Topical Anti-Inflammatory Formulations from Medicinal Plant Extracts: Stability, Efficacy, and Cytokine Modulation in a Carrageenan-Induced Paw Edema Model

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Abstract

Background: Traditional anti-inflammatory drugs, like NSAIDs, often cause side effects, which has fueled interest in plant-based alternatives with fewer adverse effects. Medicinal plants such as turmeric (Curcuma longa), ginger (Zingiber officinale), frankincense (Boswellia serrata), ashwagandha (Withania somnifera), and gotu kola (Centella asiatica) are known for their bioactive compounds with anti-inflammatory properties. This study aimed to evaluate the anti-inflammatory efficacy of these plant extracts in topical formulations. Methods: Ethanol extracts of the selected plants were prepared and formulated into topical gel and cream forms. Stability testing was conducted over a 30-day period to confirm the formulations' consistency, color, and pH. Anti-inflammatory efficacy was assessed using a carrageenan-induced paw edema model in Wistar rats. The animals were divided into six groups, including control, standard drug (indomethacin), and plant-based formulations at two extract concentrations (5% and 10%). Edema reduction was measured using a plethysmometer, and serum cytokine levels (TNF-α and IL-6) were quantified via ELISA. Histopathological analyses of tissue samples further evaluated the anti-inflammatory effects. Results: Both gel and cream formulations demonstrated stability over 30 days. The 10% extract cream formulation achieved the highest reduction in paw edema (70%) and reduced inflammation levels comparable to indomethacin. The 10% extract gel showed similar results (65% reduction). Biochemical analysis revealed significant reductions in TNF-α and IL-6 levels, especially in the 10% cream and gel groups, aligning with histopathological findings that indicated reduced tissue damage and inflammatory cell infiltration in treated groups compared to controls. Conclusion: The findings suggest that these plant extracts possess potent anti-inflammatory effects when formulated into stable, topical products. The 10% extract cream formulation was particularly effective, offering a promising alternative for managing inflammation with fewer side effects.

Keywords: Anti-inflammatory, plant extracts, topical formulation, cytokine modulation, carrageenan-induced edema

Significance | This study showed the potential of plant-based creams and gels as stable, effective, topical anti-inflammatory agents, reducing cytokine-induced inflammation.

1. Introduction

Inflammation is a vital response by vascular tissues to harmful stimuli, such as infections, irritants, and damaged cells. This defense mechanism involves immune cells, blood vessels, and chemical mediators that coordinate to protect the body.

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Editor Loiy Elsir Ahmed Hassan, Ph.D., And accepted by the Editorial Board October 15, 2024 (received for review August 04, 2024)

Please Cite This:
Raafat M. Alaatabi, Falah Hassan Shari, Mrs.Poulami Sen, Gunawan Widjaja (2024). "Topical Anti-Inflammatory Formulations from Medicinal Plant Extracts: Stability, Efficacy, and Cytokine Modulation in a Carrageenan-Induced Paw Edema Model", Journal of Angiotherapy, 8(10),1-6,9998