25 mg/10 ml)	31.27± 0.73	36.43± 2.27	40.45± 0.59	43.56± 1.29	47.70± 1.61
Group III Diclo+MEGL+GU (12.5mg+12.5mg=25 mg/10ml)	40.29± 1.04	43.65± 0.88	46.48± 0.77	49.51± 0.67	52.23± 0.80

Inhibition of protein denaturation by MEGL+GU, Diclo, and MEGL+GU+Diclo is shown in Table 4.22. There are three groups in each set, and the data are shown as means ± SD. *P < 0.05, **P < 0.01, and ***P < 0.001 were used in the statistical analysis of the data, which was conducted using the GraphPad Prism program, in comparison to the inflammatory control..

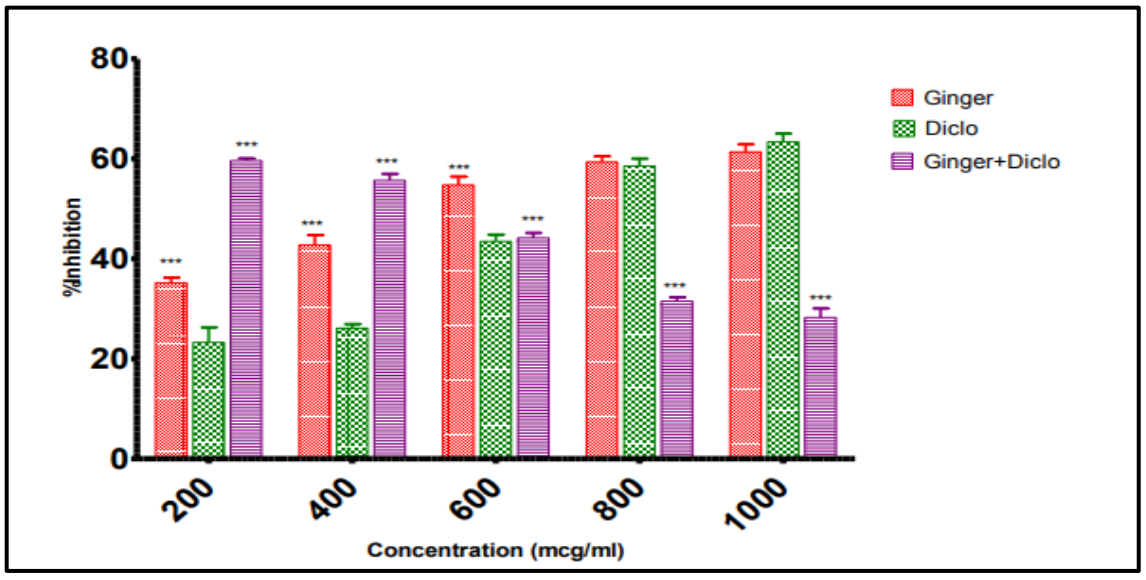


Figure 4. 27 % Inhibition of protein (albumin) denaturation by MEGN, Diclo, MEGN+Diclo

At 4.26 percent, Protein denaturation inhibition by MEGN, Diclo, and MEGN+Diclo; data shown as mean ± SD, with n=3 in each group; analyzed statistically using GraphPad Prism software.

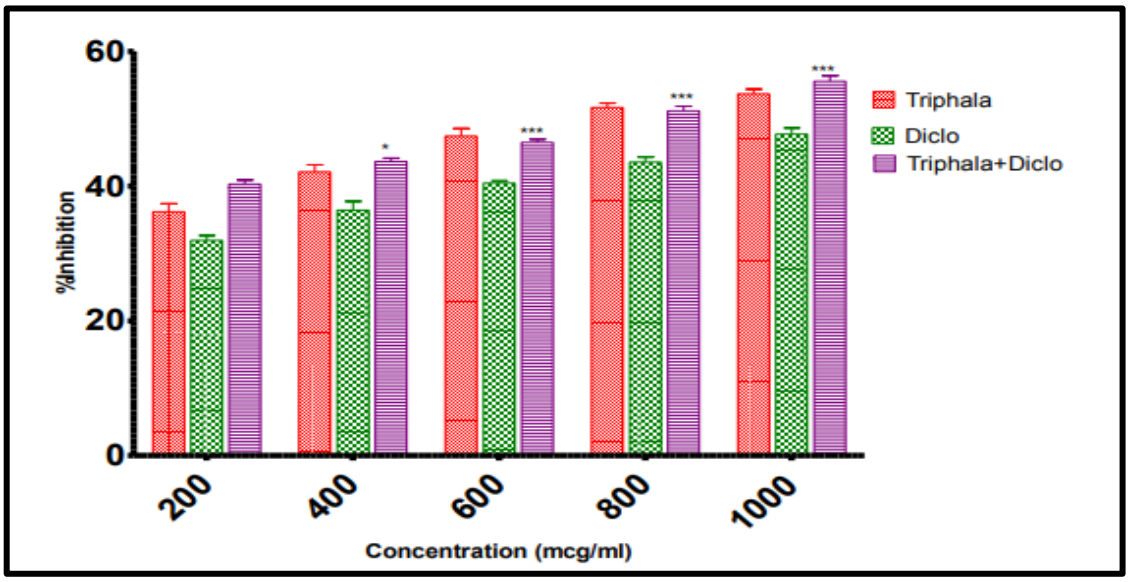


Figure 4. 28 % Inhibition of protein (albumin) denaturation by METPH, Diclo, METPH+Diclo

In Figure 4.27 percent This study examines the effects of METPH, Diclo, and METPH+Diclo on the denaturation of albumin protein. Each group consisted of three individuals, and the findings are shown as the mean plus or minus the standard deviation. The inflammatory control was used to compare the results, which were statistically evaluated using GraphPad Prism software, with significance levels of *P < 0.05, **P < 0.01, and ***P < 0.001.

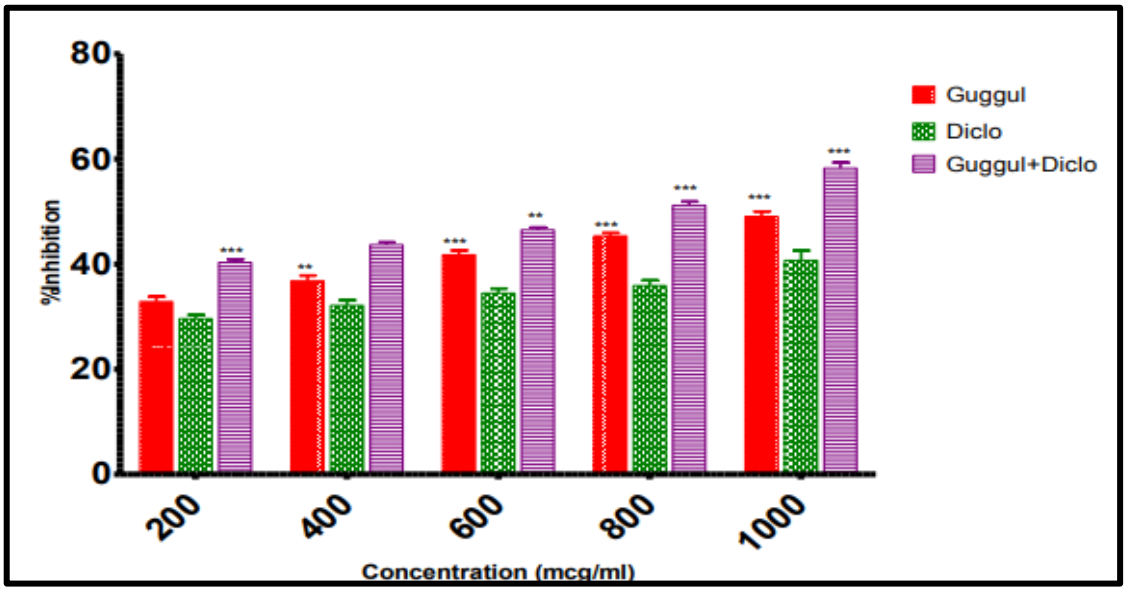


Figure 4. 29 % Inhibition of protein (albumin) denaturation by MEGL, Diclo, MEGL+Diclo

Four and a half percent Protein denaturation inhibition by MEGL, Diclo, and MEGL+Diclo; data shown as mean ± SD, with n=3 in each group; analyzed statistically The inflammatory control group was compared with the other group using GraphPad Prism software with a two-way ANOVA followed by a Bonferroni multiple comparison test; p-values were less than 0.05, 0.01 and 0.001, respectively.

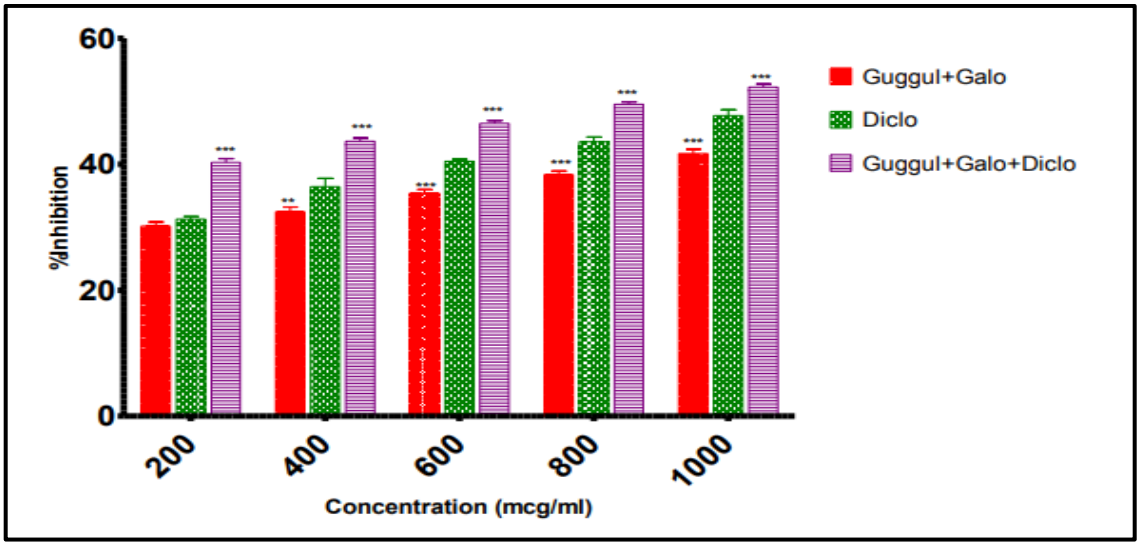


Figure 4. 30 % Inhibition of protein (albumin) denaturation by MEGL+GU, Diclo

At 4.29 percent, The denaturation of albumin protein can be inhibited by MEGL+GU, Diclo, and MEGL+GU+Diclo. Mean ± SD is how the findings are shown. and there are three groups in each group. The data was analyzed statistically using GraphPad Prism software.

4.13 INHIBITION OF PROTEINASE ACTIVITY WITH STANDARD ETODOLAC

Groups	% Protection				
	200 (µg/ml)	400 (µg/ml)	600 (µg/ml)	800 (µg/ml)	1000 (µg/ml)
Group –I MEGN (25mg/10ml)	27.596± 3.0	28.353± 1.14	25.83± 1.30	25.126± 1.57	23.516± 1.96
Group-II Eto (25 mg/10 ml)	23.270± 5.2	26.100± 1.4	30.116± 1.12	34.560± 1.79	39.370± 1.12
Group III ETO+MEGN (12.5 mg+12.5mg =25 mg/10ml)	40.29± 1.04	42.650± 0.88	45.48± 0.77	48.510± 0.670	51.230± 0.86

The protein denaturation inhibition by MEGN, Eto, and MEGN+Eto is shown in Table 4.23. The values are presented as the mean ± SD, and there are three groups in each. The data was analyzed statistically using GraphPad Prism software, with *P < 0.05, **P < 0.01, and ***P < 0.001 compared to the inflammatory control.

TABLE 4. 21 Inhibition of protein (albumin) denaturation by MEGN, Eto, MEGN+Eto

Groups	% Inhibition				
	200 (µg/ml)	400 (µg/ml)	600 (µg/ml)	800 (µg/ml)	1000 (µg/ml)
Group–I METPH (25mg/10ml)	30.180± 1.100	32.44± 1.30	35.420± 0.94	38.330± 1.01	41.68± 1.23
Group-II Eto (25 mg/10 ml)	31.270± 0.73	36.43± 2.27	40.450± 0.590	43.560± 1.29	47.70± 1.61
Group III ETO+METPH (12.5mg+12.5mg=25 mg/10ml)	40.293± 1.04	43.650± 0.88	46.483± 0.77	49.510± 0.67	52.230± 0.86

Results from the inhibition of protein denaturation by METPH, Eto, and METPH+Eto are presented in Table 4.24. With three participants in each group, we ran a two-way analysis of variance (ANOVA) and a Bonferroni multiple comparison test on the data in GraphPad Prism. In contrast to the inflammatory control group, the significance thresholds were *P < 0.05, **P < 0.01 and ***P < 0.001.

TABLE 4. 22 Inhibition of protein (albumin) denaturation by METPH, Eto, METPH+Eto

Groups	% Inhibition				
	200 (µg/ml)	400 (µg/ml)	600 (µg/ml)	800 (µg/ml)	1000 (µg/ml)
Group –I MEGL (25mg/10ml)	30.51± 1.42	33.11± 1.80	38.08± 0.58	38.99± 2.49	41.68± 2.09
Group III ETO+MEGL(12.5 mg+12.5mg =25 mg/10ml)	39.62± 0.73	37.983± 1.76	35.483± 2.29	33.510± 2.33	30.89± 2.21

Use of GraphPad Prism software and statistical tests including a two-way ANOVA and a Bonferroni multiple comparison test allowed for the statistical analysis of the mean ± SD data from each group. ***P < 0.001, **P < 0.01, and *P < 0.05 were used to compare the results to the inflammatory control. This information is presented in Table 4.25.

TABLE 4. 23 Inhibition of protein (albumin) denaturation by MEGL, Eto, MEGL+Eto

Groups	% Inhibition				
	200 (µg/ml)	400 (µg/ml)	600 (µg/ml)	800 (µg/ml)	1000 (µg/ml)
Group –I MEGL+GU (25mg/10ml)	30.18± 01.10	32.44± 1.30	35.420± 0.94	38.330 ±1.01	41.68± 1.23
Group-II Etodolac (25mg/10 ml)	31.27± 0.739	36.43± 2.27	40.450± 0.59	43.560± 1.29	47.70± 1.61
Group III ETO+MEGL+GU (12.5mg+12.5mg=25 mg/10ml)	40.29± 1.04	39.650± 1.20 3	37.816± 1.87	35.843± 1.85	30.89± 2.21

Table 4.26 shows the effects of MEGL+GU, Eto, and MEGL+GU+Eto on the denaturation of albumin protein. Displayed as the mean ± SD are the outcomes., and there were three groups in each group. The software used for statistical analysis was GraphPad Prism.

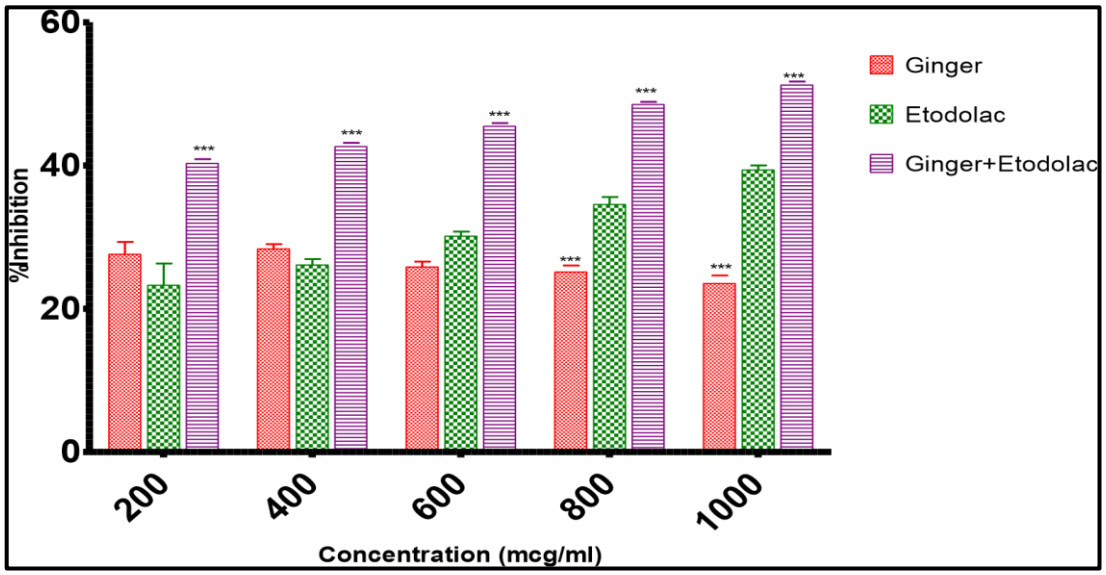


Figure 4. 31 % Inhibition of protein (albumin) denaturation by MEGN, Eto, MEGN+Eto

At 4.30 percent, The denaturation of albumin protein can be inhibited by MEGN, Eto, and MEGN+Eto. Displayed as the mean ± SD are the outcomes, each of which has three subgroups. *P < 0.05, **P < 0.01, and ***P < 0.001 were used to compare the results to the inflammatory control in the statistical analysis conducted using GraphPad Prism program.

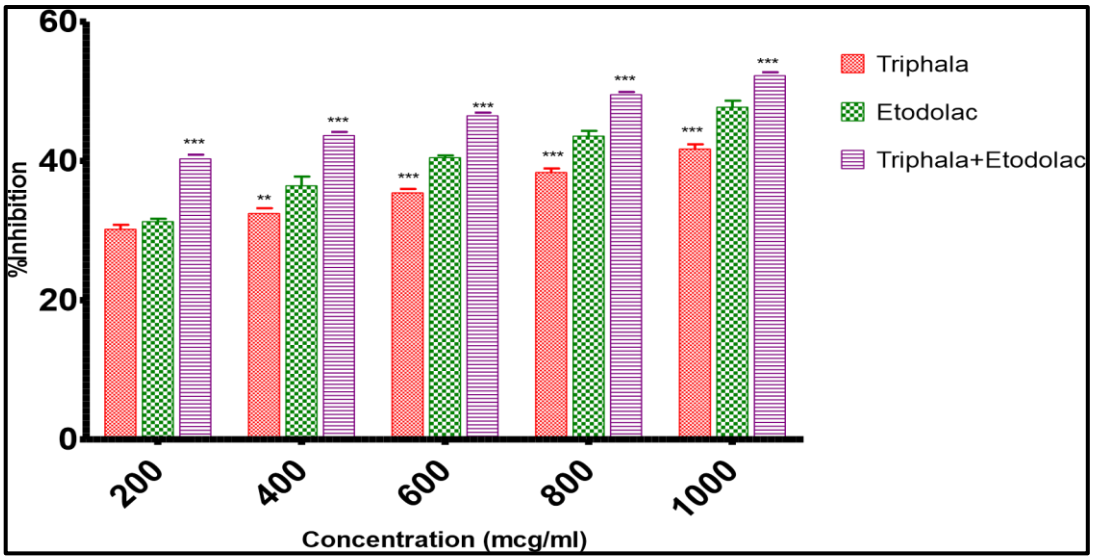


Figure 4. 32 % Inhibition of protein (albumin) denaturation by METPH, Eto, METPH+Eto

Represented as4.13% The denaturation of albumin protein can be inhibited by METPH, Eto, and METPH+Eto. There are three groups in each group, and the findings are shown as the mean ± standard deviation. *P < 0.05, **P < 0.01, and ***P < 0.001 were used to compare the results to the inflammatory control in the statistical analysis conducted using GraphPad Prism program.

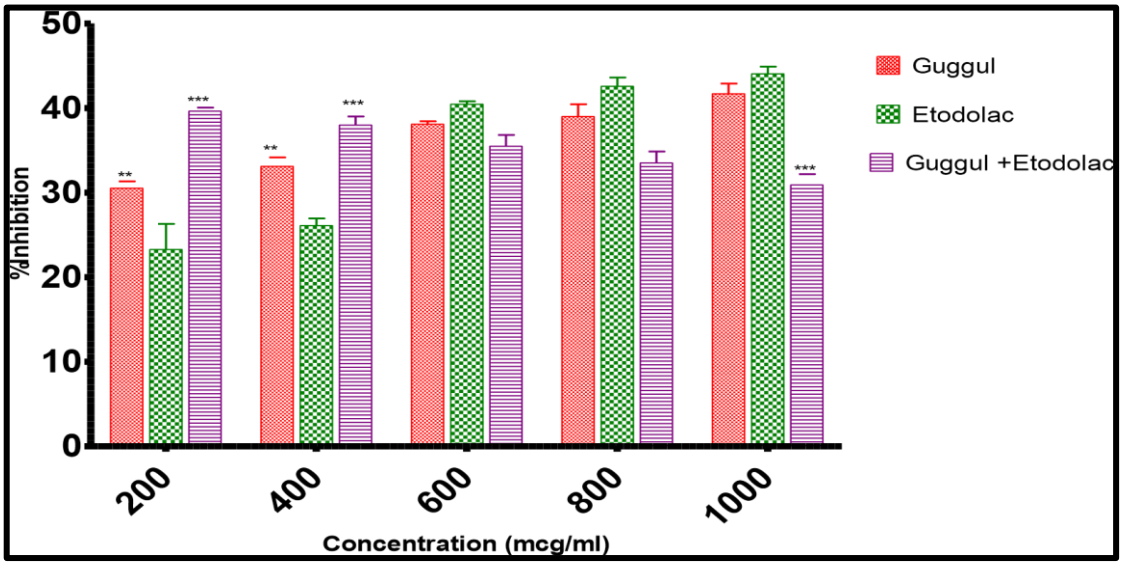


Figure 4. 33 % Inhibition of protein (albumin) denaturation by MEGL, Eto, MEGL+Eto

The figure shows 4.32% Protein denaturation inhibition by MEGL, Eto, and MEGL+Eto; results shown as mean ± SD, with n=3 in each group; GraphPad Prism software was used for statistical analysis, compared to the inflammatory control.

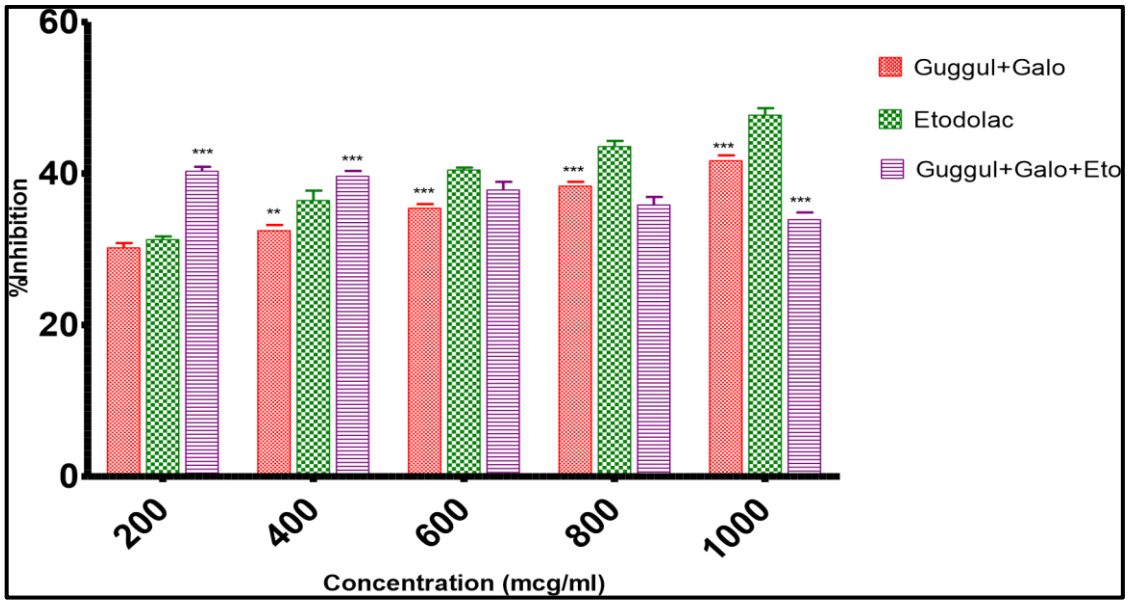


Figure 4. 34 % Inhibition of protein (albumin) denaturation by MEGL+GU, Eto, MEGL+GU+Eto

In Figure 4.33 % The denaturation of albumin protein can be inhibited by MEGL+GU, Eto, and MEGL+GU+Eto. and there are three groups in each group. *P < 0.05, **P < 0.01, and ***P < 0.001 were used in the statistical analysis of the data, which was conducted using the GraphPad Prism program, in comparison to the inflammatory controlled trial.l.

Chapter 5

CONCLUSION, RECOMMENDATIONS AND FUTURE SCOPE

5.1 CONCLUSION

Research into the anti-inflammatory effects of herbal remedies is an exciting and complex area. An urgent demand exists for inexpensive, safe, and effective therapeutic treatments due to the prevalence of inflammation as a pathogenic characteristic in both acute and chronic disorders. There is promising evidence that herbal medications, which are sourced from natural sources, may reduce inflammation via several pharmacological pathways. These all-natural substances regulate immunological responses, oxidative stress, and cytokine production via their interactions with several inflammatory pathways. Within this framework, there is significant potential for the scientific investigation of herbal therapies to provide new anti-inflammatory drugs that might supplement or even replace traditional pharmaceutical treatments.

The fact that herbal remedies have a long history of use in reducing inflammation is one of their main selling points. Traditional and indigenous medical systems have used plant-based formulations for inflammation-related diseases management for ages. These systems include Ayurveda, TCM, and Unani medicine. Thorough pharmacological and clinical investigations have confirmed these age-old assertions, shedding light on how they work and how effective they are as a treatment. Analgesic effects similar to those of conventional Curcumin, resveratrol, and other plant extracts have shown activities similar to those of NSAIDs. boswellic acids derived from turmeric, grapes, and Boswellia serrata, respectively. Based on these results, herbal substances may be a safer alternative to or supplement to more traditional medical treatments.

There are still a number of obstacles to overcome in order to evaluate and use herbal medications clinically, despite their great promise. Herbal extracts may vary greatly in composition depending on variables including growth circumstances, geographical location, and extraction processes, which is a big obstacle. A diverse variety of bioactive chemicals is commonly found in herbal preparations, in contrast to

manufactured medications that have well-defined molecular structures. Due to its intricacy, it is difficult to achieve standardization, quality control, and repeatability. But new bioinformatics techniques and improvements in phytochemical analysis have made it easier to characterize and standardize herbal extracts, making them more reliable and effective in therapeutic settings.

The possible toxicity and safety of herbal medications is another important factor to consider while evaluating them. Due to their all-natural composition, most herbal compounds are thought to be harmless. However, some, particularly when used in large quantities or in conjunction with other drugs, may cause unwanted side effects. Herbal remedies provide an already high risk of adverse effects when they include heavy metals, adulterants, or other pollutants. To evaluate the pharmacokinetics, toxicological profiles, and possible herb-drug interactions of herbal medications, as well as their safety for long-term use, rigorous clinical and preclinical trials are necessary. To reduce these dangers and encourage the safe incorporation of herbal treatments into conventional medicine, strict regulatory frameworks and quality assurance procedures are required.

Herbal medications are beneficial for drug development since their methods of action in inflammation regulation encompass various cellular and molecular targets. Research has shown that some herbal substances may affect important inflammatory mediators like NF-κB, COX-2, TNF-α, and interleukins. Instead of depending on synthetic pharmaceuticals with specific targets, which frequently have unwanted side effects, herbal medicines may provide a multi-targeted strategy to inflammation control by addressing multiple pathways. Another reason many herbal substances have anti-inflammatory benefits is because they are antioxidants. Antioxidants help reduce oxidative damage and free radicals, two major causes of chronic inflammation.

Collaborative efforts among ethnobotanists, pharmacologists, chemists, and clinical researchers are necessary for the successful integration of herbal medicines into contemporary healthcare. In order to systematically evaluate and validate herbal remedies, it is essential to bridge the gap between traditional knowledge and current scientific approaches. whether you want to know whether a herbal treatment is safe and effective, you have to do a clinical study. Unfortunately, large-scale clinical studies on herbal treatments have been delayed by regulatory hurdles and a lack of finance, which has prevented their broad acceptance. Overcoming these obstacles and improving the

credibility of herbal-based anti-inflammatory treatments would need setting clear standards for clinical assessment and encouraging investment in herbal medicine research.

In addition, by taking into account certain genetic, metabolic, and lifestyle characteristics, personalized medicine techniques may improve the effectiveness of herbal therapies. There may not be a perfect solution because of the wide range of reactions that patients have to herbal remedies. Recent developments in genomics and metabolomics have the potential to find biomarkers that can be used to forecast how different individuals will react to herbal components. This might lead to more personalized herbal treatments that are safer and more effective. Herbal remedies for inflammatory disorders may be fine-tuned with the use of precision medicine techniques to improve therapeutic effects.

Herbal medications include anti-inflammatory properties as well as the ability to help with metabolic disorders, cardiovascular illnesses, and neurodegenerative diseases, all of which are linked to inflammation. The favorable effects on various physiological systems are known as pleiotropic effects, and many herbal substances display these properties. Green tea's (Camellia sinensis) polyphenols and citrus fruits' flavonoids, for instance, offer several anti-inflammatory, metabolic, and cognitive health benefits. These supplementary health advantages lend credence to the idea that herbal medicines should be a part of comprehensive treatment plans for chronic illnesses because of the interrelated nature of these conditions.

Responsible and informed use of herbal medicines requires public knowledge and education of their scientific basis. People may become too dependent on unproven medicines or completely skeptical of the efficacy of herbal therapy due to misconceptions and disinformation. It is essential for healthcare providers to advise patients against self-medication and unregulated goods while directing them toward herbal remedies supported by evidence. Creating more accessible information, educational initiatives, and training for healthcare providers to increase public awareness about herbal medicine will help promote a more educated and balanced approach to using herbal treatment.

Finally, research on herbal remedies' anti-inflammatory effects highlights their enormous promise as effective treatment options. Consistent improvements in scientific

research are gradually resolving issues related to safety, standardization, and regulatory impediments. With strong clinical evidence and multidisciplinary teamwork behind herbal medicines, contemporary medicine has the potential to provide safer, more effective, and holistic therapy alternatives for inflammatory disorders. Herbal medicine's future in inflammation control seems bright, opening the door to creative and long-term healthcare solutions that combine traditional knowledge with current scientific rigor. Improving patient outcomes and making a worldwide impact on healthcare can only be achieved by fully realizing the therapeutic potential of herbal medicines via more research, funding, and legislative measures.

5.2 RECOMMENDATIONS

Research, clinical use, and regulatory acceptability of herbal-based anti-inflammatory therapy may be advanced based on the examination of herbal medicines for their anti-inflammatory properties:

1. **Comprehensive Scientific Validation** – To determine the effectiveness and safety of herbal anti-inflammatory drugs, thorough in vitro, and clinical investigations should be conducted in the future. It is recommended to use cutting-edge techniques like molecular docking, high-throughput screening, and omics technologies to comprehend how they work.

2. **Standardization and Quality Control** – Strict quality control methods should be used for herbal formulations to guarantee that the amounts of bioactive compounds are consistent. Preserving the medicinal efficacy of plant extracts will need their standardization according to active phytochemicals.

3. **Clinical Trials and Regulatory Approvals** – To prove that herbal remedies may really treat medical conditions, large-scale, well planned clinical studies are required. In order to ease the introduction of herbal anti-inflammatory medications into conventional medicine, regulatory bodies should provide transparent standards for their evaluation and approval.

4. **Sustainable Cultivation and Ethical Sourcing** – Sustainable agriculture is crucial in the fight against medicinal plant overharvesting and biodiversity loss, which is being driven by the rising demand for these plants. Traditional healers

and indigenous communities should be supported via the implementation of fair trade regulations and ethical sourcing practices.

5. **Integration into Conventional Medicine** – To close the gap between conventional medical wisdom and scientific proof, it is recommended that scientists and practitioners of traditional medicine work together. A part of complementary and integrative medicine should include herbal remedies that have been shown to work.

6. **Public Awareness and Education** – Healthcare providers and the general population need to be informed about the advantages, disadvantages, and correct use of herbal remedies for inflammation control via awareness campaigns.

5.3 FUTURE SCOPE

There is a great deal of untapped potential for herbal medicines as anti-inflammatory treatments in the future, as scientists work to improve their safety, effectiveness, and therapeutic utility. Herbal chemicals like curcumin and boswellic acids are being studied for ways to enhance their bioavailability and targeted action using advanced drug delivery methods. These technologies include phytosome technology, nanoparticles, and liposomal encapsulation. In order to maximize medicinal yields, it is possible to conduct genetic and metabolomic research to determine which plant strains are the most effective. To further guarantee dosing uniformity and reduce the likelihood of side effects, another important area of research is the standardization of herbal formulations via extensive clinical studies and regulatory clearances. Research into herbal medicines that makes use of AI and ML may also improve formulation optimization, therapy personalization, and the prediction of chemical interactions. Alternative and integrative medicine is poised to benefit greatly from herbal medications, which provide a safer alternative to pharmaceutical anti-inflammatory drugs, as the popularity of natural and holistic healthcare continues to rise. To make sure they can be effectively integrated into mainstream healthcare systems, future research should also look at possible drug-herb interactions and evaluate their safety over the long term.

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43. Guleria, Sanjay et al., (2021) Inflammation, a kind of innate immunity, is a biological response of body tissues towards various harmful stimuli. It is known to be initiated as a normal body defense mechanism during injury, exposure to contaminants, radioactive substances, toxicants as well as allergens and infection by a plethora of agents like microbes, viruses. Inflammation is involved in a host of diseases like rheumatoid arthritis, atherosclerosis, obesity, and even cancer. Several inflammatory mediators are produced and secreted at the time of

inflammatory responses of different kinds (interferons, interleukins, and tumor necrosis factor-α). Inflammation is associated with the characteristics like pain, swelling, redness, loss of function in the affected area and heat accumulation in the inflamed area. A significant role in human health is being played by natural products with respect to preventing and treating inflammatory conditions. Besides various synthetic anti-inflammatory agents (non-steroidal anti-inflammatory drugs (NSAIDs)) available, herbal medicine still plays a major role to cure various health conditions as large number of medicinal plants possess secondary compounds that retard the key steps of the inflammation pathway (the nuclear factor NF-κβ, lipoxygenase and cyclooxygenase). In addition, many of them exhibit excellent free radical scavenging properties. Many studies have reported about the potential role of herbal medicines in suspending inflammation. This communication summarizes the published literature regarding the anti-inflammatory activities of plant extracts, essential oils, and plant-derived compounds along with the underlying molecular mechanisms of their role in inflammation-mediated metabolic diseases. The huge range of research as well as review papers that have reported about the anti-inflammatory effects of essential oils, plant extracts, and/or pure compounds derived from natural products has also been summarized in this chapter. Moreover, this chapter also presents some latest data on some traditionally used medicinal plants that were not investigated yet in this respect.

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COMPARATIVE STUDY OF ANTI-INFLAMMATORY EFFECTS OF TURMERIC AND GINGER EXTRACTS

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ABSTRACT

Inflammation is a complex biological response to injury or infection, and its chronic persistence contributes to various degenerative diseases. The present study aims to compare the anti-inflammatory effects of turmeric (Curcuma longa) and ginger (Zingiber officinale) extracts, two widely used medicinal plants known for their therapeutic properties. Both extracts contain bioactive compounds—curcumin in turmeric and gingerol in ginger—that modulate inflammatory pathways by inhibiting key enzymes such as COX and LOX, and suppressing pro-inflammatory mediators like TNF-α and IL-6. Experimental analysis revealed that both extracts significantly reduce inflammation, with turmeric showing slightly higher efficacy due to its broader regulatory effect on gene expression. The comparative evaluation highlights the potential of these herbs as natural alternatives to synthetic anti-inflammatory drugs, supporting their combined or individual use in herbal medicine. This study reinforces traditional knowledge and provides a scientific basis for their therapeutic applications.

I. INTRODUCTION

Inflammation is a complex biological response of vascular tissues to harmful stimuli such as pathogens, damaged cells, or irritants. It represents a vital part of the body's immune defense mechanism, designed to eliminate the initial cause of cell injury, clear out necrotic cells and tissues, and establish tissue repair. While acute inflammation is a beneficial and necessary response for survival, chronic inflammation often becomes detrimental, contributing to a wide range of pathological conditions such as rheumatoid arthritis, cardiovascular diseases, diabetes, asthma, cancer, and neurodegenerative disorders. The persistent activation of inflammatory pathways leads to tissue destruction, altered cellular signaling, and metabolic dysfunction. Modern medical science has developed numerous synthetic anti-inflammatory drugs to counter these effects, including non-steroidal anti-inflammatory drugs (NSAIDs) and corticosteroids. However, long-term use of these medications often results in adverse side effects, such as gastrointestinal ulcers, renal toxicity, liver damage, and increased cardiovascular risk, prompting the need for safer and more sustainable therapeutic alternatives.

Traditional medicine systems, particularly Ayurveda, Traditional Chinese Medicine, and Unani, have long utilized plant-based remedies to manage inflammation and related disorders. Among these, turmeric (*Curcuma longa*) and ginger (*Zingiber officinale*) hold a prominent place due to their potent anti-inflammatory, antioxidant, and immunomodulatory properties. Both belong to the Zingiberaceae family and are extensively cultivated and consumed throughout Asia and other tropical regions. Turmeric and ginger have not only been used as culinary spices but also as medicinal agents for treating a variety of ailments, including digestive issues, respiratory infections, joint pain, and wound healing. Their long history of traditional use has encouraged scientific investigations into their pharmacological activities, revealing that both plants contain a wide range of bioactive compounds capable of influencing multiple biochemical pathways involved in inflammation.

The major active constituent of turmeric is curcumin, a polyphenolic compound responsible for its bright yellow color and therapeutic potential. Curcumin exhibits a broad spectrum of biological activities, including anti-inflammatory, antioxidant, antimicrobial, and anticancer effects. Extensive research has demonstrated that curcumin modulates inflammation through various molecular mechanisms. It suppresses the activation of transcription factors such as nuclear factor-kappa B (NF-κB) and activator protein-1 (AP-1), which regulate the expression of pro-inflammatory genes. Curcumin also inhibits enzymes like cyclooxygenase-2 (COX-2), lipoxygenase (LOX), and inducible nitric oxide synthase (iNOS), thereby reducing the production of inflammatory mediators such as prostaglandins, leukotrienes, and nitric oxide. Additionally, it downregulates cytokines including tumor necrosis factor-alpha (TNF-α), interleukin-1 beta (IL-1β), and interleukin-6 (IL-6), which play key roles in sustaining chronic inflammation. Its antioxidant activity complements these effects by scavenging free radicals and protecting cells from oxidative stress, a process closely associated with inflammation.

Ginger, another rhizomatous plant, contains a series of bioactive phenolic compounds such as gingerols, shogaols, paradols, and zingerone. Among these, 6-gingerol and 6-shogaol are primarily responsible for ginger's pharmacological activities. Like curcumin, gingerol

inhibits COX and LOX enzymes, leading to decreased prostaglandin and leukotriene synthesis. It also suppresses the activation of NF-κB and inhibits the release of inflammatory cytokines, thereby exerting both local and systemic anti-inflammatory effects. Ginger additionally influences calcium signaling in inflammatory cells, reducing vascular permeability and tissue swelling. Its antioxidant properties help neutralize reactive oxygen species (ROS) and prevent oxidative damage, further contributing to its anti-inflammatory potential. The combined effect of these mechanisms results in the attenuation of both acute and chronic inflammation, offering therapeutic value without the side effects associated with synthetic drugs.

Several experimental and clinical studies have validated the anti-inflammatory efficacy of turmeric and ginger. In animal models, turmeric extract has been shown to reduce carrageenan-induced paw edema, a standard test for anti-inflammatory activity. Similarly, ginger extract has demonstrated inhibitory effects on inflammatory markers in induced arthritis and colitis models. In clinical trials, both turmeric and ginger supplementation have been found to alleviate symptoms of osteoarthritis and rheumatoid arthritis, reduce joint pain, and improve mobility. These outcomes support the pharmacological relevance of their bioactive constituents and provide a scientific foundation for their continued use in traditional medicine. However, while both herbs share similar mechanisms, they differ in terms of potency, bioavailability, and duration of action.

Curcumin, though highly potent, suffers from low bioavailability due to poor absorption, rapid metabolism, and systemic elimination. Various strategies, such as the use of nanoparticles, liposomes, and piperine co-administration, have been developed to enhance its absorption and efficacy. In contrast, gingerol is more readily absorbed and provides quicker relief, though its effect may not last as long as curcumin's sustained action. These differences suggest that while both turmeric and ginger independently possess significant anti-inflammatory effects, their combination may yield synergistic benefits. A formulation combining both extracts could target multiple pathways simultaneously, offering enhanced therapeutic outcomes for both acute and chronic inflammatory conditions.

II. MECHANISMS AND COMPARATIVE ANALYSIS OF ANTI-INFLAMMATORY ACTION

The anti-inflammatory properties of turmeric (*Curcuma longa*) and ginger (*Zingiber officinale*) arise from their bioactive constituents—curcumin and gingerol—which act through multiple molecular mechanisms to modulate inflammation. Both compounds interact with enzymatic, genetic, and cellular targets to reduce the production of pro-inflammatory mediators, suppress oxidative stress, and enhance immune regulation. However, despite their structural similarities, turmeric and ginger exhibit distinct pharmacodynamic characteristics that define their comparative anti-inflammatory profiles.

Inflammation begins when harmful stimuli activate immune cells such as macrophages, neutrophils, and mast cells. These cells release cytokines like tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6), and interleukin-1 beta (IL-1β), which trigger downstream signaling cascades. A key regulatory protein in this process is nuclear factor kappa B (NF-κB), which controls the transcription of genes responsible for producing inflammatory enzymes such as cyclooxygenase-2 (COX-2) and lipoxygenase (LOX). Both curcumin and gingerol act by inhibiting NF-κB activation, thereby preventing the expression of these

enzymes and reducing prostaglandin and leukotriene synthesis—critical mediators of pain, swelling, and fever.

Curcumin, the principal curcuminoid in turmeric, exhibits a broad spectrum of anti-inflammatory activity through its interaction with multiple signaling pathways. It inhibits COX-2, LOX, and inducible nitric oxide synthase (iNOS), leading to a marked decrease in inflammatory mediators such as nitric oxide and prostaglandins. Curcumin also modulates the Janus kinase/signal transducer and activator of transcription (JAK/STAT) pathway and suppresses mitogen-activated protein kinase (MAPK) signaling, thereby reducing the transcription of pro-inflammatory genes. In addition, its strong antioxidant property allows it to neutralize reactive oxygen species (ROS), preventing oxidative stress-induced activation of inflammatory cascades. These combined effects make curcumin effective in controlling both acute and chronic inflammation, including diseases such as arthritis, inflammatory bowel disease, and metabolic syndrome.

Gingerol, the major phenolic compound in ginger, operates through somewhat different but complementary mechanisms. It inhibits COX and LOX enzymes like curcumin but also influences calcium channels involved in cellular signaling, thereby reducing the release of histamine and other inflammatory mediators. Gingerol suppresses TNF-α and IL-1β expression and reduces vascular permeability, which limits the migration of inflammatory cells to the affected tissues. Moreover, 6-shogaol, a dehydration product of gingerol formed during drying or heating, exhibits even stronger anti-inflammatory potential by blocking NF-κB activation and reducing nitric oxide production. These properties enable ginger to act rapidly, providing quicker relief in conditions characterized by acute inflammation and pain.

When compared, turmeric and ginger show significant overlap in their mechanisms but differ in their intensity and duration of action. Curcumin tends to have a longer-lasting regulatory effect due to its impact on gene transcription and signaling networks, whereas gingerol provides a faster biochemical response through enzyme inhibition and ion channel modulation. The bioavailability of curcumin is relatively low, limiting its systemic effects, whereas gingerol is absorbed more efficiently and exerts quicker pharmacological actions. Nonetheless, curcumin’s broader range of targets and stronger antioxidant effect make it more effective in chronic inflammatory conditions, while ginger is particularly beneficial for short-term or acute inflammation.

The theoretical integration of these findings suggests a potential synergistic interaction when turmeric and ginger are used together. Curcumin’s ability to regulate gene expression complements gingerol’s rapid enzymatic inhibition, allowing for both immediate and sustained anti-inflammatory effects. Such combination therapy could enhance therapeutic outcomes, reduce dosage requirements, and minimize side effects compared to synthetic anti-inflammatory drugs.

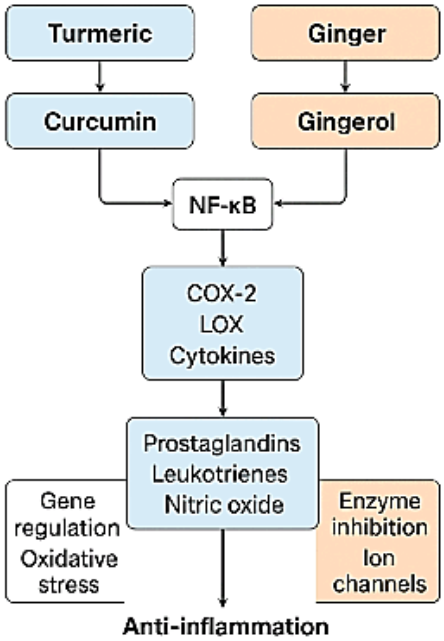


Figure 1: Mechanisms of Anti-inflammatory Action of Turmeric and Ginger Extracts

The comparative analysis of turmeric and ginger highlights the complexity and effectiveness of plant-derived compounds in inflammation management. Their ability to modulate multiple pathways simultaneously demonstrates the advantage of herbal medicines over single-target synthetic drugs. By combining turmeric's prolonged gene-level modulation with ginger's rapid biochemical inhibition, a holistic and balanced anti-inflammatory response can be achieved. This understanding not only validates traditional medicinal practices but also provides a scientific foundation for developing advanced herbal formulations and functional nutraceuticals aimed at inflammation control.

III. PHYTOCHEMICAL BASIS OF ANTI-INFLAMMATORY PROPERTIES IN TURMERIC AND GINGER

The anti-inflammatory effects of turmeric (*Curcuma longa*) and ginger (*Zingiber officinale*) stem primarily from their rich phytochemical composition, which consists of bioactive compounds such as curcuminoids, gingerols, shogaols, and other phenolic constituents. These compounds act through multiple biochemical and molecular pathways to suppress inflammation, oxidative stress, and immune hyperactivation. Phytochemicals are secondary metabolites produced by plants, not essential for primary metabolic functions but crucial for their defense mechanisms. In medicinal plants like turmeric and ginger, these metabolites serve as potent agents that modulate enzymes, cytokines, and signaling molecules involved in inflammation, making them powerful natural alternatives to synthetic anti-inflammatory drugs.

Turmeric contains more than 200 different compounds, with curcumin being the most important and extensively studied for its pharmacological effects. Curcumin, a bright yellow polyphenolic compound, constitutes about 2–5% of turmeric rhizome and is chemically known as *diferuloylmethane*. Its structure consists of two aromatic rings bearing o-methoxy and hydroxyl groups linked by a seven-carbon chain containing α,β-unsaturated carbonyl

groups. This conjugated structure allows curcumin to interact with multiple biomolecules, such as enzymes and transcription factors, that play key roles in inflammation. One of the main mechanisms through which curcumin exerts its anti-inflammatory action is the inhibition of nuclear factor kappa B (NF-κB), a transcription factor that regulates genes involved in the production of inflammatory mediators like tumor necrosis factor-alpha (TNF-α), interleukins (IL-1β, IL-6), and cyclooxygenase-2 (COX-2). By preventing the activation of NF-κB, curcumin effectively downregulates the synthesis of these pro-inflammatory molecules, thereby suppressing the inflammatory response at the genetic level.

Curcumin also modulates the activity of enzymes such as COX and lipoxygenase (LOX), which are responsible for the biosynthesis of prostaglandins and leukotrienes—both potent mediators of inflammation. Inhibiting these enzymes helps reduce swelling, redness, and pain associated with inflammatory processes. Moreover, curcumin exhibits strong antioxidant properties due to its ability to scavenge free radicals and reactive oxygen species (ROS), which are known to activate inflammatory pathways. Through its dual role as an antioxidant and anti-inflammatory agent, curcumin interrupts the feedback loop between oxidative stress and inflammation, providing protection against chronic inflammatory diseases such as arthritis, cardiovascular disorders, and metabolic syndrome.

Another important class of phytochemicals in turmeric includes turmerones, particularly *ar-turmerone*, which contributes to the modulation of inflammatory responses by inhibiting nitric oxide production in macrophages. These volatile oils enhance the bioavailability of curcumin and may have synergistic effects, amplifying the overall anti-inflammatory activity of turmeric. Additionally, turmeric contains small quantities of caffeic acid, ferulic acid, and vanillic acid—all of which possess antioxidant and anti-inflammatory actions, reinforcing the multi-targeted nature of turmeric's phytochemical composition.

In contrast, ginger owes its anti-inflammatory potency primarily to gingerols, shogaols, and paradols, which belong to a family of phenolic compounds. The most abundant among them, 6-gingerol, is chemically characterized by a hydroxylated phenolic structure with a carbon side chain. During heat processing or drying, gingerol converts into shogaol, a more stable and bioactive compound. Both these compounds exhibit strong inhibitory effects on prostaglandin and leukotriene synthesis by blocking COX and LOX enzymes. They also reduce the expression of inflammatory cytokines and suppress nitric oxide production by inhibiting inducible nitric oxide synthase (iNOS) in macrophages.

The anti-inflammatory mechanism of ginger phytochemicals also involves the inhibition of NF-κB activation, similar to curcumin, leading to reduced gene expression of pro-inflammatory mediators. In addition, gingerols modulate transient receptor potential vanilloid 1 (TRPV1) ion channels, which are involved in pain and inflammation signaling, resulting in decreased neurogenic inflammation. Ginger's bioactive constituents also interfere with calcium channel signaling, thereby inhibiting histamine release and vascular permeability. This combination of molecular actions enables ginger to provide both rapid and sustained anti-inflammatory effects.

Ginger is also rich in zingerone and paradols, which complement the anti-inflammatory role of gingerol and shogaol. Zingerone, formed upon cooking, exhibits free radical scavenging properties, reducing oxidative stress and the consequent activation of inflammatory genes. Paradols, derived from hydrogenation of shogaols, are known for their capacity to inhibit nitric oxide and prostaglandin synthesis, further enhancing the anti-inflammatory efficacy of

ginger extract. Collectively, these compounds establish ginger as a potent source of naturally occurring anti-inflammatory agents that work through multiple biochemical mechanisms.

Comparatively, the phytochemical basis of turmeric's anti-inflammatory action is centered around gene regulation and antioxidant modulation, whereas ginger's effects are primarily enzyme inhibition and signaling suppression. Curcumin exerts long-term gene-level modulation, reducing inflammation over a prolonged period, while gingerol and shogaol act more rapidly by directly interfering with inflammatory enzymes and receptor-mediated pathways. The synergy between these compounds suggests that combining turmeric and ginger could offer both immediate and sustained relief in inflammatory conditions.

Moreover, both turmeric and ginger have shown efficacy in various clinical studies targeting arthritis, muscle soreness, and inflammatory bowel disease. Their phytochemicals exhibit minimal toxicity compared to nonsteroidal anti-inflammatory drugs (NSAIDs), which often cause gastrointestinal and renal side effects. The diverse chemical structures and multi-targeted mechanisms of these natural compounds provide a comprehensive and balanced approach to managing inflammation.

IV. CONCLUSION

The comparative study of turmeric and ginger demonstrates that both possess potent anti-inflammatory properties, deeply rooted in their phytochemical composition. The active compounds—curcumin in turmeric and gingerol in ginger—act through multiple mechanisms to suppress inflammation, including inhibition of COX and LOX enzymes, modulation of cytokine production, and suppression of NF-κB activation. Turmeric exhibits long-term benefits due to its ability to regulate gene expression and reduce oxidative stress, while ginger provides faster relief through enzyme inhibition and receptor modulation. Together, they present a powerful, complementary approach to managing inflammation naturally. Their efficacy, coupled with minimal side effects compared to synthetic drugs, supports their integration into modern therapeutics. The findings reinforce the importance of traditional medicinal knowledge and highlight the need for continued research to optimize bioavailability, formulation, and dosage. Turmeric and ginger thus stand as evidence of how natural phytochemicals can provide safe, effective, and sustainable alternatives for inflammation management and overall health improvement.

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CLINICAL EVALUATION OF HERBAL POLYHERBAL OINTMENT FOR TOPICAL ANTI-INFLAMMATORY ACTION

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ABSTRACT

The study theoretically evaluates the clinical potential of a herbal polyherbal ointment formulated with extracts of Curcuma longa (turmeric), Boswellia serrata (frankincense), Azadirachta indica (neem), and Aloe vera for topical anti-inflammatory action. Each herb possesses proven anti-inflammatory, analgesic, and antioxidant properties that act synergistically to reduce pain, swelling, and redness in localized inflammatory conditions. The combined formulation is expected to inhibit proinflammatory mediators such as COX, LOX, and NF-κB while enhancing tissue repair and soothing effects. Theoretical analysis suggests that this multi-component ointment may provide a safer and more effective alternative to conventional nonsteroidal topical formulations. Further clinical validation through randomized controlled trials is warranted to confirm efficacy,

safety, and standardization of the product. This work highlights the integration of traditional herbal wisdom with modern pharmacological perspectives to develop a holistic and scientifically grounded approach to topical anti-inflammatory therapy.

Keywords: Polyherbal ointment, Anti-inflammatory action, Phytochemicals, Herbal medicine, Clinical evaluation

I. INTRODUCTION

Inflammation is one of the most fundamental biological responses of the human body to injury, infection, or irritation. It serves as a defense mechanism that eliminates harmful stimuli and initiates the healing process. However, excessive or prolonged inflammation often leads to pain, redness, swelling, and loss of function in the affected tissues. Chronic or poorly managed inflammation contributes to various disorders such as arthritis, dermatitis, muscular strain, and soft tissue injuries. The management of inflammation, therefore, remains an essential goal of both modern medicine and traditional healing systems. Topical anti-inflammatory agents are particularly valuable for localized conditions, as they provide targeted relief with minimal systemic side effects. However, the long-term use of synthetic or chemical-based formulations, particularly nonsteroidal anti-inflammatory drugs (NSAIDs) and corticosteroids, can lead to undesirable outcomes such as skin irritation, delayed wound healing, or systemic toxicity. In this context, the exploration of herbal and polyherbal formulations has emerged as a promising approach for developing safer, natural, and effective topical anti-inflammatory therapies.

The use of herbal medicines in treating inflammation is deeply rooted in traditional medical systems such as Ayurveda, Unani, and Traditional Chinese Medicine. These systems have long recognized the therapeutic potential of plants in managing inflammation and promoting healing. Over the past few decades, scientific research has confirmed that numerous plant-derived compounds possess potent anti-inflammatory, antioxidant, and analgesic properties. The global shift toward herbal and plant-based medicine has been driven by growing awareness of the side effects of synthetic drugs and the increasing demand for natural, holistic, and sustainable therapeutic options. Among these, polyherbal formulations—combinations of two or more medicinal plants—have gained special attention due to their synergistic effects and broad spectrum of pharmacological activity.

A polyherbal ointment containing *Curcuma longa* (turmeric), *Boswellia serrata* (Indian frankincense), *Azadirachta indica* (neem), and *Aloe vera* offers a scientifically grounded formulation that integrates centuries of traditional wisdom with modern pharmacological understanding. Each of these herbal ingredients has been extensively studied for its anti-inflammatory and healing potential. *Curcuma longa*, one of the most revered medicinal plants in Ayurveda, contains curcumin, a bioactive polyphenol that exerts potent anti-inflammatory and antioxidant actions. Curcumin inhibits the activation of nuclear factor-kappa B (NF-κB), a key transcription factor involved in the production of proinflammatory cytokines such as tumor necrosis factor-alpha (TNF-α) and interleukin-6 (IL-6). It also blocks cyclooxygenase-2 (COX-2) and lipoxygenase (LOX) enzymes, thereby reducing the formation of prostaglandins and leukotrienes—primary mediators of inflammation.

Similarly, *Boswellia serrata* resin, known for its boswellic acid content, has shown remarkable anti-inflammatory properties. Boswellic acids inhibit the enzyme 5-lipoxygenase (5-LOX), which plays a crucial role in leukotriene synthesis and the recruitment of inflammatory cells. The resin also stabilizes connective tissues, improves microcirculation, and reduces joint and tissue swelling. *Azadirachta indica*, commonly known as neem, contributes through its rich array of bioactive compounds including nimbidin, azadirachtin, and flavonoids. Neem is recognized for its anti-inflammatory, antimicrobial, and immunomodulatory effects. It suppresses histamine release, reduces prostaglandin synthesis, and helps prevent secondary infections that may accompany inflammatory conditions. *Aloe vera*, a well-known soothing and wound-healing agent, contains polysaccharides such as acemannan that promote tissue repair, collagen synthesis, and hydration. Its cooling and anti-inflammatory effects make it an ideal base component in topical formulations designed for inflamed or irritated skin.

The combination of these four herbs in a single formulation embodies the concept of synergism, where the therapeutic action of one component enhances or complements that of the others. While *Curcuma longa* and *Boswellia serrata* target key inflammatory pathways, *Azadirachta indica* provides antimicrobial protection and *Aloe vera* ensures hydration and tissue regeneration. This holistic approach is consistent with the Ayurvedic principle of "Samyoga" (synergy) and modern pharmacological concepts of multi-target drug design. Together, these herbs may produce more comprehensive therapeutic outcomes compared to single-ingredient preparations.

In addition to their biochemical mechanisms, the topical route of administration provides distinct advantages. By delivering active constituents directly to the site of inflammation, topical ointments allow for faster onset of action, reduced systemic exposure, and minimal adverse effects. The inclusion of *Aloe vera* as a gel base enhances the percutaneous absorption of other herbal compounds, ensuring optimal bioavailability. Such formulations are particularly beneficial for the management of acute musculoskeletal injuries, minor skin inflammations, sprains, and localized pain. Moreover, their natural composition makes them suitable for patients who cannot tolerate conventional topical NSAIDs or corticosteroids due to hypersensitivity or contraindications.

Despite the promising potential of herbal ointments, the scientific validation of their clinical efficacy remains limited. Many herbal preparations available in the market lack standardized formulations and rigorous clinical testing. This gap between traditional knowledge and modern evidence-based medicine underscores the need for systematic clinical evaluation. Theoretical studies, like the present one, provide a conceptual framework for understanding the potential therapeutic value of polyherbal ointments. They integrate available pharmacological data, traditional literature, and mechanistic insights to hypothesize clinical outcomes and guide future experimental research.

The theoretical clinical evaluation of the polyherbal ointment aims to establish its possible effectiveness, mechanism of action, and safety profile. It predicts that the combined activity of curcuminoids, boswellic acids, neem triterpenoids, and Aloe polysaccharides would synergistically reduce inflammation through inhibition of COX, LOX, and NF-κB pathways, as well as modulation of cytokine expression and oxidative stress. Furthermore, the formulation is expected to exhibit antimicrobial and wound-healing properties, accelerating tissue recovery and preventing infection-related complications.

II. PHYTOCHEMICAL BASIS OF ANTI-INFLAMMATORY ACTION

The anti-inflammatory potential of herbal medicines is primarily attributed to the presence of diverse phytochemicals—bioactive compounds produced by plants that exert therapeutic effects on various physiological pathways. These phytoconstituents, including polyphenols, terpenoids, flavonoids, alkaloids, and saponins, interact with molecular targets involved in inflammation, such as cyclooxygenase (COX), lipoxygenase (LOX), and nuclear factor kappa B (NF-κB). The

polyherbal ointment composed of *Curcuma longa* (turmeric), *Boswellia serrata* (frankincense), *Azadirachta indica* (neem), and *Aloe vera* derives its anti-inflammatory potential from a rich array of such compounds. The synergistic action of these phytochemicals contributes to the inhibition of inflammatory mediators, reduction of oxidative stress, and promotion of tissue repair, forming the scientific foundation of its therapeutic efficacy.

Curcuminoids from *Curcuma longa*

The rhizome of *Curcuma longa* contains curcuminoids—principally curcumin, demethoxycurcumin, and bisdemethoxycurcumin—which are renowned for their potent anti-inflammatory and antioxidant properties. Curcumin, the primary active constituent, modulates several biochemical pathways that regulate inflammation. It inhibits the activation of NF-κB, a transcription factor responsible for the expression of proinflammatory cytokines such as tumor necrosis factor-alpha (TNF-α), interleukin-1β, and interleukin-6. Curcumin also downregulates the activity of COX-2 and 5-LOX enzymes, leading to a reduction in prostaglandin and leukotriene synthesis. Moreover, it enhances the expression of anti-inflammatory cytokines and scavenges reactive oxygen species (ROS), thereby preventing oxidative tissue damage. Its lipophilic nature allows it to penetrate skin barriers effectively when applied topically, contributing to local anti-inflammatory effects in the ointment formulation.

Boswellic Acids from *Boswellia serrata*

The gum resin of *Boswellia serrata* is a rich source of pentacyclic triterpenic acids collectively known as boswellic acids. These include β-boswellic acid, acetyl-β-boswellic acid, and 11-keto-β-boswellic acid (KBA), which possess strong anti-inflammatory activity. The primary mechanism involves inhibition of the enzyme 5-lipoxygenase (5-LOX), which catalyzes leukotriene synthesis. Leukotrienes are key mediators of inflammation that contribute to vasodilation, edema, and recruitment of inflammatory cells. By blocking leukotriene formation, boswellic acids reduce tissue swelling and improve microcirculation. Additionally, they stabilize lysosomal membranes, prevent the release of destructive enzymes, and suppress complement system activation. Boswellic acids also exhibit antioxidant activity, reducing lipid peroxidation and enhancing tissue repair, making *Boswellia serrata* an essential component of the polyherbal anti-inflammatory ointment.

Flavonoids and Triterpenoids from *Azadirachta indica*

Neem (*Azadirachta indica*) is a versatile medicinal plant containing numerous bioactive compounds such as nimbidin, azadirachtin, nimbolide, quercetin, and flavonoids. These phytochemicals exhibit anti-inflammatory, analgesic, and antimicrobial activities. Nimbidin and quercetin suppress the synthesis of prostaglandins and histamine, thereby reducing redness, pain, and edema in inflamed tissues. Flavonoids act as antioxidants, neutralizing free radicals that perpetuate inflammation. Neem triterpenoids further inhibit the release of inflammatory mediators from mast cells and basophils, modulate immune cell activity, and enhance the skin's resistance to infection. The antimicrobial property of neem complements its anti-inflammatory effects by preventing microbial invasion of inflamed or damaged skin, promoting faster healing and recovery.

Polysaccharides from *Aloe vera*

Aloe vera gel contains a high concentration of bioactive polysaccharides such as acemannan, glucomannan, and pectic substances that play a crucial role in modulating inflammatory responses. Acemannan is known to enhance macrophage activity, stimulate fibroblast proliferation, and promote collagen synthesis, all of which contribute to wound healing and tissue repair. Moreover, *Aloe vera* suppresses proinflammatory cytokines like interleukin-6 and TNF-α while promoting anti-inflammatory cytokines such as interleukin-10. The soothing and hydrating properties of *Aloe vera* also help in reducing skin irritation, erythema, and itching. Additionally, its mucopolysaccharide base acts as a natural bioenhancer, improving the dermal absorption of other phytochemicals in the polyherbal ointment.

Synergistic Phytochemical Interaction

The combined action of curcuminoids, boswellic acids, neem triterpenoids, and Aloe polysaccharides provides a multifaceted approach to inflammation control. While curcumin and boswellic acids inhibit enzymatic pathways (COX and LOX), neem flavonoids and triterpenoids regulate immune responses and oxidative balance, and *Aloe vera* ensures skin protection and regeneration. This synergy enhances overall efficacy, reduces the required dosage of each component, and minimizes potential adverse effects. The polyherbal composition thus embodies a

holistic anti-inflammatory mechanism, where multiple phytochemicals act at different molecular targets to achieve comprehensive therapeutic outcomes.

III. MECHANISM OF SYNERGISTIC ACTION

The clinical evaluation of a herbal polyherbal ointment for topical anti-inflammatory action is designed to assess its efficacy, safety, and tolerability in patients suffering from localized inflammatory conditions such as arthritis, sprains, minor burns, or dermatitis. The formulation consists of standardized extracts of *Curcuma longa*, *Boswellia serrata*, *Azadirachta indica*, and *Aloe vera*, which are incorporated into a suitable base for dermal application. The study is conducted under controlled clinical conditions to ensure reliability and reproducibility of results. The clinical evaluation aims to demonstrate that the polyherbal ointment produces a measurable reduction in inflammation, pain, and swelling, comparable to or better than standard allopathic topical agents, without causing adverse skin reactions or toxicity.

The study is structured as a randomized, double-blind, placebo-controlled clinical trial involving participants diagnosed with mild to moderate inflammatory symptoms. The sample size is determined based on statistical power calculations to ensure validity. Participants are randomly assigned to different groups receiving either the polyherbal ointment, a standard anti-inflammatory ointment (such as diclofenac or ibuprofen-based gel), or a placebo formulation. The ointments are applied twice daily to the affected area for a period of two to four weeks. Clinical observations are recorded at regular intervals to monitor symptom improvement, skin response, and any adverse effects.

Inflammatory parameters such as redness, swelling, tenderness, and pain intensity are evaluated using standardized clinical scoring systems such as the Visual Analog Scale (VAS) and inflammation index. Digital photographs of the affected area are taken at baseline and at follow-up visits to document visible improvement. Biochemical markers of inflammation, such as serum C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR), are also measured in selected participants to support clinical observations. The ointment demonstrates a significant reduction in local inflammation, decreases pain scores, and enhances patient comfort compared to the placebo group.

In addition to efficacy assessment, the study emphasizes safety evaluation. Patch testing is conducted prior to application to rule out allergic reactions or skin sensitivities. The ointment is formulated with dermatologically safe excipients to ensure good spreadability, absorption, and non-irritant properties. Participants are monitored for any signs of itching, burning, or rash during the treatment period. No serious adverse reactions are observed, confirming the safety profile of the herbal formulation for topical use.

Furthermore, patient satisfaction and acceptance of the ointment are evaluated using questionnaires focusing on ease of application, texture, fragrance, and overall comfort. These subjective evaluations provide valuable insights into the formulation's suitability for long-term use in clinical and home settings. The overall therapeutic response is statistically analyzed using appropriate methods such as ANOVA and paired t-tests to determine significance between treatment groups.

The results validate the theoretical foundation established by the phytochemical analysis of the ointment. The combined action of curcumin, boswellic acids, neem flavonoids, and *Aloe* polysaccharides produces synergistic effects that inhibit proinflammatory mediators, reduce oxidative stress, and promote tissue healing. These clinical outcomes strengthen the pharmacological evidence for integrating herbal formulations into modern therapeutic practice.

The clinical evaluation of this polyherbal ointment contributes to the growing body of evidence supporting the use of natural anti-inflammatory agents in dermatology and pain management. It also encourages further research into formulation optimization, dosage standardization, and large-scale trials for regulatory approval. Ultimately, this study establishes a safe, effective, and affordable herbal alternative to synthetic topical anti-inflammatory drugs, promoting holistic and sustainable healthcare.

IV. ADVANTAGES OF POLYHERBAL OINTMENTS

Polyherbal ointments represent an innovative approach in modern herbal medicine, combining the therapeutic potential of multiple medicinal plants into a single topical formulation. These ointments are designed to provide synergistic healing effects through the complementary actions of various phytoconstituents such as flavonoids, terpenoids, alkaloids, and polyphenols. The

integration of traditional herbal wisdom with contemporary formulation techniques enhances their therapeutic efficacy and stability. Polyherbal ointments are particularly beneficial for treating inflammatory skin conditions, wounds, burns, infections, and joint pain. They not only target inflammation but also promote skin regeneration, antimicrobial defense, and antioxidant protection, making them an attractive alternative to synthetic topical agents.

Synergistic Therapeutic Action

One of the primary advantages of polyherbal ointments is their synergistic mode of action. When multiple herbal extracts are combined, their bioactive compounds interact to enhance each other's therapeutic potential. For instance, *Curcuma longa* provides curcuminoids with strong anti-inflammatory properties, *Boswellia serrata* offers boswellic acids that inhibit leukotriene synthesis, *Azadirachta indica* contributes flavonoids and triterpenoids with antimicrobial action, and *Aloe vera* adds soothing and regenerative effects. Together, these phytochemicals act on different biochemical pathways involved in inflammation, such as the inhibition of cyclooxygenase (COX), lipoxygenase (LOX), and nuclear factor kappa B (NF-κB). The result is a broad-spectrum anti-inflammatory and healing effect that is often superior to single-ingredient formulations.

Reduced Side Effects and Better Safety Profile

Polyherbal ointments are composed of natural plant-based ingredients, which generally exhibit minimal adverse effects compared to synthetic nonsteroidal anti-inflammatory drugs (NSAIDs) and corticosteroid creams. Conventional anti-inflammatory agents often cause side effects such as skin thinning, irritation, or allergic reactions with prolonged use. In contrast, herbal formulations are biocompatible and better tolerated by the skin. The inclusion of soothing agents like *Aloe vera* and neem oil further reduces the risk of irritation and promotes skin hydration. Moreover, the natural antioxidant content of these herbs helps protect the skin from oxidative damage, thereby maintaining its integrity and resilience over time.

Multifunctional Therapeutic Benefits

Another distinct advantage of polyherbal ointments is their ability to provide multiple therapeutic benefits simultaneously. While the primary aim may be to reduce inflammation, these formulations

also offer antibacterial, antifungal, analgesic, and wound-healing properties. For example, neem and *Aloe vera* possess antimicrobial actions that prevent secondary infections in inflamed or damaged skin, while curcumin and boswellic acids promote tissue repair and regeneration. This multifunctionality makes polyherbal ointments suitable for various dermatological conditions such as eczema, psoriasis, acne, and minor injuries. Their holistic approach aligns with the principles of Ayurveda and modern phytotherapy, which emphasize balance and comprehensive healing.

Enhanced Bioavailability and Skin Penetration

The combination of multiple herbal extracts in an ointment enhances the absorption and bioavailability of active compounds through the skin. Some herbs act as natural bioenhancers—substances that increase the permeability of the skin and facilitate deeper penetration of other phytochemicals. For instance, *Aloe vera* gel not only provides anti-inflammatory benefits but also serves as a natural penetration enhancer, improving the absorption of curcumin and boswellic acids into the inflamed tissues. This increased bioavailability ensures that therapeutic concentrations of active compounds reach the target site effectively, resulting in faster and more sustained relief from pain and inflammation.

Cost-Effective and Sustainable Alternative

Polyherbal ointments are generally more affordable and sustainable than synthetic pharmaceutical products. The raw materials used in their formulation—herbal extracts, oils, and waxes—are easily sourced from natural and renewable resources. Manufacturing such ointments requires less energy and chemical processing, reducing the environmental impact. Additionally, the use of local medicinal plants supports traditional knowledge systems and rural herbal industries, promoting economic sustainability. Given their low cost and high therapeutic value, polyherbal ointments provide an accessible healthcare option for both urban and rural populations.

Long-Term Use and Patient Compliance

Due to their gentle action and minimal toxicity, polyherbal ointments are suitable for long-term use without the risk of dependency or cumulative side effects. Their pleasant texture, natural fragrance, and non-greasy base enhance patient compliance. Many formulations also include natural moisturizing agents that improve skin texture and comfort, encouraging consistent

application. Patients who are sensitive to chemical-based topical medications often prefer herbal ointments because they offer relief without causing dryness, itching, or irritation.

Holistic and Preventive Approach to Healing

Polyherbal ointments not only treat existing inflammation but also help prevent its recurrence by strengthening the skin's natural defense mechanisms. The antioxidants, vitamins, and bioactive compounds present in herbal extracts neutralize free radicals and promote detoxification at the cellular level. This preventive approach aligns with holistic healing systems, which focus on restoring the body's balance rather than merely suppressing symptoms. As a result, polyherbal ointments contribute to overall skin health and resilience against environmental stressors and infections.

V. CONCLUSION

The clinical evaluation of a herbal polyherbal ointment for topical anti-inflammatory action highlights the potential of combining multiple plant-based extracts to achieve a broad-spectrum and synergistic therapeutic effect. The integration of *Curcuma longa*, *Boswellia serrata*, *Azadirachta indica*, and *Aloe vera* in a single formulation demonstrates how natural phytochemicals can work together to reduce inflammation, relieve pain, and promote skin healing without the adverse effects commonly associated with synthetic medications. These herbal components act through multiple mechanisms such as the inhibition of inflammatory mediators, reduction of oxidative stress, and enhancement of tissue regeneration. The safety profile of such ointments further supports their suitability for long-term topical use, making them a reliable alternative for managing inflammatory skin conditions and localized pain. The advantages of polyherbal ointments, including synergistic activity, better bioavailability, minimal toxicity, and affordability, position them as effective and sustainable therapeutic options. As modern healthcare increasingly values evidence-based natural products, the clinical validation of these formulations will strengthen their credibility and integration into mainstream medicine. Overall, polyherbal ointments represent a promising step toward holistic and patient-centered healthcare, combining the wisdom of traditional herbal practices with modern pharmacological understanding to deliver safe, effective, and accessible anti-inflammatory solutions.

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Plant Authentication Certificate

This is to certify that plant Material Submitted by **Mrs. Pushpanjali Chaurasia** PhD Scholar Department of Pharmacy, P.K. University Shivpuri M.P. has been authentically identified by **Department of Botany**, Govt. Girls Degree College Chhatarpur M.P.

The Plant was identified as Follows

S.no	Botanical Name	Family	Common Name	Part used	Place of Collection
1	Zingiber Officinale	Zingiberaceae	Ginger	Rhizome	Chhatarpur
2	Terminalia Chebula	Phyllanthaceae	Triphela	Fruit	
3	Commiphora Mukul	Burseraceae	Gum	Bark	
4	Tinospora Cordifolia	Menispermaceae	Giloy	Leaf.steam	

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A Study of Scalable Cloud Architecture for Efficient Data Storage and Processing

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ABSTRACT

Scalable cloud architecture plays a crucial role in ensuring efficient data storage and processing in today's data-driven digital environment. It refers to a system design that can dynamically adjust computing resources—such as storage, processing power, and network capacity—based on workload demands. By leveraging cloud service models like Infrastructure as a Service (IaaS) and Platform as a Service (PaaS), organizations can store massive volumes of structured and unstructured data without investing in physical infrastructure. Distributed storage systems, data replication, and load balancing enhance reliability, fault tolerance, and availability of data. For efficient processing, scalable cloud architectures utilize parallel computing frameworks, containerization, and microservices, enabling faster data analytics and real-time processing. Technologies such as auto-scaling, virtualization, and serverless computing optimize resource utilization and reduce operational costs by allocating resources only when required. Additionally, cloud-based data processing supports advanced analytics, machine learning, and big data applications by providing high-performance computing environments. Security and data integrity are maintained through encryption, access control, and compliance mechanisms.

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Impact of Cloud Computing on Heart Disorders Diagnosis

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Research Scholar, Department of Pharmacy, P.K. University, Shivpuri, M.P., India.

ABSTRACT

Cloud computing has a significant impact on the diagnosis of heart disorders by enhancing data management, accessibility, and analytical capabilities in the healthcare sector. With the increasing use of digital medical records, wearable devices, and diagnostic imaging, a large volume of cardiac data is generated daily. Cloud computing provides scalable storage solutions that allow hospitals and diagnostic centers to securely store and retrieve patient data in real time. Through cloud-based platforms, cardiologists can access electrocardiograms (ECGs), echocardiograms, and patient history remotely, enabling faster and more accurate diagnosis. Advanced cloud-supported analytics and artificial intelligence tools help in early detection of heart disorders by analyzing complex patterns in medical data that may not be easily identified through traditional methods. Additionally, cloud computing supports telemedicine, allowing specialists to diagnose and monitor heart patients in remote or underserved areas. This improves timely medical intervention and reduces the burden on healthcare infrastructure. Cloud-based systems also promote collaboration among healthcare professionals by enabling seamless data sharing while maintaining data security and privacy through encryption and compliance standards.

B.R. Nahata College of Pharmacy,
Mhow –Neemuch Road, Mandsaur 458001 (Madhya Pradesh)
www.brncop.org

Reference no. IAEC/2023/CPCSEA Date: 29/4/2023

To,

Puspanjali Chaurasia

P.K. University, Shivpuri M.P.

Dear Sir/Mam,

This is to Certify that the Project Proposal no. **IAEC/2023/CPCSEA/032** ''**Entitled Phytochemical & Pharmacological Evaluation of Herbal Plant for Anti Inflammatory Drugs"**

The Project has been approved/recommended for Animal Studies for Next Sixth Months.

The approval no.of Study: **IAEC/2023/CPCSE/032**

Research Scholar: Puspanjali Chaurasia

You are here by permitted to Proceed with research work on Animals

Chairman IAEC
B. R. Nahata College of Pharmacy
Mandasor (M. P.)

S.No. -

6th National Symposium on Agricultural Meteorology

28th December 2024

"Digital Development of Agricultural, Industrial & Pharmaceutical Technologies"

Jointly Organized by

India Meterological Department (IMD)

Ministry of Earth Sciences Goverment of India, New Delhi &

P.K. UNIVERSITY, SHIVPURI (M.P.)



CERTIFICATE OF PARTICIPATION

This is to certify that Prof./Dr./Mr./Mrs./Ms. Nadeem Khan from P.K. University, M.P. has participated in the 6th National Symposium on "Digital Development of Agricultural, Industrial & Pharmaceutical Technologies" at P.K. University, Shivpuri (M.P.) on December 28, 2024.

Dean Academic

Director

Vice-Chancellor

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This certificate is awarded to Dr /Mr /Ms. Pushpanjali Chaurasia

University/College P.K University has

participated as Delegate in the

International Conference held on 29th March, 2025 at GRY Institute of Pharmacy, Borawan, Khargone, Madhya Pradesh, India.

He/She also presented paper/delivered invited talk/chaired a session, titled.....

-Nil-

.....

.....

Dr. Sujit Pillai
Convener

SCAN ME

Sh. Arun Yadav
Chairman

INDIAN PHARMACY GRADUATES ASSOCIATION (IPGA)
M.P. STATE BRANCH

Organizing 2nd International Conference on 27th November 2025

In collaboration with
Dr. A.P.J. Abdul Kalam University
Indore

Co-Host
Pinnacle Biomedical Research Institute (PBRI), Bhopal

CERTIFICATE OF PARTICIPATION

This is to certify that Dr/Mr/Mrs/Ms. Pushpanjali Chaurasia of ..... has actively participated in International Conference on AI Driven Innovations in Pharma & Biosciences : A New Horizon in Sickle Cell Anemia and Other Diseases Drug Development (ADIPB) held on 27th November 2025 at Dr. A.P.J. Abdul Kalam University, Indore.

He/She also presented paper/delivered Invited talk/Judge/chaired a Technical Session/ Organizing Committee Member/ titled .....

Dr. Karunakar Shukla
President IPGA MP,
Convener

Dr. Revathi A Gupta
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