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Review Article

REVIEW ON PREPARATION AND EVALUATION OF INSECT REPELLENT FORMULATIONS

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Abstract

Insect-borne diseases such as malaria, dengue, and chikungunya pose serious global health challenges, emphasizing the need for effective vector control. Insect repellents, both synthetic (DEET, picaridin) and natural (citronella, neem, eucalyptus), play a critical role in preventing bites and reducing disease transmission. This review summarizes various formulation strategies, including emulsions, creams, gels, sprays, ointments, and solid forms, highlighting the roles of excipients and functional additives in ensuring stability, efficacy, and user acceptability. Evaluation parameters such as repellency, safety, stability, and organoleptic properties are discussed. The review emphasizes the importance of optimizing formulation techniques, active ingredients, and testing methods to develop safe, effective, and consumer-friendly insect repellent products.

Keywords: Insect repellents, Formulation techniques, Natural and synthetic actives, Evaluation methods, Stability

1. Introduction

Insect-borne diseases such as malaria, dengue, chikungunya, and Zika virus pose a significant global health threat, especially in tropical and subtropical regions. According to the World Health Organization, millions of people are affected annually, resulting in substantial morbidity, mortality, and economic losses. These diseases not only strain healthcare systems but also impact agricultural productivity and community well-being. Controlling the spread of such diseases remains a priority for public health agencies and governments worldwide[1].

Figure 1: Mosquito Bite and Hazard

Insect repellents play a vital role in reducing the risk of insect bites and, consequently, the transmission of vector-borne diseases. They serve as personal protective agents and are also used in vector control strategies across households, outdoor recreational areas, and agricultural fields. Effective repellents are essential for safeguarding vulnerable populations, particularly in regions with high insect activity or during outbreaks[2].

Insect repellents are broadly classified into natural and synthetic categories. Natural repellents, derived from herbal extracts and essential oils such as citronella, eucalyptus, and neem, offer eco-friendly and skin-friendly alternatives but may have limited residual action and lower potency. Synthetic repellents, including N,N-diethyl-meta-toluamide (DEET) and picaridin, provide long-lasting protection and higher efficacy but are sometimes associated with adverse skin reactions or environmental concerns[3].

This review aims to explore various formulation strategies and evaluation methods used in the development of insect repellent products. It focuses on enhancing efficacy, safety, and stability by examining different excipients, active ingredients, and delivery systems. It addresses challenges related to formulation performance, regulatory compliance, and user acceptance, offering insights for researchers and formulators to develop effective and safe insect repellent products for diverse applications[1-3].

2. Objectives

- To explore preparation techniques used in insect repellent formulations
- To summarize commonly used ingredients and their functional roles
- To highlight evaluation methods for repellent efficacy, safety, and stability, and discuss challenges in developing formulations that balance effectiveness with skin compatibility.

3. Methodology

- A systematic literature search was carried out using PubMed, Scopus, ScienceDirect, and Google Scholar.
- Keywords such as "insect repellent formulation," "natural repellents," "synthetic repellents," "evaluation methods," and "stability studies" were used in various combinations.
- The search aimed to cover a wide range of studies on formulation strategies and evaluation approaches[4].
- Articles published in the last 10 years were considered to ensure up-to-date information.
- Only peer-reviewed journals, patents, and pharmaceutical reports were included for reliability.
- Irrelevant, non-scientific, or incomplete sources were excluded to maintain focus.
- Data was collected on formulation types, active ingredients, excipients, preparation methods, and testing protocols.
- The extracted information was categorized under preparation techniques and evaluation methods[4-6].
- This structured approach helped in comparing different strategies for efficacy, safety, and stability.
- The methodology ensured a thorough and relevant review to assist researchers in developing improved insect repellents[6].

4. Findings of this Review

Insect repellents play a vital role in preventing vector-borne diseases and enhancing outdoor comfort. Various formulation types, including emulsions, creams, gels, sprays, ointments, and solid forms, have been developed to deliver active ingredients effectively. Both synthetic agents like DEET and natural plant-based compounds such as citronella and neem oil are widely used, often in combination to enhance efficacy. Excipients and functional additives help maintain stability, improve texture, and increase skin compatibility. Evaluation parameters such as repellency, safety, stability, and user acceptability are critical for optimizing performance. This review

summarizes the preparation techniques, active ingredients, excipients, and assessment methods used in insect repellent formulations.

4.1 Preparation Techniques for Insect Repellent Formulations

A. Emulsions (O/W and W/O types): Emulsions, both oil-in-water (O/W) and water-in-oil (W/O) types, are widely used in insect repellent formulations due to their ease of application and effective delivery of active agents. O/W emulsions disperse oil droplets in water, offering a light, non-greasy feel suitable for sprays and lotions, while W/O emulsions are more occlusive, providing prolonged protection. Emulsification is achieved using mechanical methods such as high-shear mixing or homogenization, along with stabilizers like lecithin, span, and tween surfactants to prevent phase separation. These formulations are preferred in sprays and creams because they ensure uniform distribution of the active ingredients on the skin and maintain stability over time[7-8].

B. Creams and Lotions: Creams and lotions serve as convenient topical forms of insect repellents, offering ease of spreadability and skin comfort. Creams typically have a semi-solid consistency, while lotions are more fluid, allowing for rapid application over large areas. Formulation involves the selection of suitable base agents such as water, oils, and emulsifiers, along with emollients and skin-conditioning agents like glycerin or aloe vera to enhance moisturization and reduce skin dryness. The choice of base influences the product's texture, absorption rate, and stability, which are critical for consumer acceptability and effective repellency[7-8].

C. Gels: Gels are polymer-based semi-solid formulations often prepared using carbopol, hydroxypropyl methylcellulose (HPMC), or other gelling agents. These formulations are valued for their transparency, cooling effect, and ability to control the release of active repellent compounds. The incorporation of humectants ensures that gels do not dry out quickly, while careful pH adjustment maintains skin compatibility. Gels can offer long-lasting protection without leaving a greasy residue, making them suitable for hot and humid climates where comfort during application is important[8-9].

D. Sprays and Aerosols: Sprays and aerosols are designed for convenient, quick application over large areas, particularly for outdoor use. These formulations include a propellant system to deliver the active ingredient uniformly, along with stabilizers to maintain suspension of the active agents. The formulation must ensure application efficiency, proper coverage, and droplet size that maximizes skin retention while minimizing inhalation risk. Aerosols require careful selection of compatible propellants, while pump sprays emphasize even distribution and user safety[9].

E. Ointments and Pastes: Ointments and pastes are thick formulations intended for localized use on specific areas of the skin. They provide a moisturizing effect and can create a protective barrier that prolongs the presence of the active repellent. The challenge lies in balancing thickness and stickiness to ensure that the product is effective without being uncomfortable for the user. These formulations often include occlusive agents like petrolatum or lanolin, which enhance retention of volatile essential oils and synthetic repellents[10].

F. Solid Forms (Sticks, Powders): Solid forms, such as sticks and powders, offer convenience, portability, and controlled release of active ingredients. Sticks are often prepared by blending waxes with active agents and emollients to produce a solid applicator that can be rubbed directly onto the skin. Powders may contain talc or starch as carriers, allowing for dusting over exposed areas. These formulations are particularly beneficial for travelers and outdoor enthusiasts because they are easy to carry and reduce the risk of spillage or evaporation of volatile agents.

4.2 Active Ingredients Used

Insect repellent formulations rely on both synthetic and natural active agents. Synthetic agents like DEET, picaridin, and IR3535 are widely used for their high efficacy and long duration of protection

against mosquitoes and other insects. Natural agents, including citronella oil, eucalyptus oil, neem oil, lemongrass, and camphor, are preferred for their low toxicity and eco-friendly profile, although their protection duration may be shorter. Combining different actives in synergistic formulations can enhance repellency and extend protection time. The concentration of active ingredients is critical, as it directly impacts efficacy, skin tolerance, and user comfort, and must be optimized for each type of formulation[8-11].

4.3 Excipients and Functional Additives:

Excipients play a vital role in the stability, aesthetics, and safety of insect repellent formulations. Emulsifiers and stabilizers maintain the uniform dispersion of active agents in emulsions and creams, while preservatives prevent microbial contamination. Humectants and solvents ensure proper consistency, prevent drying, and enhance skin absorption. Additionally, skin-conditioning agents improve texture and reduce irritation. Fragrances and masking agents are often incorporated to neutralize unpleasant odors of active ingredients and enhance user acceptability. The selection of excipients must balance stability, efficacy, and sensory properties to ensure consumer satisfaction[10].

4.4 Evaluation Parameters:

The effectiveness and safety of insect repellent formulations are assessed through multiple evaluation parameters. Efficacy tests, such as repellence percentage, protection duration, and mosquito landing tests, measure the product's ability to prevent bites. Safety assessments, including skin irritation, patch tests, and sensitization studies, ensure formulations are non-toxic and suitable for human use. Stability studies evaluate physical characteristics, phase separation, microbial growth, and shelf-life under various storage conditions.

Organoleptic evaluation assesses texture, odor, color, and spreadability to optimize sensory appeal. Finally, user acceptability studies gather feedback on comfort, stickiness, residue, and overall usability, providing insight into real-world performance and consumer preference[11].

Figure 2: Mosquito repellent market product

Table 1: Formulations of insect repellents[12,13]

Sr. No.	Brand	Formulation Type	Approx. Price (INR)
1	Good Knight	Liquid Vaporizer Refill	₹150–₹200
2	Odomos (Dabur)	Cream/Lotion	₹50–₹150
3	Mamaearth	Mosquito Patches	₹230–₹250
4	Bodyguard	Herbal Mosquito Spray	₹129–₹350
5	All Out	Liquid Vaporizer Refill	₹150–₹200
6	Hit	Mosquito Spray	₹150–₹200
7	Mortein	Mosquito Spray	₹150–₹200
8	Good Knight Naturals	Natural Mosquito Spray	₹200–₹250
9	Mamaearth	After Bite Roll-On	₹284–₹299
10	Mother Sparsh	Natural Insect Repellent Spray	₹224–₹249

Some market available formulations of insect repellents are given in below table no 1.

5. Discussion

The review of insect repellent formulations reveals a diverse range of preparation techniques, each tailored to optimize efficacy, stability, and user acceptability. Emulsions, creams, and gels provide controlled release and ease of application, while sprays and solid forms offer convenience and portability. The choice of active ingredients, whether synthetic like DEET or natural such as citronella and neem oil, significantly influences protection duration and safety. Combining actives often enhances repellences and broadens the spectrum of action. Excipients and functional additives are critical for maintaining formulation stability, preventing phase separation, and improving sensory properties. Evaluation parameters, including efficacy, safety, stability, and organoleptic attributes, ensure that formulations are both effective and user-friendly. The analysis highlights that while synthetic agents offer longer-lasting protection, natural agents are preferred for low-toxicity and eco-friendly applications. However, variability in formulation methods and concentration ranges can lead to differences in performance. Despite extensive research, gaps remain in long-term stability studies, standardized testing protocols, and optimization of synergistic combinations. Overall, the findings emphasize the importance of selecting appropriate formulation strategies, active agents, and evaluation methods to achieve safe, effective, and acceptable insect repellents.

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7. Conflict of Interest: None

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