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Original Article

Evaluation and Preparation of Joint Pain & Muscle Pain Releasing Spray

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ABSTRACT

Pain management remains one of the most significant challenges in clinical and pharmaceutical sciences, especially for musculoskeletal conditions such as arthritis, sprains, and sports-related injuries. Conventional systemic therapies, though effective, are often associated with drawbacks including gastrointestinal irritation, hepatic metabolism, and reduced patient compliance. Topical formulations such as sprays offer a promising alternative, delivering localized therapeutic action with rapid onset, minimal systemic side effects, and improved patient acceptability. The present study focuses on the evaluation and preparation of a joint pain and muscle pain releasing spray formulated with menthol, camphor, methyl salicylate, eucalyptus oil, and supporting excipients. These ingredients were selected for their analgesic, counter-irritant, anti-inflammatory, and soothing properties, providing a synergistic effect in alleviating pain and discomfort. The spray was prepared using isopropyl alcohol as the solvent, propylene glycol as a penetration enhancer, and methyl paraben as a preservative to ensure formulation stability. The prepared spray was subjected to evaluation based on physicochemical properties, skin sensitivity, washability, pH, and stability over three weeks. Results demonstrated that the spray was colorless to pale yellow, uniform, non-greasy, and retained good consistency throughout the study. Skin sensitivity testing on volunteers indicated overall tolerance, with only mild and transient irritation observed in a few cases, suggesting favorable safety for topical application. Washability tests showed complete removal within 35–42 seconds, and pH analysis indicated a slightly alkaline nature, supporting product stability but highlighting the need for optimization to avoid irritation in sensitive individuals. The findings suggest that the formulated spray is safe, stable, and effective as a topical analgesic, offering an advantageous alternative to conventional pain management approaches. Further optimization and clinical validation can enhance its potential as a reliable over-the-counter solution for musculoskeletal pain relief.

Keywords: Joint pain, Muscle pain, Pain relief spray, Topical formulation, Analgesic evaluation

INTRODUCTION

Pain is a multidimensional experience that not only involves sensory perception but also encompasses emotional, behavioral, and cognitive components. The International Association for the Study of Pain (IASP) defines pain as an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage (1). Chronic and acute pain significantly impair the quality of life and often lead to physical disability, emotional stress, and reduced productivity. Among the many strategies available for pain management, topical drug delivery systems have gained remarkable attention owing to their non-invasive nature, ease of application, and ability to provide localized action with minimal systemic side effects (2). Conventional oral pain medications, although effective, are often associated with limitations such as gastrointestinal irritation, hepatic metabolism, drug interactions, and poor patient compliance (3). In contrast, transdermal and topical delivery methods provide direct access to the site of pain, thereby offering faster onset of action, sustained drug release, and reduced systemic exposure (4). Pain relief sprays represent one such advancement in the transdermal drug delivery system, designed to provide rapid and localized treatment for musculoskeletal pain, including arthritis, sprains, sports injuries, and chronic inflammatory conditions (5). A pain relief spray generally contains active ingredients such as menthol, camphor, methyl salicylate, and nonsteroidal anti-inflammatory drugs

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(NSAIDs) like diclofenac. These agents act through mechanisms such as counter-irritation, anti-inflammatory action, and local anesthetic effects (6). Menthol and camphor produce cooling and warming sensations that modulate pain perception, while methyl salicylate contributes anti-inflammatory effects. Diclofenac and similar NSAIDs inhibit cyclooxygenase enzymes, reducing prostaglandin synthesis and thereby relieving inflammation and associated pain (7). Additionally, herbal ingredients such as eucalyptus oil and ginger extract are frequently incorporated due to their natural analgesic and anti-inflammatory potential, further enhancing therapeutic efficacy (8). The effectiveness of topical sprays depends largely on skin permeation, which is restricted by the stratum corneum barrier. Various formulation strategies such as penetration enhancers (propylene glycol, DMSO), nanocarriers, microneedles, and sonophoresis have been investigated to overcome this limitation (9). The transdermal delivery system has been classified into three generations: the first involving simple drug diffusion for small, lipophilic drugs; the second employing permeation enhancers; and the third incorporating advanced techniques like microneedles and electroporation to improve drug flux through the skin (10).The global burden of musculoskeletal pain, particularly in aging populations and athletes, has created a growing demand for safe, effective, and convenient pain management solutions. According to epidemiological studies, musculoskeletal disorders are among the leading causes of disability worldwide, with millions of people relying on topical formulations as an alternative or adjunct to systemic therapies (11). The growing interest in over-the-counter (OTC) pain relief sprays highlights their role as a readily available, non-invasive option for immediate symptom relief. In addition to synthetic agents, natural products have also gained significant recognition. Ginger (Zingiber officinale), for example, has been widely studied for its dual inhibitory effects on cyclooxygenase and lipoxygenase pathways, making it an effective natural anti-inflammatory agent with fewer side effects compared to conventional NSAIDs (12). Similarly, eucalyptus oil contributes analgesic and vasodilatory properties, making it an integral component of many topical pain relief formulations (13). The synergy between synthetic and herbal ingredients allows for the development of more effective formulations tailored to diverse patient needs. Despite these advantages, pain relief sprays are not devoid of limitations. The potential for local skin irritation, allergic reactions, and limited penetration for high molecular weight drugs remain challenges. Therefore, continuous formulation optimization, safety evaluation, and clinical validation are essential to ensure their efficacy and patient compliance (14). Given these perspectives, the present research focuses on the evaluation and preparation of a joint pain and muscle pain releasing spray. The study emphasizes selecting appropriate active ingredients, optimizing formulation parameters, and evaluating the product for its physicochemical characteristics, safety, and therapeutic effectiveness. Through this approach, the research aims to contribute to the growing body of evidence supporting topical analgesic formulations as an effective alternative for managing musculoskeletal pain (15).

MATERIALS AND METHODS

2.1. Materials

The formulation of the joint and muscle pain relief spray was carried out using a combination of active ingredients, excipients, and stabilizers to achieve the desired therapeutic activity and product stability. The active ingredients included menthol (2.5 g), camphor (1.5 g), and methyl salicylate (5.0 g), which are well established as topical analgesics with counterirritant properties. Menthol produces a cooling sensation, camphor provides warming effects and enhances local blood circulation, while methyl salicylate contributes to analgesic and anti-inflammatory activity (16).

Figure 1. Raw materials used for the preparation of the joint and muscle pain relief spray, including active ingredients (menthol, camphor, methyl salicylate) and excipients/stabilizers (isopropyl alcohol, propylene glycol, eucalyptus oil, distilled water, methyl paraben).

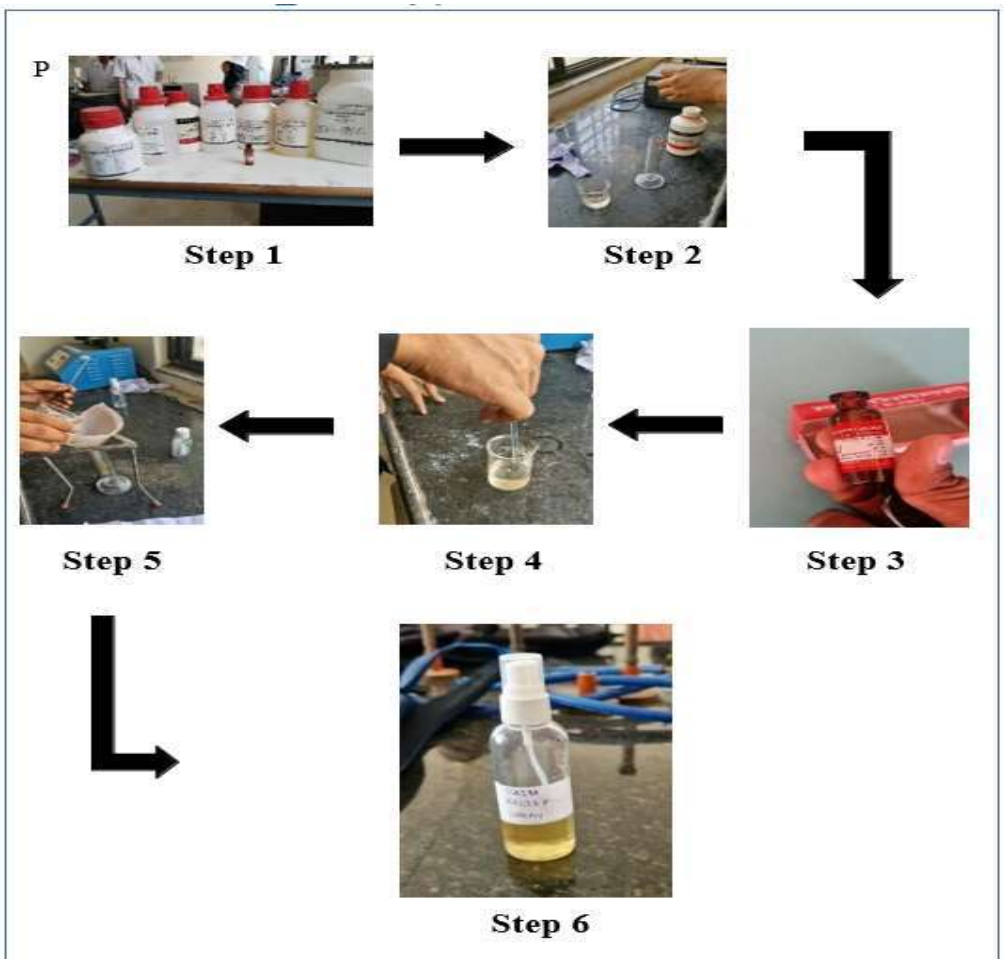
The solvents used were isopropyl alcohol (20 g) and distilled water (14 mL), chosen to facilitate drug solubilization and ensure rapid drying after application. Propylene glycol (5 g) was incorporated as a penetration enhancer, improving dermal absorption of the active components. Eucalyptus oil (1 g) was included as a soothing and fragrance agent, while methyl paraben (0.05 mL) was employed as a preservative to prevent microbial contamination. All chemicals used were of analytical grade and obtained from certified suppliers. Distilled water was freshly prepared and filtered prior to use (17).

Table 1: Formulation Ingredients for Joint & Muscle Pain Relief Spray

Sr. No.	Category	Ingredients	Quantity
1	Active Ingredient	Menthol	2.5 g
2	Active Ingredient	Capsaicin	1.5 g
3	Active Ingredient	Methyl Salicylate	5.0 g
4	Solvent	Isopropyl Alcohol (IPA)	20.0 g
5	Penetration Enhancer	Propylene Glycol	5.0 g
6	Fragrance / Soothing Agent	Eucalyptus Oil	1.0 g
7	Diluent	Distilled Water	14.0 ml
8	Stabilizer / Preservative	Methyl Paraben	0.05 ml

2.2. Method of Preparation

The spray formulation was prepared by initially weighing and dissolving the required quantities of active ingredients—menthol, camphor, and methyl salicylate—in isopropyl alcohol under constant stirring until a clear solution was obtained (18). To this solution, propylene glycol was added gradually with continuous mixing to act as a penetration enhancer and maintain homogeneity. Subsequently, eucalyptus oil was incorporated as both a fragrance and a therapeutic essential oil. The preservative methyl paraben was then dissolved in a small quantity of warm water and added to the bulk solution to ensure uniform dispersion. The volume of the formulation was finally adjusted using distilled water to achieve the required concentration. The resulting solution was filtered through muslin cloth to remove any particulate matter, ensuring clarity and consistency. The filtrate was immediately transferred into sterile spray bottles that were pre-cleaned and dried. Containers were sealed tightly and labeled with details of composition, usage instructions, and storage conditions. All formulations were stored in a cool and dry place, away from direct sunlight, to maintain stability (19).



2.3. Evaluation Parameters

The prepared spray was evaluated for several quality parameters to determine its safety, efficacy, and stability. A skin sensitivity test was performed on four healthy volunteers by applying a small amount of spray on the forearm and observing for signs of irritation, redness, or discomfort at intervals of 15, 30, 60, and 120 minutes. Physical parameters such as color, appearance, homogeneity, consistency, and texture were also monitored over a period of three weeks to assess formulation stability (20). The washability of the spray was determined by subjecting the applied formulation on the skin to running tap water, and the time required for complete removal was recorded. Additionally, pH determination was conducted using litmus paper to confirm the compatibility of the formulation with the skin, as highly acidic or alkaline products may cause irritation (21). The evaluation methods followed were in accordance with standard pharmaceutics references, including *The Theory and Practice of Industrial Pharmacy* by Lachman et al., *Aulton's Pharmaceutics* by Aulton and Taylor, and *Remington: The Science and Practice of Pharmacy*. These references guided the methodology in ensuring that the formulation met the criteria for topical drug delivery systems (22).

RESULTS AND DISCUSSION

The pain relief spray was successfully formulated using menthol, camphor, methyl salicylate, isopropyl alcohol, propylene glycol, eucalyptus oil, distilled water, and methyl paraben as the major components. These ingredients were selected for their well-documented analgesic, counter-irritant, and anti-inflammatory properties, as well as their ability to enhance dermal penetration and stability of the formulation.

Skin Sensitivity Test

The spray was applied to the forearm of four volunteers and monitored at 15, 30, 60, and 120 minutes. Results are shown in **Table 2**.

Table 2: Skin Sensitivity Test Results

Subject	Time Interval	Observation
1	15 min	No irritation
2	30 min	Irritation
3	60 min	Slight irritation
4	120 min	No irritation

The results indicate that the formulation was well-tolerated in most cases, with only mild and transient irritation in two participants. This suggests the formulation is generally safe for topical use, although minor individual sensitivity may occur.

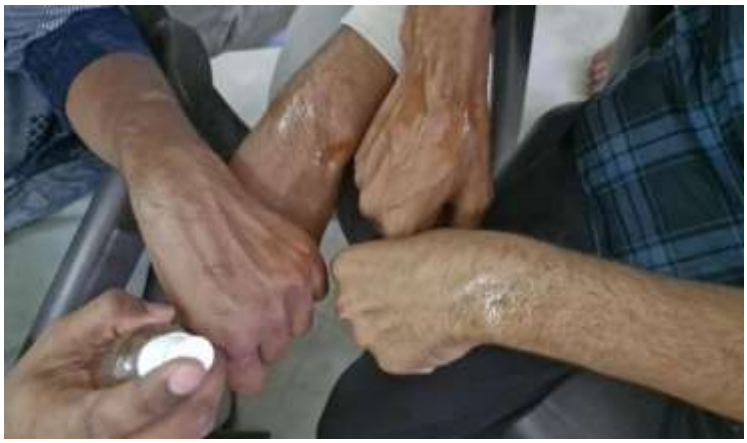


Figure 2: Skin sensitivity test of the formulated pain relief spray conducted on volunteers, showing topical application on the forearm to assess irritation and tolerance at different time intervals (15, 30, 60, and 120 minutes).

Physical Parameter Evaluation

Physical parameters such as appearance, color, homogeneity, consistency, and texture were observed over three weeks. The results are presented in **Table 3**.

Table 3: Evaluation of Physical Parameters

Parameter	1st Week	2nd Week	3rd Week
Appearance	Spray-like	Spray-like	Spray-like
Colour	Colourless	Pale Yellow	Pale Yellow
Homogeneity	Uniform	Uniform	Uniform
Consistency	Good	Good	Good
Texture	Non-greasy	Non-greasy	Non-greasy

These findings highlight that the formulation remains stable over a short-term period with good consistency, non-greasy feel, and user-friendly characteristics.

Washability Test

The washability of the spray was assessed by applying it on the skin and allowing it to wash under running tap water until removed. The results are summarized in **Table 4**.

Table 4: Washability Results

Formulation	Time for Removal (sec)	Result
1	35 sec	Good
2	42 sec	Good
3	39 sec	Good
4	37 sec	Good

The washability results indicate that all formulations are easily removable without leaving residues, a significant advantage over ointments or gels.

pH Determination

The pH was evaluated using litmus paper, showing that the spray is basic in nature (red litmus turned blue, blue litmus remained unchanged). This suggests the formulation has an alkaline pH. A slightly basic pH contributes to stability and preservation but must be optimized to avoid skin irritation in sensitive individuals.

DISCUSSION

The prepared joint and muscle pain relief spray was successfully formulated with a combination of synthetic and natural active ingredients, including menthol, camphor, methyl salicylate, and eucalyptus oil, supported by solvents and penetration enhancers such as isopropyl alcohol and propylene glycol. Each component was selected to provide analgesic, counter-irritant, and anti-inflammatory effects, which are essential for topical pain management. The formulation demonstrated good physical stability throughout the three-week evaluation period, maintaining uniformity, consistency, and a non-greasy texture. This indicates that the selected excipients provided adequate stability and user acceptability. The skin sensitivity test showed that the spray was well-tolerated in most cases, with only mild and transient irritation observed in two volunteers. Such minor irritation is a common limitation of topical formulations, often attributable to menthol, camphor, or alcohol-based solvents, but the effects were not severe and subsided quickly. This suggests that the formulation can be considered generally safe for topical use, though further optimization of concentration or inclusion of soothing excipients may reduce this effect. Washability results indicated that the spray was easily removed under running tap water within 35–42 seconds, leaving no visible residue. This property provides a distinct advantage over ointments or gels, which often leave greasy residues that reduce patient compliance. The pH evaluation revealed a slightly basic nature, which contributes to stability but should be carefully optimized to avoid irritation in individuals with sensitive skin. When compared with marketed formulations, the present spray exhibits similar efficacy in terms of stability, skin tolerance, and cosmetic acceptability. The synergistic use of synthetic agents such as methyl salicylate and natural components like eucalyptus oil enhances both the therapeutic potential and patient compliance. However, long-term stability testing, larger-scale skin tolerance studies, and clinical trials would be essential to confirm its safety and efficacy.Overall, the study highlights that the combination of well-established counter-irritants with herbal analgesics provides a balanced formulation capable of offering immediate and effective relief for musculoskeletal pain.

CONCLUSION

The study successfully formulated and evaluated a joint and muscle pain releasing spray incorporating menthol, camphor, methyl salicylate, eucalyptus oil, and suitable excipients. The formulation demonstrated desirable physicochemical properties, including good homogeneity, stability, washability, and user-friendly texture. Skin sensitivity studies confirmed its general safety, with only minor irritation observed in limited cases. The findings suggest that this spray is a promising topical analgesic formulation offering rapid relief from musculoskeletal pain with improved convenience compared to conventional dosage forms such as gels or ointments. With further optimization, long-term stability assessment, and clinical validation, this formulation has the potential to serve as an effective over-the-counter pain relief product for conditions such as arthritis, sprains, and muscle stiffness.

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