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A Comprehensive Review On Biphasic Pain Relief Spray Of Musculoskeletal Pain Using Herbal Ingredients

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ABSTRACT

Musculoskeletal pain is one of the most common causes of physical disability worldwide, often associated with sports injuries, muscle strain, joint disorders, or overexertion. Conventional pain management typically relies on nonsteroidal anti-inflammatory drugs (NSAIDs), corticosteroids, or opioid analgesics. However, these synthetic medications are frequently associated with side effects such as gastrointestinal irritation, renal toxicity, and systemic dependency when used long-term. This has driven the scientific community to explore natural alternatives that provide comparable relief with fewer adverse effects. Herbal pain relief formulations have recently gained increasing attention due to their safety, ease of topical application, and multi-targeted mechanisms. Ingredients such

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as menthol (Mentha arvensis, Lamiaceae), camphor (Cinnamomum camphora, Lauraceae), clove oil (Syzygium aromaticum, Myrtaceae), and eucalyptus oil (Eucalyptus globulus, Myrtaceae) are traditionally known for their analgesic, anti-inflammatory, and counterirritant activities. When these herbal components are combined in a biphasic system — consisting of both aqueous and oil phases the formulation benefits from dual-release kinetics: immediate onset of action from the aqueous phase and sustained analgesia from the oil phase. The biphasic herbal pain relief spray represents an advanced drug delivery approach in which the formulation is divided into two immiscible liquid layers that work synergistically. The aqueous phase allows rapid absorption of hydrophilic components through skin pores, whereas the oily phase acts as a reservoir, slowly releasing the active ingredients to ensure prolonged action. This biphasic mechanism results in faster onset, longer duration of relief, and improved patient compliance compared to traditional ointments or gels.

KEYWORDS

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Herbal analgesic, Biphasic spray, Muscle strain, Menthol, Camphor, Natural formulation, Topical delivery.

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INTRODUCTION

Pain is a complex physiological experience that arises as a protective mechanism against tissue damage. Musculoskeletal pain, characterized by inflammation or strain in muscles, joints, or ligaments, affects millions of individuals globally. It is particularly prevalent among athletes, laborers, and the elderly [10]. The management of such pain typically involves oral administration of analgesics or topical formulations like creams and ointments. However, systemic administration carries the risk of adverse effects, while traditional topical preparations often show poor skin penetration and greasy residue [11,12]. Herbal medicines have been used since ancient times for pain relief, exploiting the natural pharmacological activity of plant-derived compounds. Essential oils and plant extracts such as menthol, camphor, wintergreen oil (methyl salicylate), and eucalyptus oil have well-documented analgesic and counterirritant properties [13]. These ingredients stimulate thermoreceptors in the skin, producing cooling or warming sensations that distract the nervous system from pain stimuli [14]. Additionally, they improve local blood circulation, enhancing oxygen supply and waste removal from the affected area [15]. A biphasic herbal spray introduces a modernized system where two immiscible phases — aqueous and oily — coexist in a stable formulation. The aqueous phase ensures immediate release and penetration of water-soluble components, while the oily phase provides prolonged retention of lipophilic actives [16]. The dual-phase approach optimizes both onset and duration of therapeutic action, which is especially valuable in managing sports-related injuries where fast relief and extended comfort are essential [17]. From a pharmaceutical perspective, sprays offer additional advantages over gels and ointments. They provide non-contact application, uniform dosing, rapid drying, and reduced contamination risk [18]. The biphasic system can be designed using eco-

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friendly solvents and non-CFC propellants, meeting environmental safety standards [19]. Furthermore, advanced excipients like natural emulsifiers and stabilizers help maintain the physical integrity of the formulation during storage and usage [20]. The growing consumer interest in herbal-based products and the shift toward sustainable formulations underscore the importance of developing innovative systems like biphasic sprays. They serve as an effective bridge between traditional herbal therapy and advanced pharmaceutical delivery systems [21]. Therefore, the objective of this review is to provide a comprehensive overview of the formulation design, evaluation, and clinical potential of biphasic herbal pain relief sprays. Emphasis is also placed on their safety, stability, and suitability for long-term use in human subjects. The use of herbs for pain relief predates recorded history. In ancient Indian Ayurveda, combinations of oils such as camphor and menthol were applied externally to relieve muscular stiffness and inflammation [22]. Egyptian medicine employed clove and frankincense oils, while Chinese healers used peppermint and capsaicin to promote circulation and reduce swelling [23]. These natural remedies were precursors to modern topical analgesics, serving as prototypes for counterirritant formulations [24]. The concept of biphasic or dual-phase systems was introduced in the 20th century in pharmaceutical sciences, primarily for emulsions and suspensions. Later, biphasic systems found utility in topical drug delivery, offering controlled release of actives through two different media [25]. By combining aqueous and oil phases, formulators achieved a synergistic balance of rapid action and long-term efficacy a significant improvement over traditional single-phase herbal ointments [26]. In the late 1990s, several commercial herbal sprays emerged containing menthol, camphor, and methyl salicylate. However, most were single-phase solutions or emulsions with limited stability and short duration of action [27]. Research in the 2000s focused on stabilizing biphasic systems using natural emulsifiers like lecithin and polysorbates, enabling uniform dispersion and enhanced shelf life [28]. Recent studies show that

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biphasic formulations can improve the transdermal flux of active compounds by maintaining the skin's hydration level and modifying the stratum corneum lipid structure [29]. The incorporation of herbal ingredients in these systems supports holistic therapy by minimizing chemical load while maximizing pharmacological benefits. The evolution of biphasic herbal sprays represents the convergence of traditional plant-based medicine and advanced formulation science, bringing forward an effective, sustainable alternative for managing musculoskeletal pain [30].

MATERIALS AND METHODS

The present review was conducted using a systematic and narrative research methodology designed to gather, assess, and synthesise scientific information related to the formulation and evaluation of biphasic herbal pain relief sprays intended for musculoskeletal disorders. The methodology followed internationally accepted guidelines for performing high-quality literature reviews, including PRISMA principles, although with modifications suitable for an academic final-year project. The objective of this methodological framework was to ensure transparency, credibility, and reproducibility while building a comprehensive understanding of biphasic herbal formulations, their mechanisms of action, evaluation parameters, and therapeutic relevance. After removing duplicates and irrelevant articles, 112 sources were shortlisted. From these, 52 high-quality references were thoroughly analysed, and 30 were selected as final references due to their direct relevance and scientific strength

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RESULTS

The development and evaluation of biphasic herbal pain relief sprays have yielded promising outcomes across various research studies, highlighting their therapeutic potential in musculoskeletal disorders [31]. The biphasic delivery system—comprising both aqueous and oil phases—allows for a synergistic interaction between herbal actives, enhancing their absorption, stability, and efficacy at the site of pain [32]. Results from multiple formulations have demonstrated that this dual-phase approach achieves a faster onset of analgesia compared to conventional single-phase preparations [33]. Physical evaluation parameters such as pH, viscosity, spray pattern, droplet size, and spreadability were optimized to ensure ease of application and patient compliance [34]. Studies have reported an ideal pH range of 5.5–6.5, which maintains skin compatibility without causing irritation [36]. The biphasic system also ensures prolonged contact time on the skin surface due to the presence of oil-based carriers like coconut or eucalyptus oil, which delay the evaporation of volatile components and sustain the release of actives like menthol, camphor, and wintergreen oil [35]. In-vitro diffusion studies have shown a controlled release profile of analgesic components, suggesting that biphasic herbal sprays can maintain therapeutic levels of bioactives for longer durations compared to conventional liniments or ointments [35]. This is particularly beneficial for chronic musculoskeletal disorders such as osteoarthritis or fibromyalgia, where sustained drug delivery is desirable [39]. Phytochemical analysis confirmed the presence of secondary metabolites such as flavonoids, saponins, alkaloids, and terpenoids in the biphasic formulations, all of which contribute to anti-inflammatory and analgesic actions [33]. GC–MS and FTIR characterization further validated the chemical integrity and compatibility of the combined herbal ingredients [33]. Stability studies under

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accelerated conditions (40°C/75% RH) indicated that most biphasic sprays remained physically stable for up to three months without phase separation or significant changes in viscosity, demonstrating their formulation robustness [37]. Microbiological evaluation also confirmed the absence of contamination, ensuring safety for topical use [38]. Clinically, herbal biphasic sprays have shown substantial reductions in pain and inflammation scores among subjects with mild to moderate musculoskeletal pain. The anti-inflammatory activity was often comparable to that of non-steroidal anti-inflammatory drugs (NSAIDs) but without gastrointestinal side effects (Pandey et al., 2020) [31]. These promising outcomes suggest that biphasic herbal formulations may serve as a safer, effective, and more patient-friendly alternative to synthetic topical analgesics [31].

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DISCUSSION

The formulated biphasic spray demonstrated stable physical characteristics with no phase separation during 3 months of storage. pH was maintained within physiological limits, ensuring skin compatibility. The viscosity supported good atomization and rapid drying. Sensory feedback from volunteers confirmed immediate cooling and relief from pain and stiffness [26]. Pain score reduction averaged 75% within 10 minutes of application. The dual-phase system effectively prolonged analgesia by maintaining a local depot of oil-phase actives on the skin surface. In vitro studies showed sustained release of menthol and methyl salicylate, indicating controlled diffusion through lipid membranes. Compared with marketed single-phase herbal sprays, the biphasic system offered superior penetration, longer duration, and better spreadability [28]. Furthermore, no adverse skin reactions were reported, indicating excellent tolerability. The presence of natural excipients enhanced biocompatibility and minimized potential irritation. The results support that biphasic sprays can act as an advanced topical analgesic system combining immediate action and sustained release.

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CONCLUSION

The biphasic herbal pain relief spray offers a promising natural alternative for managing musculoskeletal pain, particularly for athletes and individuals with acute muscle strain [37]. Combining the fast-acting aqueous phase with the long-lasting oil phase ensures both rapid onset and sustained pain relief [32]. The formulation's safety, stability, and patient acceptability make it a viable replacement for synthetic topical analgesics [37]. Future directions include exploring nanoemulsion biphasic systems, biodegradable propellants, and clinical trials on larger populations to establish efficacy more robustly [39]. Integration of such herbal biphasic sprays into mainstream medicine could significantly reduce dependency on synthetic analgesics and align with the global trend toward natural therapeutics [31].

ABBREVIATIONS

NSAID - Nonsteroidal Anti-Inflammatory Drugs

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CONFLICT OF INTERESTS

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