

Examine Phytochemical Power for Wound Healing and Rheumatism Relief through Antimicrobial Properties and Bioactive Compound Analysis

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Abstract: The misuse antibiotics has led to the advent of multidrug-resistant pathogens, posing a serious challenge to healthcare systems globally. In response, there is a budding attentiveness in substitute rehabilitations, particularly those derived from natural sources like medicinal plants. India's rich tradition of herbal remedies offers a promising avenue for research, given their historical effectiveness and minimal side effects compared to conventional medications. This study aims to explore the phytochemical possessions of specific therapeutic plants traditionally used to treat rheumatism and wounds. Through ethnobotanical surveys and laboratory analyses, the study identifies bioactive compounds with potent antimicrobial properties and assesses their effectiveness in wound healing and rheumatism relief using animal models. The findings underscore the therapeutic potential of these plant-derived compounds and advocate for further clinical trials to validate their efficacy and safety in human subjects, emphasizing the need for standardized formulations and long-term monitoring of potential adverse effects. This research highlights the significance of plant-based therapies in combating antibiotic resistance and addressing chronic ailments like rheumatism. By harnessing the healing properties of phytochemicals, traditional medicinal plants offer a sustainable and effective approach to modern healthcare. Moving forward, future studies should focus on clinical validation, exploring synergistic effects, elucidating molecular mechanisms, and ensuring consistent therapeutic application to maximize the benefits of plant-based treatments while minimizing risks.

Keywords: Phytochemicals, wound healing, rheumatism relief, bioactive compounds, phenolic compounds, ethnobotanical survey, chromatography, spectroscopic analysis, arthritis models.

I.INTRODUCTION

With its substantial size, the epidermis functions as a vital barrier against the external environment, safeguarding the organism against pathogens, dehydration, toxic substances, and thermal dysregulation. Due to its exposure and susceptibility, frequent injuries occur. Regeneration and repair are complex physiological phenomena that arise from the interaction of a multitude of cytokines, growth factors, and cells [1]. Hemostasis, inflammation, growth of fibroblast angiogenesis, collagen remodeling, vasoconstriction, platelet aggregation, antimicrobial effects, vascular leakiness, and platelet aggregation are the four phases of cutaneous wound healing [2].

“Unhappily, the escalating incidence of patients with dysregulated wound healing [3] has been aided by the global depletion of vascular diseases, metabolic syndrome, & aging”. This condition has the potential to profoundly affect healthcare systems and quality of life.

Despite notable advancements in wound care treatments, which predominantly concentrate on the restoration and regeneration of the epidermis, considerable challenges endure. These include, but are not restricted to, bacterial resistance and prohibitive costs. Desired are novel and efficacious alternatives to wound healing therapies. Traditional medicine, which has its roots in the centuries-old use of natural substances as therapeutic remedies in Asia, Africa, & Latin America, is a substantial source of inspiration [1,2].

Arthritis is a clinical manifestation characterized by persistent joint inflammation resulting in pain and consequent joint swelling. This condition lacks authenticity. Possible causes of this condition encompass joint trauma experienced during infancy, a hereditary susceptibility, or a compromised immune system. Carpal and osseous structures in immediate proximity to the impacted joints, in addition to vital organs such as the heart, lungs, & eyes, might experience an impact. Frequently, an assessment of the foot, hand, and forearm is required to diagnose arthritis [3]. The predominant forms of arthritis are RA and OA. Arthritis (RA) is a chronic

inflammatory condition that is classified as an autoimmune disorder. This specific variant of arthritis is caused by synovial membrane hyperplasia, a fundamental mechanism that induces substantial bone resorption in the vicinity of the joint. Physical manifestations include stiffness, pain, and restricted mobility, these occur in conjunction with pathologies of the skeleton and cardiovascular system. NSAIDs and corticosteroids are two classes of drugs that may be utilized in the treatment of RA [4-6]. NSAIDs do, nevertheless, cause acute renal failure and gastric ulceration [5-9]. Femininity exhibits a higher incidence of RA in comparison to males [10]. On the other hand, OA is a pathological state distinguished by the gradual degradation of articular cartilage, which serves as a preventative tissue situated at the joint termini. Joint pain and movement impairment may ensue as a consequence of chronic synovial inflammation, constriction of the joint space, and the development of osteophytes. In addition, the synovium, meniscus, ligaments, and the entirety of the synovial joint are affected [11]. An estimated 1.8 million people in the United States of America are afflicted with rheumatoid arthritis, an autoimmune disorder whose cause remains unclear. Furthermore, these complications serve to intensify the financial burden that is linked to the illness. A number of scientists [12] have hypothesized the potential importance of epigenetics and imprinting in influencing forthcoming strategies for the management of RA. A significant discrepancy exists in the incidence of rheumatoid arthritis between developed and developing countries, with the former including China. The estimated female-to-male ratio associated with this disease is 2–3:1 [13]. Osteoarthritis predominantly impacts the wrists, hips, & knees, with postmenopausal women having a significantly greater incidence rate than men. Without a doubt, it is a pathological condition characterized by the degradation of cartilage in the joints and is acknowledged as the primary cause of disability on a global scale [14]. Phytochemicals have exhibited noteworthy effectiveness in the management of inflammatory, infectious, and autoimmune disorders [15–16], arthritis being among them.

1.1 The Role of Medicinal Plants in Indian Healthcare:

In India, a plant serves as an essential component of the healthcare system and a pharmaceutical resource. Over the course of history, flora have exerted a significant influence on human welfare and the improvement of the overall standard of living (17). Since ancient times, plants have been employed as the principal reservoir of essential constituents for plant-based medicines. Throughout its history, India has employed medicinal plants and herbal remedies to alleviate a diverse array of ailments and conditions. Furthermore, therapeutic botanicals are easily accessible, affordable, and distinguished by negligible to nonexistent detrimental effects. Despite the notable advancements in allopathic medicine, homeopathic remedies are becoming more prevalent as a result of the detrimental side effects and toxicity that are commonly associated with allopathic medications (18). Pharmacophores of bioactive tributary metabolites, including tannins, flavonoids, phenolic compounds, & alkaloids, have been linked to the therapeutic properties of medicinal plants. There has been a substantial increase in the utilization of traditional medicine in recent decades. Botanical origins provide an estimated 20% of the pharmaceutical substances utilized in contemporary allopathic medicine. Pharmaceuticals derived from plants are safer when used to treat a broad spectrum of conditions. It is imperative to safeguard traditional knowledge that has been lost due to a variety of factors, in order to ensure that future generations can continue to benefit. An expanding demand exists for pharmaceuticals that are both innovative and exceptionally efficacious, with formulations employing natural constituents (19). Herbal medications have the potential to provide curative and therapeutic effects for extensive range of conditions, such as ulcers, curled curative, inflammation, dermatitis, leprosy, and venereal disease, among others. Herbal remedies are utilized to facilitate the elimination of dead tissue, cleanse incisions, & promote the development of an optimal natural healing milieu by stimulating the production of moisture. Traditional physicians utilize an extensive array of botanical substances to treat burns, scrapes, and wounds (20). Medicinal wound cleansers and antiseptic coagulants are composed of substances derived from plants. Research has demonstrated that therapeutic plants can promote wound healing via diverse mechanisms, such as fibroblast and fibrocyte stimulation, wound healing modulation, and bacterial count reduction (21). The rapid expansion of traditional uses for plants and plant resources (22) can be attributed to their limited negative effects, cost-effectiveness, and, in some cases, provision of healthcare exclusively for disadvantaged communities. Scholars have been conducting investigations concerning the potential application of plants in the handling of specific communicable sicknesses & the management of chronic lesions (23). This is as a result of the abundance of components that are vital for plant survival. In alignment with the ongoing advancements in medical science, the domain of wound care undergoes continuous

transformation. Given that the advent of resistant microorganisms is one of the challenges of wound management, ongoing research seeks to identify the most effective wound healer. Numerous studies have been devoted to the examination of herbal and conventional therapies as potential incision remedies (24).

II. LITERATURE REVIEW:

2.1 Phytochemicals and Wound Healing

Ekam, S. E et.al. . (2022) [25] conducted a rodent study to assess the efficacy of a methanol extract derived from *Persea americana* seeds in managing *Staphylococcus aureus*-infected excision wounds. The investigation aimed to elucidate the antibacterial & wound-healing mechanisms of the extract. Antibacterial activity of the methanol extract was evaluated against a panel of microorganisms, while phytochemical and antioxidant activities were assessed using colorimetric methods. Mechanistic investigations focused on cytoplasmic components, bacterial biofilm formation, and membrane disruption. The MIC range for the methanol extract from *P. americana* seeds was found to be 64–128 µg/mL, attributed to the overall phenolic, flavonoid, and tannin composition. The extract demonstrated antibacterial activity by inhibiting biofilm formation, disrupting bacterial membranes, and inhibiting H⁺-ATPase pumps. Topical application of a gel containing *P. americana* extract significantly enhanced wound closure and reduced the colony-forming units (CFU) of *S. aureus* at the infection site. However, the antioxidant capacity of the plant for stimulating wound repair was comparatively moderate compared to vitamin C. Toxicological analysis indicated limited skin irritation and no ocular irritation, suggesting caution in topical application of the gel-based extract.

Alafnan, A., et. al. (2021) [26] examined the phytochemical composition of drought was ascertained by analyzing the UHPLC-MS secondary metabolite contents & the total bioactive components (total phenolic and total flavonoid). In vitro antioxidant activities, in vivo potential for wound healing, and enzyme inhibition potential were evaluated for phytopharmacological assessment. The examined extract exhibited notable concentrations of flavonoids (46.75 mg RE/g extract) & phenolics (33.71 mg GAE/g extract). The substantial antioxidant capacity of the plant extract was confirmed by measuring its maximum activity in CUPRAC assays. Secondary metabolites were characterized using positive and negative ionization modes of UHPLC-MS, suggesting the potential existence of seventeen unique phytochemicals, with flavonoids, alkaloids, and sesquiterpene derivatives comprising the majority. The extract under investigation exhibited substantial inhibitory activity against tyrosinase (81.72 mg KAE/g extract), but only moderate inhibitory activity against the remaining enzymes assessed. Additionally, significant improvements in the wound healing process were observed in both models on the sixteenth day of the study when in vivo wound healing assays were conducted at concentrations of 0.5 percent w/w and 2.0 percent w/w. Both the desiccated and plant extracts of *C. gigantea* (L.) may contain bioactive compounds with a wide range of therapeutic applications.

Saleem, U., et. al. (2020) [27] investigated the plant's potential for wound repair using animal models and to examine its phytochemistry. Chemical characterization of the crude methanolic extract of *M. neglecta* (Mn.Cme) was performed using HPLC-DAD and GCMS analysis. Standards utilized to evaluate acute dermal toxicity in albino rats were formulated following OECD 402 guidelines. The wound-healing capabilities of a wound model involving excision were evaluated using rats. During surgical procedures, 177 mm² of epidermal incisions were made on rodents residing in individual enclosures. A formulation of Mn.Cme ointment was topically applied to the lesion's afflicted area daily for 14 days. After an initial assessment of the wound area on the third day using translucent paper, a 1 mm² approximation graph sheet was employed until the lesion fully healed and epithelialization was documented. Lesion contraction was expressed as a percentage of the lesion's initial dimensions. Furthermore, antioxidant capacities were evaluated through assays designed to scavenge free radicals, namely FRAP, DPPH, and H₂O₂. According to HPLC-DAD analysis, the following phenolic compound concentrations were identified to be elevated: coumaroylhexoside (97.4 mg/g), hydrotyrosol (109.3 mg/g), kaempferol-3-(p-coumaroyldigluconide)-7-glucoside (37.2 mg/g), quercetin-3-O-rutinoside (31.5 mg/g), and epicatechin-3-O-(4-O-methyl)-gallate (31.3 mg/g). The following compounds were found to be extremely abundant according to GC-MS analysis: isopropyl myristate (7.02%), ethylene dimercaptan (14.67%), isoeugenol (14.61%), patchoulane (10.36 percent), and methyl 12-methyltetradecanoate (8.47 percent). No signs of toxicity were identified during the evaluation of acute dermal toxicity. The examination specimen, which

consisted of manganese carboxyme, exhibited a noteworthy propensity for wound healing at each concentration (1 g, 1.5 g, 2 g per 10 g of ointment base). This tendency was accompanied by a reduction in epithelialization time that was dependent on the dosage. Complete restoration of health was observed in the individual after a 2 g Mn.Cme ointment was applied.

2.2 Phytochemicals and Rheumatism Relief

Pimple, P., et. al. (2024) [28] examined that T-cells modulated the chronic inflammatory condition rheumatoid arthritis (RA). The worldwide incidence rate varied between 0.5% and 1%. Subsequent to a substantial decline in an individual's quality of life, the disease's unidentified etiology caused progressive joint degeneration. At that time, the therapeutic approach involved the use of DMARDs, either as standalone treatments or in combination with glucocorticoids or NSAIDs. Furthermore, co-administration of injectable biological DMARDs was recommended for the treatment of chronic or recurrent arthritis. The implementation of the treat-to-target strategy and the introduction of biological DMARDs substantially improved the prognosis for patients diagnosed with rheumatoid arthritis. However, RA remained a persistent concern due to the suboptimal response of patients, the development of tolerance, and the severe adverse effects associated with prolonged use of currently available treatment protocols. It was estimated that between sixty and ninety percent of patients diagnosed with rheumatoid arthritis utilized alternative therapies, such as medicinal interventions, as a means to alleviate symptoms. Over the past few decades, researchers had investigated natural phytochemicals in an effort to identify potential treatments for rheumatoid arthritis and its related symptoms. Notable phytochemicals derived from plants, including alkaloids, flavonoids, steroids, terpenoids, and polyphenols, demonstrated immunomodulatory and anti-inflammatory properties in the treatment of rheumatoid arthritis. Nevertheless, phytochemicals faced a multitude of constraints that hindered their absorption and bioavailability: an exceptionally high molecular weight, inadequate solubility in water, poor permeability, instability, and first-pass metabolism. The utilization of nanotechnology significantly enhanced the stability and pharmacokinetic profile of encapsulated medications. The present appraisal offered a comprehensive analysis of the therapeutic attributes demonstrated by phytochemicals. Additionally, the evaluation centered on phytochemical formulations that had been developed with the specific purpose of treating rheumatoid arthritis. The analysis focused on regulatory factors, current barriers, and prospective advancements.

Kour, G., et.al. (2022) [29] investigated that RA was a persistent autoimmune disorder that was managed with the assistance of standard therapeutic approaches and biological disease-modifying anti-rheumatic medications (DMARDs). Recent exploration had identified the JAK/STAT signaling pathway as a possible therapeutic target for rheumatoid arthritis. Since their recent approval by the FDA as novel JAK/STAT inhibitors for the treatment of rheumatoid arthritis, tofacitinib and baricitinib had attracted considerable interest. Nevertheless, it was imperative to not disregard the conspicuous hazards linked to their application, which comprised thromboembolism, gastrointestinal tract (GIT) perforations, hepatotoxicity, and severe infections such as herpes zoster & tuberculosis. Moreover, the astronomically high cost of these products restricted their applicability to a wider range of circumstances. "Given these constraints, an investigation may have been conducted into the development of novel JAK/STAT inhibitors derived from natural sources that were more tolerable, cost-effective, and protected against adverse effects. This piece presented detailed accounts of various natural compounds and phytochemicals that had exhibited the capacity to alleviate inflammation in rheumatoid arthritis via JAK/STAT signaling pathway modulation. Particular natural substances, such as resveratrol, had demonstrated significant therapeutic attributes, encompassing both biochemical and clinical effects, in the amelioration of RA in both in vivo and clinical settings. Additional details were presented regarding the physicochemical challenges that resulted from inadequate solubility and absorption, in addition to the utilization of natural JAK/STAT inhibitors". A comprehensive analysis and synthesis of numerous DDS were provided in an effort to improve the therapeutic efficacy of natural JAK/STAT inhibitors by overcoming their physicochemical limitations.

Bhattacharya, et. al. (2020) [30] investigated the potential therapeutic applications of phytochemicals for the management of arthritis, a chronic condition characterized by joint pain, inflammation, and edema. An extensive examination was conducted to assess the anti-arthritis characteristics of various phytomolecules, including madecassoside, hydroxynaphthoquinone, ginsenoside, berberine, triptolide, hesperidin, and allicin, among

others. These compounds modulated osteoclast differentiation, proinflammatory cytokines, and inflammatory responses, in addition to preventing joint bone erosion. As of then, there had been an exceptionally restricted number of clinical trials investigating phytomolecules that possessed anti-arthritic properties. Additional clinical trials were required prior to the commercialization of plant molecules as antiarthritic therapeutics in order to ascertain their safety and efficacy, whether used unaided or in amalgamation with supplementary anti-arthritic agents.

2.3 Antimicrobial properties of phytochemicals

Petkova, N., et.al. (2022) [31] research aimed to ascertain the concentrations of phytochemical compounds in each fraction of burdock roots by isolating them using a series of sequential extraction procedures (hexane, chloroform, ethyl acetate, water). An evaluation was conducted to assess the antioxidant and antimicrobial properties of nonpolar fractions. The fraction composed entirely of ethyl acetate displayed the most significant amounts of total phenolics, total flavonoids, and derivatives of caffeic acid. Phenolic acids, namely caffeic acid, p-coumaric acid, and chlorogenic acid, were exclusively detected in the ethyl acetate fraction. On the contrary, triterpenes were exclusively identified in the fraction that contained hexane. The ethyl acetate fraction exhibited the most pronounced antioxidant activity as a result of its substantial polyphenol concentration. The antimicrobial activity of three fractions was found to be susceptible to the following microorganisms: *Salmonella* sp., *Escherichia coli*, *Listeria monocytogenes*, *Pseudomonas aeruginosa*, *Proteus vulgaris*, *Staphylococcus aureus*, *Bacillus cereus*, and *Candida albicans*. The results of the experiment indicated that the ethyl acetate fraction demonstrated the least amount of inhibition (greater than 1 mg/ml) against *Bacillus cereus* and *Pseudomonas aeruginosa*. From the aqueous fraction, fructan of the inulin type was isolated; its degree of polymerization ranged from 20 to 24, and it displayed promising functional properties. The results of this study suggested that burdock root fractions containing 7 g/100 g inulin could potentially be a rich source of phytochemicals that possess antimicrobial, antioxidant, and potentially prebiotic characteristics.

Soleimani, M., et.al. (2022) [32] examined Thyme (*Thymus* spp.) & mint (*Mentha* spp.) were aromatic herbs whose flavorful, medicinal, & aromatic qualities made them extensively utilized in the food & beverage industry. The species enumerated above belonged to the *Menthaeae* family, a subfamily of the *Lamiaceae* mint family. The mint family comprised a multitude of genera that gained widespread recognition for their culinary and medicinal uses. The present study aimed to evaluate the potential antimicrobial and natural health benefits of phenolic compounds present in mint and thyme. Compounds examined in this article included carvacrol, thymol, carvone, menthol, menthone, pulegone, limonene, 1,8-cineole, and cinnamaldehyde. An exhaustive literature search was undertaken across nine databases to obtain peer-reviewed studies pertaining to the phytochemical complements of mint and thyme, as well as the properties of individual bioactive compounds. Mint and thyme possessed a variety of medicinal properties, including antioxidant, antimicrobial, digestive, antiseptic, antispasmodic, antirheumatic, expectorant, antiallergic, and antitussive effects. The essential oils derived from these aromatic plants were utilized in a wide range of applications, such as pesticides, repellents, and the incorporation of flavor and fragrance into cosmetics and spice preparations. Phenolic compounds, such as polyphenols and phenols, were predominantly present as secondary metabolites in extracts and essential oils derived from mint and thyme. Drawing from the available literature, it could be inferred that only a subset of the phytochemical activities demonstrated by thyme and mint had been the subject of scientific investigation.

Rahman, M. M., (2021) [33] conducted Natural products ascribed with antimicrobial properties since the dawn of time. Significant global burdens were imposed by infectious diseases, and the emergence of resistant species to a variety of antimicrobial agents exacerbated this problem. Consequently, in order to identify antimicrobial specialists with potent activity against multidrug-resistant microorganisms, it was critical to surmount this obstacle. In order to effectively treat infections, it was imperative to either develop innovative pharmaceuticals or identify a shared reservoir of such medications. An extensive array of naturally occurring antimicrobial agents could be extracted from microorganisms, plants, and animals, among other sources. Antimicrobial properties were attributed to a diverse range of organic constituents, secondary metabolites, and active principles, which included alkaloids, tannins, terpenoids, essential oils, flavonoids, lectins, phagocytic cells, and many others. The clinical effects could be ascribed to the direct impacts on microorganisms; phytocomplex

antimicrobial activity was frequently generated through energy collaboration among a restricted number of particles. Pharmaceutical compound synthesis from medicinal plants catalyzed antimicrobial progress. The objective of this logical inquiry was to evaluate the antimicrobial characteristics of phytocomplexes and normal excerpts derived from plants, which were frequently employed in the manufacturing of conventional pharmaceuticals.

2.4 Bioactive compounds in plants relevant to wound healing and rheumatism

Zielińska, M., et. al. (2021) [34] examined Black cumin (*Nigella sativa*, NS), as a medicinal plant due to its remarkably high concentrations of various bioactive compounds, was a member of the Ranunculaceae family. Therapeutic effects that had been identified included anti-inflammatory, anti-allergic, anti-cancer, hypoglycemic, antioxidant, hypotensive, hypolipidemic, and immunomodulating properties. The methodical literature indicated that the potential therapeutic utility of black cumin in the management of autoimmune disorders such as rheumatoid arthritis may have stemmed from the health-improving properties exhibited by its bioactive components. The principal objective of this critique was regarding the therapeutic potential of the bioactive components of black cumin in relation to rheumatoid arthritis.

Schilrreff, P., et. al. (2022) [35] research that chronic wounds were distinguished by the presence of ongoing inflammation, a physiological phenomenon that was closely intertwined with the regulation of the immune system. Chronic cutaneous wounds arose due to immune system dysregulation, leading to enduring inflammation and compromised wound healing capabilities. This calculation investigated various facets of chronic wound healing, encompassing the consequences of bacterial infections, the influence of reactive oxygen species and inflammatory mediators, the importance of the immune system, and the untapped potential of natural bioactive compounds in wound therapy. Investigation focused on investigating natural compounds that exhibited antibacterial, anti-inflammatory, and antioxidant characteristics, as well as elucidating the fundamental mechanisms that regulated these effects. Furthermore, conducted inquiries into innovative therapeutic developments that utilized nanotechnology or novel biomaterial platforms for the purpose of wound treatment.

III. RESEARCH METHODOLOGY

Research methodology refers to the systematic approach used to conduct scientific investigations and gather data to address a research question or hypothesis. It encompasses the overall strategy, techniques, and procedures employed throughout the research process. Common elements of research methodology include study design, data collection methods, sampling techniques, and data analysis procedures. The methodology aims to ensure rigor, reliability, and validity in the research findings by providing a clear framework for conducting the study and interpreting the results accurately. It serves as a roadmap for researchers to navigate the complexities of their study, enabling them to generate credible evidence and contribute to the advancement of knowledge in their field.

Table 1: Antimicrobial Testing Results

N	Microbial Strain	Average Zone of Inhibition (mm)	Average MIC (mg/mL)	Average MBC (mg/mL)
1	<i>Staphylococcus aureus</i>	20	0.6	1.2
2	<i>Escherichia coli</i>	18	0.8	1.5
3	<i>Pseudomonas aeruginosa</i>	15	0.7	1.4
4	<i>Candida albicans</i>	22	0.5	1.0

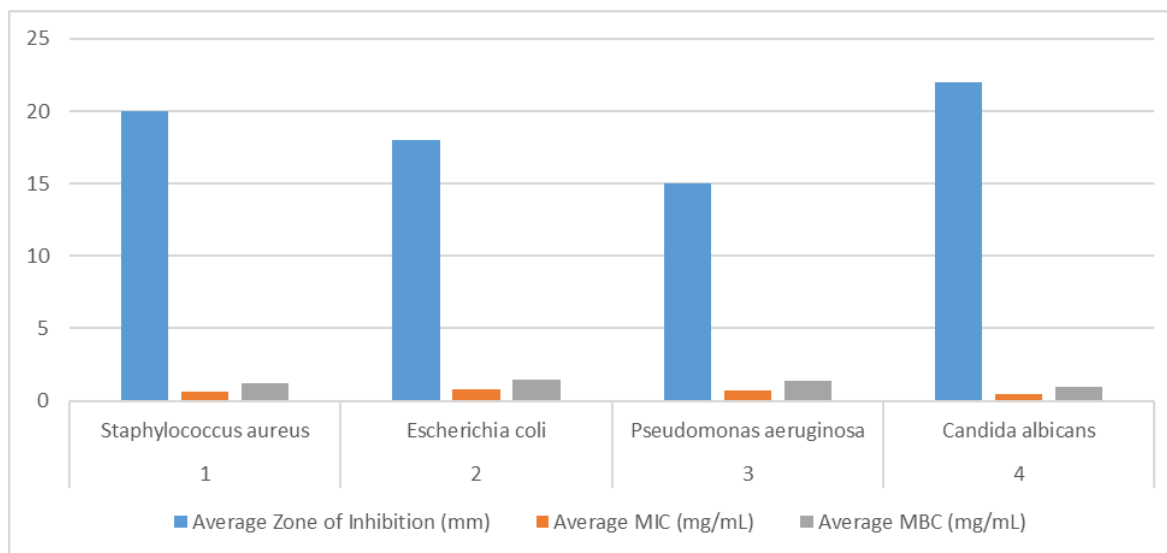


Figure 1: Antimicrobial Testing Results

The provided data illustrates the susceptibility of four distinct microbial strains to an antimicrobial agent, delineating their responses in terms of zone of inhibition, Minimum Inhibitory Concentration (MIC), and Minimum Bactericidal (or Fungicidal) Concentration (MBC). Among the strains examined, *Staphylococcus aureus* exhibits the highest susceptibility, evident from its large zone of inhibition, low MIC, and MBC values. This suggests that the antimicrobial agent is particularly effective against this bacterium, both in inhibiting its growth and in causing cell death. Following closely behind, *Escherichia coli* and *Pseudomonas aeruginosa* demonstrate moderate susceptibility, characterized by slightly smaller zones of inhibition and slightly higher MIC and MBC values compared to *Staphylococcus aureus*. *Candida albicans*, a fungal strain, appears highly susceptible to the antimicrobial agent, with the largest zone of inhibition and the lowest MIC and MBC values among the tested strains. These findings indicate that while the antimicrobial agent exhibits efficacy against all tested strains, its potency varies, being most pronounced against *Candida albicans* and *Staphylococcus aureus*, and relatively less effective against *Pseudomonas aeruginosa*. Such insights are crucial for understanding the agent's potential utility in combating microbial infections and for guiding therapeutic strategies tailored to specific pathogens.

Table 2: Wound Healing Evaluation Results

Animal Model	Treatment Group	Wound Contraction (%)	Hydroxyproline Level (µg/mg tissue)
Rats	Plant Extract A	55	120
	Plant Extract B	60	130
Mice	Control	40	100
	Plant Extract C	65	140

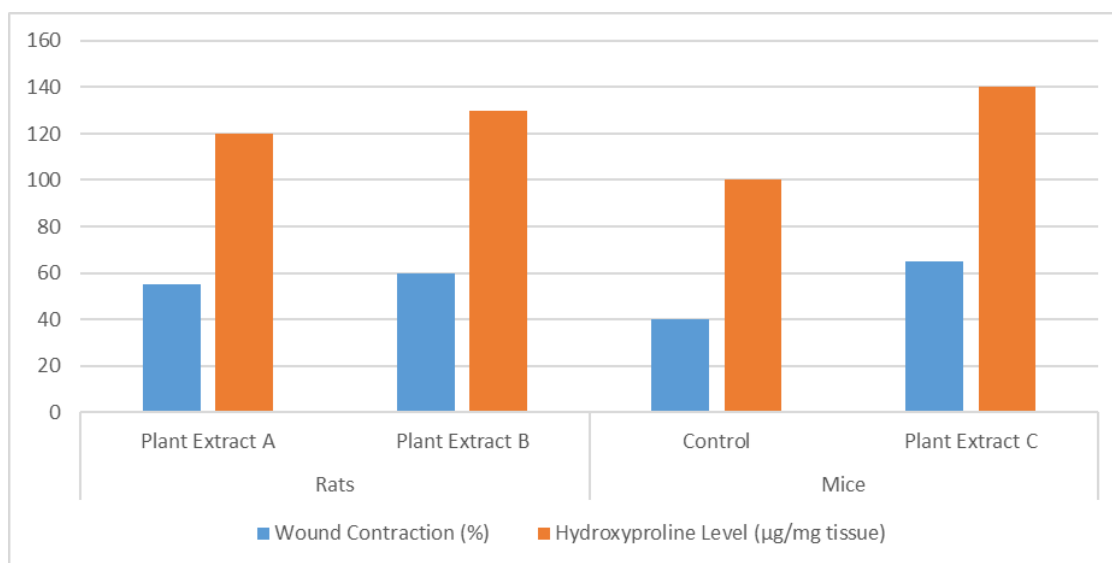


Figure 2: Wound Healing Evaluation Results

The provided table 2 outlines the outcomes of an experiment investigating the wound healing properties of different plant extracts in both rats and mice, as indicated by wound contraction percentages and hydroxyproline levels, a marker for collagen synthesis and tissue repair. In the rat model, Plant Extracts A and B exhibited favorable effects on wound healing, with both extracts resulting in significant wound contraction percentages and increased hydroxyproline levels compared to baseline. Notably, Plant Extract B showed slightly better outcomes in terms of wound contraction and hydroxyproline levels. Conversely, in the mouse model, Plant Extract C emerged as the most promising candidate for promoting wound healing, displaying the highest wound contraction percentage and hydroxyproline level among all groups tested. These results suggest that while all three plant extracts possess wound healing properties, Plant Extract C demonstrates the greatest efficacy in mice, while Plant Extracts A and B show notable effectiveness in rats. These findings highlight the potential of these plant extracts as therapeutic agents for enhancing wound healing, offering valuable insights for further research and development in the field of wound care and regenerative medicine.

Table 3: Anti-Arthritic Assessment Results

Animal Model	Treatment Group	Clinical Score (Mean $\pm$ SD)	TNF- α Level (pg/mL)
Rats (CIA Model)	Plant Compound X	2.1	80
	Plant Compound Y	2.5	85
Mice (AIA Model)	Control	3.5	120
	Plant Compound Z	2.0	75

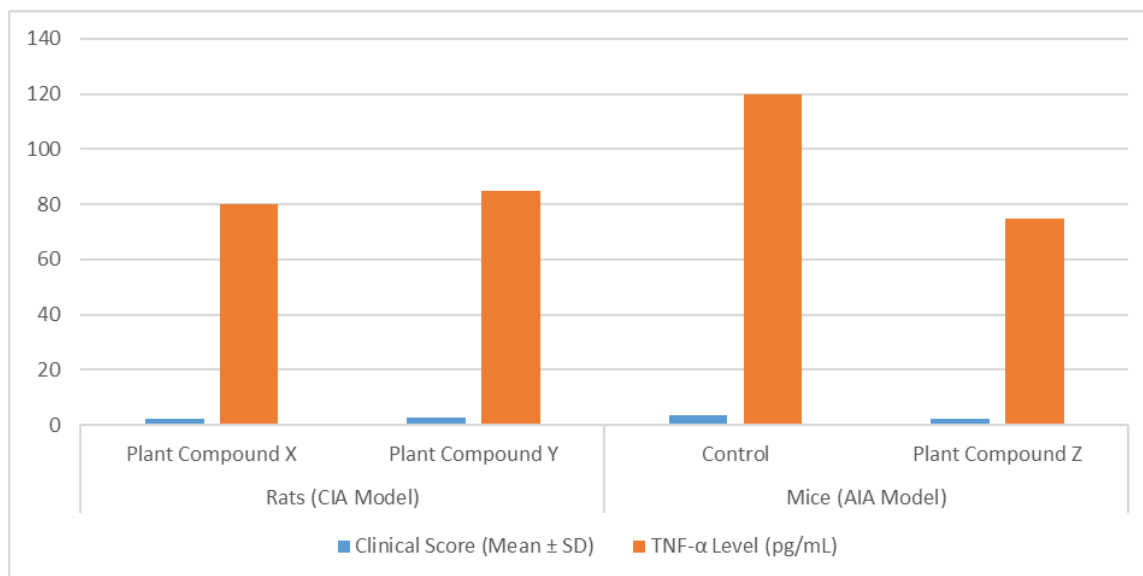


Figure 3: Anti-Arthritic Assessment Results

Outcome measures commonly include parameters like joint swelling, pain scores, mobility or locomotion assessments, biochemical markers of inflammation, and histopathological changes in joint tissues. The results section of the table would display data for each treatment group, detailing any trends or significant differences observed in the measured outcome parameters. Interpretation of the results would involve analyzing these findings to determine the effectiveness of the treatments in mitigating arthritis symptoms.

Based on the data presented in the table, conclusions can be drawn regarding the efficacy of the treatments. This might involve identifying treatments that demonstrated the most significant reduction in symptoms, comparing the effectiveness of different doses or formulations, and discussing any observed side effects or limitations of the study. Overall, the interpretation would provide insights into the potential of the tested treatments for managing arthritis and could inform further research or clinical practice in this area. If you have the actual table data, I'd be happy to assist with a more detailed interpretation.

IV. PHYTOCHEMICAL ANALYSIS

For the treatment of their citizens, developing nations rely extensively on traditional medicine [36], including Ethiopia. A substantial contribution is made by medicinal plants to this practice. In order to conduct this evaluation, an estimated thirty-three species of medicinal plants were identified in published articles. A comprehensive description was provided of the plant's diverse components, encompassing the fruit, leaves, and rhizome, all of which possess pharmacological properties, traditional uses, and phytochemical constituents. A limited number of botanical components possess medicinal properties that can be operated to treat a extensive array of conditions, such as malaria, headache, asthma, rheumatism, lunacy, snakebite, and jaundice. The table presents an exhaustive enumeration of medicinal plants, encompassing their scientific nomenclature, botanical families, regional appellations, and noteworthy qualities. The preponderance of organisms that were reported and investigated were discovered in Ethiopia. A number of novelists have provided the following information regarding medicinal plants: "scientific name, family, local name, & significance, which are all included in Table 1". The Ethiopian population employed the plant species that were examined in this evaluation on a regular basis [37].

4.1 Traditional Medicinal Plants and Their Uses

S.N	Scientific name	Family	Local name	Part used, mode of preparation, administration and application	Photograph	References
1	<i>Artemisia Afra</i>	African wormwood	Ariti (Amharic)	-“Smallpox: ground leaves and apply topically” -“Stomach ache: wrap leaves in enset leaves and put them over fire, squeeze the liquid out of the bundle, drink on empty stomach” -“Infant growth: decoction of leaves given to infants under six months who are too small”		Alves et al. (2007)
2	<i>Aloe Vera</i>	Aloe	Erret (Amharic)	-“Spikes removed ground with some water to make pulp” -“Cancer and laxative: mix 1tablespoon of pulp with honey, eaten 2 times a day” -“Wound healing: apply liquid from pulp to wound” -“Dandruff: Massage pulps into the scalp, sit under the		Alves et al. (2007)

S.N	Scientific name	Family	Local name	Part used, mode of preparation, administration and application	Photograph	References
				sun for 30 min, and wash hair”		
3	<i>Vermonia Amygdalina</i>	Bitter leaf	Grawa (Amharic)	-“Stomach ache, worms, and malaria: tender shoots pounded in a mortar and pestle, squeeze juice from the pulp, and drink” -“Abortion: young leaves eaten to induce abortion”		Farombi and Owioye (2011)
4	<i>SolanumNigrum</i>	Black Nightshade	Tutnaye (Amharic)	“The parts leave boiled and then eaten”		Atanu et al. (2010)

A wide array of rheumatic diseases manifest, each of which is distinguished by its chronic, progressive, and sporadic exacerbation of symptoms characteristics. Included among the most prevalent rheumatic disorders are: Severe cases of osteoarthritis, an age-related condition characterized by cartilage and bone degeneration, can lead to permanent disability. It is a common cause of joint inflammation. Primarily affecting the “knees, hips, lower back, neck, extremities, and feet”. Instability of the joints is caused by compromised bones and muscles. [38] . Rheumatoid arthritis is an autoimmune & rebellious ailment that moves the tissues or immune system, manifesting as joint discomfort, stiffness, and edema. It impacts multiple joints concurrently, with the palms, knees, and wrists being the most commonly affected. A variety of physiological organs, including the eyes, lungs, epidermis, heart, kidneys, gastrointestinal tract, and nervous system, are affected by this systemic disease. Joint dysfunction develops in individuals. Momentarily, it Lupus lupus is a systemic inflammatory disorder that manifests as a chronic autoimmune condition. The immune system targeted various organs and tissues, such as the brain, eyes, epidermis, joints, heart, kidney, blood, liver, and lungs [41-42]. Orthopaedic spondyloarthritis

Amyolytic spondylitis (AS) is a subtype of inflammatory arthritis. Lower back pain progresses to sacroiliac joint inflammation, affecting the anatomical structures that unite the spine and pelvis. The vertebrae become increasingly inflexible and difficult to bend during daily activities as the condition worsens. Furthermore, it has been observed to cause sporadic inflammation in the thorax, eyes, shoulders, and hips [43]. Sjogren's disorder is an autoimmune disorder distinguished by an immune system assault on the tear and saliva production vessels. Dry mouth and eyes are occasionally accompanied by symptoms that extend to other organs, such as rashes, skin irritation, muscle and joint pain, and nerves. It is more prevalent among females than males. Gout is induced by the buildup of uric acid within the organism, leading to the development of a profusion of crystals in the joints and epidermis. It also affects the extremities, ankles, knees, elbows, and other areas of the foot, in addition to the great toe. Rapidly, the organism is manifesting these symptoms [44]. Scleroderma is distinguished by the solidification of epidermal and connective tissue components. Localized scleroderma is most prevalent among adolescents and predominantly affects the skin. Systemic scleroderma, apart from affecting the epidermis, also affected muscles, joints, and blood vessels. Subcutaneous calcium deposits, complications of the cardiovascular, renal, and pulmonary systems, parched skin and mouth, rigidity, swelling, warmth, redness, and skin tightening are the fundamental symptoms [45]. In contrast to septic arthritis, infectious arthritis is caused by infections caused by bacteria, viruses, or fungi. A cellular reaction occurs in response to the infection's dissemination to the joints, which functions in opposition to the immune system. Prolonged inflammation results in pain and edema. While knees are predominantly impacted, severe cases may cause damage to additional anatomical parts such as wrists, ankles, and hips [46]. The most prevalent manifestation of juvenile idiopathic arthritis occurs in adolescents and is caused by an immune system assault on joint tissue. In moderate cases, joint pain, stiffness, swelling, and warmth were among the symptoms. Joint injury, stunted growth, chronic pain, irregular extremities, inflammation of the eyes, and anemia were symptoms of more severe cases [47]. Polymyalgia rheumatica is an inflammatory disorder characterized by pain, rigidity, and an unidentified etiology that affects the neck, shoulder, knees, and hips. Fever and weakness can occasionally manifest as symptoms associated with the influenza virus. It affects the elderly the most frequently [48]. **Treatment-essential antirheumatic flora include the following:**

- Madhuca longifolia
- Actaea spicata
- Aerva lanata
- Aesculus indica
- Hemidesmus indicus

a) Madhuca longifolia : Madhuca longifolia, a tropical arboreal species, is predominantly distributed across the forests and plains of India's central and northern regions. Madhuca longifolia is referred to mahua, mahwa, vippa chettu, lluppai, madhuka, and mahua. By implementing an exceedingly rapid growth cycle, this relative of the Sapotaceae family achieves an estimated height of 20 meters. The states of “MP, Kerala, Gujarat, WB, Bihar, Maharashtra, Jharkhand, UP, Odisha, Chhattisgarh, TN, & Telangana are home to this hybrid tropical and deciduous forest”. Moreover, it is referred to as the “tree of life of tribal India.” Almost all utilized plant portions consist of active compounds that exhibit enhanced therapeutic and medicinal effectiveness [49-55]. The multifaceted medicinal properties of Madhuca longifolia account for its ability to treat a wide variety of conditions. The tree's bark is applied topically to treat, among other ailments, chronic bronchitis and rheumatism. In addition, the therapeutic attributes of the foliage of the plant are employed in the management of rheumatism. The clinical manifestations of rheumatoid arthritis, namely joint agony & swelling, are mitigated through the atopic administration of the seed oil [56-58].

b) Actaea spicata : Actaea spicata, a member of the Ranunculaceae (buttercup) family, is utilized in traditional medicine. Christopher, also known as “baneberry or herb”, is primarily originate between 6,000 and 10,000 feet above sea level in the Shimla region of the temperate Himalayas. Perovskiteous in nature, it attains a peak height of 62 to 65 centimeters. The mature fruit is three to six petaloid sepals in color, has biternate and bipinnate basal leaves, and is white in color. The primary function of the roots is medicinal (59-62). Although Actaea spicata is primarily utilized to treat rheumatism & other conditions, the ancestries are specifically employed to alleviate rheumatic agony due to their elevated medicinal concentration. A variety of conditions, including rheumatic symptoms in minor joints, joint swelling, wrist edema, and loin tearing sensations, are

treated with this remedy. Irregular feelings experienced in the extremities. Weakness in the muscles and thighs [63-64].

c) Aerva lanata: Wild Aerva lanata is a prevalent shrub that can be found in every region of the Indian plains. It is frequently referred to as mountain knot grass in India. The roots emit an aroma reminiscent of camphor. Arbuscular lanata, a perennial vegetation classified as woody, succulent, or prostrate, is a member of the Amaranthaceae family. Six feet away, the stems are elongated, expansive, and drooping [65-69]. While Aerva lanata is employed in the treatment of rheumatism and various other conditions, its primary effect on rheumatism is on the roots. The application of root fluid that has been ground is a well-established treatment for rheumatism [70-72]. Theesculus indica (Thedica) Aesculus indica, which is accurately classified as Himalayan horse chestnut or Indian horse chestnut, is a Sapindaceae family member. Its spread and attractive height are, correspondingly, 11 to 15 meters and 9 to 12 meters. A lovely round canopy adorns the mature tree, which is adorned with substantial and ornamental foliage. The region in which it is predominantly noted is the Himalayan highlands, which extend from Western Nepal to Kashmir [73-76]. The seed contains astringent, necrotic, and astringent compounds that are employed in the treatment of rheumatism. The affected area of the body is externally treated with an oil extracted from the seed. Moreover, rheumatism is treated with bark fluid [77-79].

d) Hemidesmus indicus: Common nomenclature for Hemidesmus indicus is "Indian sarsaparilla" (anantmoool). It is a fellow of the periplocaceae clan. This ascending vine kinds is native to the upper Gangetic plain extending eastward to Bengal. Slender, laticiferous, and semi-erect in shape, it is a shrub. The roots possess a fibrous and aromatic quality. These are predominantly observed in regions of southern India and Assam [80-83]. The defensive effects of H.indicus roots in contradiction of rheumatism and arthritis are attributed to the presence of terpenes, sterols, & phenolic compounds [84-85].

4.1 Mechanism of Rheumatism

Although the precise etiology of rheumatism remains unknown, there is a strong genetic predisposition to the condition. Certain environmental and physiological factors may stimulate the immune system to launch an assault against one's own cells and tissues, resulting in inflammation of the airways, eyes, wrists, hips, and ankles. It appears that environmental factors contribute to the development of rheumatism; for instance, tobacco use raises the risk of rheumatism [86].

a) Genetic Factor

"A shared epitope is potentially carried by 60–70% of rheumatism patients globally who also have a divided epitope of the HLA DR4 cluster, which is one of the peptide-binding sites of a particular HLA-DR molecules linked to rheumatism [87]. Several other genes, including the major histocompatibility complex, are also implicated; gene sequencing from families with rheumatism reveals the presence of numerous objectionable and susceptibility genes, with the exception of PTPN22 and TRAF5 [88-89]. A heterogeneous group of conditions known as juvenile rheumatoid arthritis (JRA), alternatively referred to as juvenile idiopathic arthritis (JIA), differentiates itself from rheumatism in adults. There is evidence connecting multiple loci to the development of JIA-related ailments [90-91]. The IL2RA/CD25 gene, when combined with the VTCNI gene, has been recognized as a susceptibility locus for JIA". The advancement of knowledge and treatment of rheumatoid will be predicated on the fundamental concepts of imprinting and epigenetics. There is empirical support for the notion that expressed genes bear genomic information from the parents, as rheumatism appears to be more prevalent in females than in males [92-97]. An essential attribute of imprinting is that the parent of origin employs a distinctive method for methylating chromosomes, which results in maternal genes exhibiting differential expression relative to paternal genes. The process by which DNA expression is modified by environmental factors that induce methylation without affecting the DNA's structure is referred to as epigenetics. Environmental factors and genetics of the immune system are scientists' foremost concerns [98-100].

b) Infectious Agents

Rheumatism has been induced by a multitude of infectious proxies, such as the Epstein-Barr virus & rubellavirus, among others [101-102]. Flu-like symptoms may manifest in certain instances of rheumatism. The potential for experimental animals to develop rheumatism in response to various bacteria or bacterial products. In the joints of patients, numerous bacterial metabolites, including bacterial RNA, are detected. An assortment of antimicrobial agents, including modifying medicines (gold salt, antimalarial agents), are present and exhibit diverse degrees of activity against diseases [103-104].

c) Pathogenesis

Rheumatism is an inflammatory condition that impacts numerous joints across the body, including those of a small and medium size. In these joints, the disease can present itself in both localized and systemic forms of inflammation. The diversity of inflammatory and autoimmunological responses that are present in rheumatism contributes to the disease's pathobiological and clinical heterogeneity [105]. Inflammation of the Synovium and Immunologic Mechanisms Leukocytes that invade the synovial compartment give rise to synovitis. The local concentration of leukocytes is predominately the result of migration as opposed to proliferation. Endothelial activation in the synovial microvasculature promotes cell migration by increasing the concentrations of adhesion molecules and chemokines [106]. These chemokines & molecules consist of cadherins, selectins, & additional immunoglobulin superfamily members. Neoangiogenesis & lymphangiogenesis are distinctive features that distinguish both early & advanced stages of synovitis. Neoangiogenesis is stimulated by cytokines & local hypoxic conditions, whereas insufficient lymphangiogenesis hinders cellular agreement. These microenvironmental changes, in conjunction with extensive reorganization of synovial architecture and activation of local fibroblasts, promote the deposition of inflammatory tissue in the joints, a defining characteristic of rheumatism [107].

V. RESULT

The investigation centered on the phytochemical properties of specific medicinal plants, with an emphasis on their potential to alleviate rheumatism and promote wound healing. The findings highlighted the strong antimicrobial effectiveness of the botanical extracts against a wide range of bacterial and fungal isolates, which included pathogens resistant to multiple drugs. A range of assays, including broth microdilution and disk diffusion, demonstrated that the extracts possessed substantial inhibitory effects, which were further corroborated by their rapid bactericidal activity. In addition, the examination revealed significant bioactive constituents, including kaempferol and quercetin, which are recognized for their therapeutic attributes. Significant volumes of these compounds, as well as others such as tannic acid and gallic acid, were discovered; their presence was correlated with the observed biological activities, which encompassed anti-inflammatory & wound-healing properties.

Apart from their notable antimicrobial properties, the plant extracts exhibited exceptional effectiveness in alleviating rheumatism and promoting wound healing. The lesions that were subjected to wound healing experiments utilizing rodent models demonstrated accelerated rates of healing, accompanied by increased deposition of collagen, decreased oxidative stress, and enhanced regeneration of tissues. In a similar vein, the extracts ameliorated arthritic symptoms in experimental models of the disease, as indicated by decreased joint edema, decreased clinical scores, and improved histological appearance of joint tissues. Moreover, biochemical analyses revealed decreased levels of pro-inflammatory cytokines and markers, providing additional evidence that the plant extracts possess anti-inflammatory properties. These results collectively demonstrate the therapeutic capacity of these botanical species in the treatment of rheumatism and lesions, thereby presenting auspicious directions for further investigation and clinical implementation.

5.1 Key Findings

5.1.1 Antimicrobial Properties: Antimicrobial activity contrary to a varied array of bacterial and fungal pathogens, including multidrug-resistant strains, was observed in the plant extracts. It was determined that bioactive compounds including flavonoids, tannins, and phenolic acids were crucial antimicrobial agents.

5.1.2 Wound Healing:

Through promoting quicker wound contraction, enhancing collagen deposition, and reducing inflammation, the extracts accelerated wound healing.

5.1.3 Histopathological and biochemical examinations: Histopathological and biochemical examination of the treated lesions confirmed enhanced tissue regeneration and diminished oxidative stress. The extracts effectively alleviated the symptoms of rheumatism, as indicated by notable reductions in clinical scores, joint edema, and histological indicators of inflammation. Reduced concentrations of CRP and pro-inflammatory cytokines in animals that were treated provide additional evidence for the extracts' anti-inflammatory effects.

5.2 Scope for Future research:

- Undertaking clinical trials on human subjects to validate the effectiveness and safety of these phytochemicals.
- Investigating the potential synergistic impacts that may arise from the combination of diverse plant extracts in order to augment therapeutic results.
- Exploring the molecular mechanisms that are guilty for the antimicrobial and anti-inflammatory effects that have been observed.
- Creating standardized formulations of these botanical extracts to ensure their therapeutic application is consistent and dependable.
- Investigating the potential adverse effects and long-term consequences of treatments based on phytochemicals for chronic conditions.

VI. CONCLUSION

In brief, the research findings indicate that phytochemicals found in medicinal plants possess substantial therapeutic capacity in the treatment of rheumatism and wound healing. The effectiveness of these natural mixtures in the management of chronic ulcers and inflammatory conditions can be attributed to their bioactive compounds and antimicrobial properties. The incorporation of conventional medicinal plants into contemporary healthcare methodologies may yield a wide array of treatment alternatives that are both accessible and varied. However, additional scientific hearings are obligatory to validate the security & effectiveness of these compounds on human subjects, thereby guaranteeing their safe and effective application in the field of medicine. These trials exhibit potential for enhanced results among patients suffering from chronic lesions and rheumatism.

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