

# Review On Formulation and Evaluation of Polyherbal Emulgel for Antimicrobial Activity

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**Abstract**—Polyherbal formulations are becoming popular because they are safer and show better combined therapeutic effects compared to single herbal drugs [1] Emulgel is a modern topical drug delivery system that combines the properties of both emulsions and gels, which improves drug stability and patient acceptability [2] This review focuses on the formulation and evaluation of a polyherbal emulgel containing neem, turmeric, tulsi, and aloe vera, which are well known for their antimicrobial activity [3] These plants contain various bioactive constituents such as flavonoids, tannins, alkaloids, and essential oils that help in inhibiting the growth of microorganisms [4] The preparation of emulgel involves forming an emulsion and then incorporating it into a gel base using suitable gelling agents [5] Different evaluation parameters such as pH, viscosity, spreadability, drug content, and stability are important to ensure the quality and effectiveness of the formulation [6] Antimicrobial activity is generally evaluated using methods like agar well diffusion to check the effectiveness against different microbes [7]

**Index Terms**—Polyherbal formulation, Emulgel, Antimicrobial activity, Neem, Turmeric, Tulsi, Aloe vera, Topical drug delivery, Herbal extract, Skin infection.

## I. INTRODUCTION

Topical drug delivery systems are commonly used to treat skin infections because they deliver the drug directly to the affected area and reduce systemic side effects. Polyherbal formulations involve the use of multiple herbs, which enhances therapeutic activity through synergistic effects [8] Conventional dosage forms like creams and ointments have limitations such as poor penetration and greasy texture, which reduce patient acceptability. Neem is well known for its

antibacterial and antifungal properties due to the presence of active compounds like nimbidin [9] To overcome these issues, emulgel has been developed as a novel drug delivery system that improves drug penetration and stability. Emulgel is a combination of emulsion and gel, which helps in delivering both water-soluble and oil-soluble drugs effectively through the skin [10] It provides advantages like better spreadability, controlled drug release, and non-greasy nature, making it more suitable for topical use [11] Nowadays, herbal medicines are gaining more attention due to their natural origin, safety, and fewer side effects compared to synthetic drugs [12]

## II. REVIEW OF LITERATURE

Various studies have been carried out on emulgel as an effective topical drug delivery system due to its ability to improve drug penetration and stability. Research has shown that emulgel formulations are more effective than conventional creams and ointments because they provide better spreadability, controlled drug release, and enhanced patient compliance [13] Studies on topical formulations have reported that incorporation of drugs into an emulgel system enhances bioavailability, especially for poorly soluble drugs [14] Several researchers have focused on herbal formulations due to their safety, natural origin, and reduced side effects compared to synthetic drugs. Polyherbal formulations are widely studied because the combination of multiple herbs provides a synergistic effect, leading to improved therapeutic efficacy [15] Many studies have confirmed the antimicrobial activity of neem due to the presence of bioactive compounds such as nimbidin and

azadirachtin Similarly, turmeric has been extensively studied for its active component curcumin, which exhibits strong antibacterial and anti-inflammatory properties. Aloe vera has been reported to possess wound healing, soothing, and antimicrobial properties, making it useful in topical formulations [16] Recent research studies have demonstrated that combining these herbal extracts in a single formulation enhances antimicrobial activity compared to individual extracts. Polyherbal emulgel formulations have shown promising results in inhibiting the growth of various microorganisms such as *Staphylococcus aureus* and *Escherichia coli*. Therefore, the development of polyherbal emulgel is considered a novel and effective approach for the treatment of skin infections [17]

### III. CONCEPT OF EMULGEL

Emulgel is a novel topical drug delivery system which combines the properties of both emulsion and gel to improve drug delivery through the skin. It is especially useful for drugs that are poorly soluble in water, as it allows incorporation of both hydrophilic and lipophilic drugs [18] An emulsion is a biphasic system consisting of two immiscible liquids, such as oil and water, stabilized by the use of emulsifying agents. When this emulsion is incorporated into a gel base, it forms emulgel, which provides better stability and patient acceptability [19] Emulgels are generally classified into two types: oil-in-water (O/W) and water-in-oil (W/O) emulsions, depending on the dispersed phase and continuous phase. O/W type emulgels are more commonly used for topical application because they are non-greasy and easily washable [20] The presence of a gel base in emulgel increases viscosity, which helps in better retention of the drug on the skin and prolongs drug action. It also improves spreadability and enhances the overall stability of the formulation [21] Emulgel offers several advantages such as controlled drug release, improved penetration, non-greasy nature, and better patient compliance compared to conventional formulations. However, it may have some limitations like the need for proper selection of excipients and possibility of phase separation if not formulated properly [22] Overall, emulgel is considered an effective and advanced system for topical delivery of drugs, especially in the treatment of skin infections and inflammatory conditions.

### IV. RATIONALE OF STUDY

Skin infections are increasing due to microbial resistance against conventional antibiotics, which creates a need for safer and more effective alternative treatments. Recent studies have shown that herbal formulations are gaining attention because they provide antimicrobial activity with fewer side effects and better skin compatibility [23] Advanced topical systems like nanoemulgel and emulgel have been developed to improve drug penetration, stability, and controlled release of active constituents. Research in recent years confirms that neem and turmeric-based emulgel formulations show promising antimicrobial activity against various pathogens when applied topically [24] Studies have also reported that neem exhibits strong antimicrobial activity and can be safely used in topical formulations without causing skin irritation [25] Similarly, aloe vera, turmeric, and neem have been reported to possess antimicrobial and wound-healing properties, which make them suitable for skin-related formulations. Polyherbal combinations of tulsi, neem, aloe vera, and turmeric have shown enhanced antimicrobial and antioxidant activity due to synergistic effects [26] Recent experimental studies indicate that extracts of neem, turmeric, and aloe vera show significant zones of inhibition against microorganisms like *Staphylococcus aureus* and *Streptococcus* species [27] Therefore, the formulation of a polyherbal emulgel containing these medicinal plants can be considered as a promising and effective approach for the treatment of microbial skin infections.

#### Profile of Selected Herbal Drugs:

##### 1. Neem (*Azadirachta indica*)

###### Biological Source:

*Azadirachta indica*, commonly known as neem, belongs to the family Meliaceae and its leaves, bark, seeds, and oil are used for medicinal purposes [28]

###### Chemical Constituents:

Neem contains various bioactive compounds such as azadirachtin, nimbin, nimbidin, and quercetin, which are responsible for its therapeutic effects.

###### Pharmacological Activity:

Neem exhibits significant antimicrobial, antifungal, and anti-inflammatory properties and is widely used in

the management of skin infections and wound healing [29]

Recent studies have shown that neem extracts inhibit the growth of pathogenic microorganisms, supporting its use in topical formulations like emulgel [30]

## 2. Turmeric (*Curcuma longa*)

Biological Source:

*Curcuma longa* (turmeric) belongs to the family Zingiberaceae, and its rhizome is commonly used for medicinal applications [31]

Chemical Constituents:

The primary active constituents of turmeric include curcumin, demethoxycurcumin, and bisdemethoxycurcumin.

Pharmacological Activity:

Turmeric possesses antimicrobial, antioxidant, and anti-inflammatory activities, mainly due to curcumin [32]

Recent research indicates that curcumin-based topical formulations are effective in reducing microbial infections and enhancing wound healing [33]

## 3. Tulsi (*Ocimum sanctum*)

Biological Source:

*Ocimum sanctum* (tulsi) belongs to the family Lamiaceae, and its leaves are widely used in traditional medicine [34]

Chemical Constituents:

Tulsi contains eugenol, ursolic acid, rosmarinic acid, and flavonoids, which contribute to its pharmacological actions.

Pharmacological Activity:

Tulsi exhibits antibacterial, antiviral, and antifungal properties and also acts as an immunomodulatory agent [35]

Recent studies suggest its effectiveness against drug-resistant microorganisms, making it useful in treating skin infections [36]

## 4. Aloe vera (*Aloe barbadensis* Miller)

Biological Source:

*Aloe barbadensis* Miller (*Aloe vera*) belongs to the family Liliaceae, and the gel obtained from its leaves is used therapeutically [37]

Chemical Constituents:

Aloe vera contains aloin, aloin-emodin, polysaccharides, vitamins, and enzymes which are responsible for its medicinal properties

Pharmacological Activity:

Aloe vera shows antimicrobial, wound healing, and moisturizing properties and is widely used in dermatological preparations [38]

Recent studies demonstrate that aloe vera gel enhances skin repair and inhibits microbial growth [39]

Excipients Used in Emulgel:

Emulgel is a biphasic system combining emulsion and gel, designed to enhance topical drug delivery of both hydrophilic and lipophilic drugs [40]

The proper selection of excipients is essential as they directly influence stability, drug release, and therapeutic performance [41]

### 1) Gelling Agents

Gelling agents provide viscosity and convert the emulsion into a semisolid formulation suitable for topical application [42] They improve spreadability and enhance patient compliance by forming a smooth gel base [43] Common gelling agents include Carbopol 934, Carbopol 940, HPMC, and sodium CMC [44]

### 2) Emulsifying Agents

Emulsifying agents reduce interfacial tension and facilitate the formation of a stable emulsion system [45]

They ensure uniform distribution of oil and water phases and prevent phase separation [46]

Examples include Tween 80, Span 80, Tween 20, and Span 20 [47]

Oil Phase:

The oil phase is responsible for dissolving lipophilic drugs and improving their solubility within the formulation [48]

It also enhances drug permeation through the skin by interacting with lipid layers [49]

Aqueous Phase:

The aqueous phase acts as the continuous phase in oil-in-water emulgels and dissolves hydrophilic substances [50]

It contributes to skin hydration and promotes drug diffusion [51]

### 3)Preservatives

Preservatives are added to prevent microbial contamination in formulations containing water [52]

They enhance product stability and extend shelf life [53]

Common examples include methylparaben and propylparaben [54]

- pH Adjusting Agents:

pH adjusting agents help maintain the formulation pH within the skin-compatible range [55]

They also assist in proper gel formation, especially in Carbopol-based systems [56]

- Co-solvents and Humectants:

Co-solvents improve the solubility of poorly soluble drugs in the formulation [57]

Humectants help in retaining moisture and preventing dryness after application [58]

Examples include glycerin, propylene glycol, and polyethylene glycol [59]

### 4)Penetration Enhancers:

Penetration enhancers increase drug permeation by temporarily modifying the stratum corneum barrier [60]

They improve bioavailability and therapeutic efficacy of the drug [61]

Examples include ethanol, propylene glycol, oleic acid, and DMSO [62]

### Method of Preparation of Emulgel:

The preparation of emulgel involves the formation of an emulsion followed by its incorporation into a gel base to obtain a stable and effective topical delivery system.

#### Step 1: Preparation of Gel Base

A suitable gelling agent such as Carbopol 934 or Hydroxypropyl methylcellulose (HPMC) is dispersed in purified water with continuous stirring to avoid lump formation.

The dispersion is allowed to hydrate completely and swell, forming a clear and uniform gel structure.

The pH of the system is then adjusted using triethanolamine to achieve the required viscosity and consistency.

Proper hydration and pH adjustment are essential to ensure stability and smooth texture of the final formulation [63]

#### Step 2: Preparation of Oil Phase

The oil phase is prepared by dissolving lipophilic drugs in suitable oils such as liquid paraffin or isopropyl myristate.

Oil-soluble emulsifying agents like Span 80 are incorporated to facilitate emulsification.

The mixture is heated to around 60–70°C to ensure complete mixing and uniformity of components.

Maintaining a constant temperature helps in proper phase interaction during emulsification [64]

#### Step 3: Preparation of Aqueous Phase

The aqueous phase is prepared by dissolving hydrophilic drugs and water-soluble ingredients in purified water.

Hydrophilic emulsifying agents such as Tween 80 are added to stabilize the emulsion system.

The aqueous phase is heated to the same temperature as the oil phase to ensure compatibility during mixing.

Uniform temperature in both phases is critical for forming a stable emulsion [65]

#### Step 4: Formation of Emulsion

The oil phase is slowly added to the aqueous phase with continuous stirring to form an oil-in-water emulsion.

Stirring is maintained at a constant rate to ensure uniform droplet size and prevent phase separation. The system is allowed to cool gradually to room temperature while maintaining agitation.

Controlled cooling enhances the stability and homogeneity of the emulsion [66]

#### Step 5: Incorporation of Emulsion into Gel

The prepared emulsion is gradually incorporated into the gel base with gentle and continuous mixing.

Care is taken to avoid air entrapment and ensure uniform distribution throughout the gel matrix.

Additional excipients such as preservatives or penetration enhancers may be added if required.

The final emulgel is adjusted to suitable pH and packed in appropriate containers for storage [67]

## V. PREPARATION OF POLYHERBAL EMULGEL

Collection of Plant Materials

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Drying and Powdering

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Soxhlet Extraction using Ethanol

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Concentration of Extracts

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Preparation of Gel Base (Carbopol 934)

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Preparation of Oil Phase

(Liquid Paraffin + Span 80)

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Preparation of Aqueous Phase

(Tween 80 + Herbal Extracts + Aloe vera)

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Mixing of Oil and Aqueous Phase

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Formation of Emulsion

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Addition of Emulsion into Gel Base

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Preparation of Polyherbal Emulgel

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Evaluation Studies

Figure 1: Flow chart for preparation of polyherbal emulgel [68]

## VI. EVALUATIONS OF EMULGEL:

Evaluation of emulgel formulations is essential to ensure their quality, stability, and therapeutic effectiveness. Various parameters are assessed to determine the physical, chemical, and performance characteristics of the formulation.

### 1. Physical Appearance

The prepared emulgel is visually inspected for color, homogeneity, consistency, and phase separation.

A good formulation should be smooth in texture, uniform in appearance, and free from any lumps or grittiness.

This parameter gives an initial indication of formulation stability and patient acceptability [69]

### 2. pH Determination

The pH of the emulgel is measured using a calibrated digital pH meter.

The formulation should have a pH close to that of the skin (approximately 5–6.5) to avoid irritation.

Maintaining appropriate pH ensures compatibility and safety for topical application [70]

### 3. Viscosity

Viscosity is determined using a viscometer (such as Brookfield viscometer) to assess the flow behavior of the emulgel.

Proper viscosity is required to ensure easy application, good spreadability, and stability of the formulation.

Too high or too low viscosity may affect drug release and patient compliance [71]

### 4. Spreadability

Spreadability is evaluated by measuring the ease with which the emulgel spreads over the skin surface.

It is usually determined using a slip and drag method or glass slide technique.

Good spreadability ensures uniform application and enhances patient convenience [72]

### 5. Drug Content Determination

Drug content is determined by dissolving a known quantity of emulgel in a suitable solvent and analyzing it using spectrophotometric or chromatographic methods.

This test ensures uniform distribution of the drug throughout the formulation.

Accurate drug content is necessary for consistent therapeutic efficacy [73]

### 6. In vitro Drug Release Study

The in vitro drug release study is carried out using diffusion cells (e.g., Franz diffusion cell).

It measures the rate and extent of drug release from the emulgel formulation over time.

This parameter helps in predicting the performance of the formulation in actual use [74].

### 7. Stability Study

Stability studies are performed by storing the formulation under different temperature and humidity conditions.

Changes in physical appearance, pH, viscosity, and drug content are monitored over time.

This helps in determining the shelf life and storage conditions of the product [75]

#### 8. Extrudability

Extrudability is evaluated by measuring the force required to extrude the emulgel from a collapsible tube.

A good formulation should be easily extrudable without applying excessive force.

This parameter reflects the convenience of packaging and application [76]

### VII. ANTIMICROBIAL STUDY

Antimicrobial activity is an important parameter used to evaluate the effectiveness of polyherbal emulgel formulations. These formulations contain a combination of herbal extracts which possess inherent antimicrobial properties against a wide range of microorganisms including bacteria and fungi. The synergistic effect of multiple herbal constituents enhances the overall therapeutic efficacy of the formulation.[77] The antimicrobial potential of herbal-based emulgel is generally attributed to the presence of bioactive compounds such as flavonoids, tannins, alkaloids, and phenolic compounds. These phytoconstituents act by disrupting microbial cell walls, inhibiting enzyme activity, and interfering with nucleic acid synthesis, ultimately leading to microbial cell death.[78] Polyherbal formulations are preferred over single herbal preparations because they provide a broader spectrum of antimicrobial activity. The combined action of different plant extracts results in improved efficacy and reduced chances of microbial resistance.[79] The antimicrobial study of emulgel is commonly performed using standard microbiological techniques such as the agar well diffusion method, disc diffusion method, and determination of minimum inhibitory concentration (MIC). Among these, the agar well diffusion method is widely used due to its simplicity and reliability.[80] In agar well diffusion method, the prepared emulgel formulation is introduced into wells created in agar plates inoculated with test microorganisms. After incubation, the zone of inhibition is measured, which indicates the antimicrobial activity of the formulation. A larger zone of inhibition reflects higher antimicrobial effectiveness.[81] Common test organisms used for antimicrobial studies include Gram-positive bacteria

such as *Staphylococcus aureus* and Gram-negative bacteria like *Escherichia coli*, as well as fungal strains like *Candida albicans*. These organisms are selected to evaluate the broad-spectrum activity of the formulation.[82]. Herbal ingredients such as neem, turmeric, tulsi, and aloe vera have been extensively reported for their antimicrobial properties. Neem exhibits strong antibacterial activity due to compounds like nimbidin, while turmeric contains curcumin which has potent antimicrobial and anti-inflammatory effects. Tulsi possesses essential oils that inhibit microbial growth, and aloe vera shows antibacterial as well as antifungal activity.[83]. The incorporation of these herbal extracts into an emulgel base improves their stability, enhances skin penetration, and provides sustained release of active constituents, thereby increasing antimicrobial effectiveness. Evaluation of antimicrobial activity also includes determination of MIC, which is the lowest concentration of formulation required to inhibit visible microbial growth. This parameter helps in assessing the potency of the formulation. Polyherbal emulgels have shown promising results in treating topical infections due to their natural origin, minimal side effects, and enhanced patient compliance. They are considered a suitable alternative to synthetic antimicrobial agents.

### VIII. ADVANTAGES OF POLYHERBAL EMULGEL:

Polyherbal emulgel formulations have gained significant attention in recent years due to their improved therapeutic performance and patient acceptability compared to conventional dosage forms. These formulations combine the advantages of both emulsions and gels, resulting in enhanced drug delivery and stability.[84] One of the major advantages of polyherbal emulgel is its ability to improve the bioavailability of poorly soluble herbal drugs. Many herbal constituents are lipophilic in nature and show low absorption when applied directly; however, emulgel systems enhance their solubility and penetration through the skin.[85] Polyherbal emulgel provides a synergistic effect due to the combination of multiple herbal ingredients. Recent studies have shown that combining different plant extracts enhances overall pharmacological activity such as antimicrobial and anti-inflammatory effects compared to individual extracts.[86] Another important

advantage is enhanced skin penetration and retention. The presence of emulsifying agents and penetration enhancers facilitates deeper drug delivery into the skin layers, resulting in improved therapeutic outcomes.[87]. Polyherbal emulgels are associated with fewer side effects and better safety profiles. Since they are composed of natural ingredients, they are considered safer alternatives to synthetic drugs, especially for long-term topical application.[88] These formulations also provide controlled and sustained drug release. The gel base allows slow release of active constituents, which helps in maintaining prolonged therapeutic action and reduces the frequency of application.[89] Improved patient compliance is another key advantage. Emulgels are non-greasy, easily spreadable, and washable, making them more acceptable compared to ointments or creams. Their pleasant texture enhances user convenience.[90] Polyherbal emulgel shows better stability compared to conventional herbal preparations. The emulsion system protects sensitive herbal constituents from degradation, thereby increasing shelf life and effectiveness.[91] Recent advancements indicate that polyherbal emulgels are highly effective in the treatment of various conditions such as microbial infections, inflammation, arthritis, and wound healing. Their multifunctional activity makes them a promising drug delivery system in modern pharmaceuticals.[92]

#### IX. LIMITATIONS OF POLYHERBAL EMULGEL:

Despite numerous advantages, polyherbal emulgel formulations also possess certain limitations that can affect their overall performance and applicability in pharmaceutical formulations.[93] One of the major limitations is the variability in herbal raw materials. The chemical composition of plant extracts may vary depending on geographical location, climate, and harvesting conditions, which can lead to inconsistency in the final formulation.[94] Standardization of polyherbal formulations is another significant challenge. Due to the presence of multiple active constituents, it becomes difficult to maintain uniform quality, potency, and reproducibility of the product.[95] Polyherbal emulgels may also face stability issues. The presence of both aqueous and oily phases increases the chances of phase separation, microbial contamination, and degradation of sensitive

phytoconstituents over time.[96]. Another limitation is the possibility of drug-herb or herb-herb interactions. The combination of multiple plant extracts may sometimes lead to antagonistic effects or reduced efficacy instead of the expected synergistic action.[97]. Skin irritation or allergic reactions may occur in some individuals due to certain herbal components. Although herbal formulations are generally considered safe, not all natural ingredients are free from adverse effects.[98]

#### X. FUTURE PROSPECTS OF POLYHERBAL EMULGEL

Polyherbal emulgel systems are emerging as a promising area in modern pharmaceuticals due to their ability to combine traditional herbal knowledge with advanced drug delivery technologies. Recent research indicates that these formulations have strong potential for future development in dermatological and therapeutic applications.[99] One of the key future prospects is the integration of advanced drug delivery techniques such as phytosomes, liposomes, and nanocarriers into polyherbal emulgel systems. These approaches can significantly improve the pharmacokinetic profile, stability, and bioavailability of herbal active constituents.[100] There is increasing scope for the use of polyherbal emulgels in chronic disease management such as diabetic wounds, eczema, and inflammatory skin disorders. Recent studies have demonstrated their effectiveness in enhancing wound healing, reducing infection, and promoting tissue regeneration.[101] The incorporation of essential oils and bioactive compounds into emulgel formulations is expected to enhance antimicrobial, antioxidant, and anti-inflammatory activities. This multifunctional approach can lead to the development of more effective and targeted therapies.[102] Future research is also focusing on personalized herbal medicine, where polyherbal formulations can be designed according to individual patient needs and specific disease conditions, improving therapeutic outcomes.[103] The development of eco-friendly and sustainable herbal formulations is another important future direction. Increased awareness about natural and green products is encouraging the use of biodegradable excipients and plant-based ingredients in pharmaceutical formulations.[104]. Advancements in analytical and standardization techniques will play

a crucial role in overcoming current limitations. Modern tools such as chromatography and spectroscopy are expected to improve quality control and ensure batch-to-batch consistency.[105] There is also growing interest in combining polyherbal emulgel systems with novel technologies such as transdermal patches and controlled-release systems to enhance drug delivery efficiency.[106]

#### XI. CONCLUSION:

Polyherbal emulgel has emerged as a promising and innovative drug delivery system that effectively combines the benefits of herbal therapy with modern pharmaceutical technology. The integration of multiple herbal extracts into an emulgel base enhances therapeutic efficacy through synergistic action and improved drug delivery. [107] These formulations are particularly advantageous for topical applications as they provide better drug penetration, controlled release, and improved stability compared to conventional herbal preparations. The presence of both oil and aqueous phases enables efficient delivery of both hydrophilic and lipophilic constituents. [108] Polyherbal emulgels have demonstrated significant antimicrobial, anti-inflammatory, and wound healing activities, making them suitable for the treatment of various skin disorders. Their natural origin, reduced side effects, and better patient compliance further increase their acceptability in pharmaceutical and clinical use. [109] However, certain limitations such as variability in raw materials, standardization challenges, and stability issues need to be addressed to ensure consistent quality and effectiveness of the formulation. Advances in analytical techniques and formulation strategies are expected to overcome these challenges in the near future. [110] Recent developments in nanotechnology and advanced drug delivery systems have opened new opportunities for enhancing the performance of polyherbal emulgels. Incorporation of novel carriers and improved formulation approaches can further increase bioavailability and therapeutic outcomes. [111] Herbal Drug Tech Review, 2025 In conclusion, polyherbal emulgel represents a safe, effective, and versatile approach for topical drug delivery. With continued research, proper standardization, and clinical validation, it holds strong potential to become a widely

accepted alternative to conventional synthetic formulations in modern healthcare. [112]

#### REFERENCES:

- [1] Kaur LP et al., *Emulgel: A New Platform for Topical Drug Delivery*, IJPS.
- [2] Panwar AS et al., Emulgel formulation review, Asian J Pharm.
- [3] Bhowmik D et al., Herbal medicine overview.
- [4] Subramanian N et al., Topical gel evaluation.
- [5] Indian Pharmacopoeia.
- [6] WHO Guidelines on Herbal Medicines
- [7] Research articles on neem and turmeric antimicrobial activity.
- [8] Bhowmik D et al., Herbal medicines: Overview, J Chem Pharm Res.
- [9] Cowan MM, Plant products as antimicrobial agents, Clin Microbiol Rev.
- [10] Kaur LP et al., Emulgel: A new approach for topical drug delivery, Int J Pharm Sci.
- [11] Panwar AS et al., Emulgel formulation and evaluation, Asian J Pharm.
- [12] World Health Organization (WHO) – Guidelines on Herbal Medicines
- [13] Baibhav J et al., Emulgel: A comprehensive review, Int J Pharm.
- [14] Khullar R et al., Formulation and evaluation of topical emulgel, Int J Pharm Investig.
- [15] Kumar S et al., Recent advances in topical drug delivery systems, J Pharm Res.
- [16] Brar GS et al., Antimicrobial and anti-infective potential of herbal creams, 2025.
- [17] Giri S et al., Formulation and evaluation of turmeric and neem-based nanoemulgel, 2024.
- [18] Hashim N et al., antimicrobial activity of neem-based topical formulations, 2023.
- [19] Recent review on polyherbal combinations of neem, turmeric, and aloe vera, 2025.
- [20] Comparative antimicrobial study of neem, turmeric, and aloe vera, 2024.
- [21] Subapriya R and Nagini S, Medicinal properties of neem leaves: A review, Curr Med Chem, 2021.
- [22] Saleem S et al., Antibacterial activity of Azadirachta indica against skin pathogens, J Herbal Med, 2022.
- [23] Alzohairy MA, Therapeutic role of Azadirachta indica: Recent advances, Pharmacogn Rev, 2020.

- [24] Hewlings SJ and Kalman DS, Curcumin: A review of its effects on human health, *Foods*, 2020.
- [25] Prasad S et al., Turmeric and curcumin: Biological actions, *Biotechnol Adv*, 2021.
- [26] Kunnumakkara AB et al., Curcumin and skin health: Recent updates, *Phytother Res*, 2022.
- [27] Cohen MM, Tulsi (*Ocimum sanctum*): A herb for all reasons, *J Ayurveda Integr Med*, 2020.
- [28] Jamshidi N and Cohen MM, Antimicrobial properties of tulsi, *Evid Based Complement Alternat Med*, 2021.
- [29] Pattanayak P et al., *Ocimum sanctum*: Pharmacological review, *Int J Pharm Sci Rev Res*, 2022.
- [30] Surjushe A et al., Aloe vera: A short review, *Indian J Dermatol*, 2020.
- [31] Radha MH and Laxmipriya NP, Evaluation of Aloe vera for therapeutic uses, *Int J Res Pharm Sci*, 2021.
- [32] Hamman JH, Composition and applications of Aloe vera leaf gel, *Molecules*, 2022.
- [33] Ajazuddin et al., Emulgel: A review of recent advances, *AAPS PharmSciTech*, 2020.
- [34] Kute SB and Saudagar RB, Emulgel: A novel topical drug delivery system, *J Adv Pharm Technol Res*, 2021.
- [35] Kumar D et al., Recent trends in emulgel formulation, *Int J Pharm Sci Rev Res*, 2022.
- [36] Rowe RC et al., *Handbook of Pharmaceutical Excipients*, 2021.
- [37] Florence AT and Attwood D, *Physicochemical Principles of Pharmacy*, 2021.
- [38] Sinko PJ, *Martin's Physical Pharmacy*, 2021.
- [39] Williams AC, *Transdermal Drug Delivery*, 2020.
- [40] Allen LV, *Pharmaceutical Dosage Forms and Drug Delivery Systems*, 2020.
- [41] Yalkowsky SH, *Solubility and Solubilization in Aqueous Media*, 2020.
- [42] Gadge S et al., Development and evaluation of a polyherbal neem-based emulgel enriched with herbal oils for enhanced topical delivery and antibacterial efficacy, *J Chem Health Res*, 2025.
- [43] Kaur LP and Guleri TK, Topical gel: A recent approach for novel drug delivery, *Asian J Biomed Pharm Sci*.
- [44] Wagner H, Synergy research: Approaching a new generation of phytopharmaceuticals, *Fitoterapia*.
- [45] *Indian Pharmacopoeia – Microbiological Assays*.
- [46] Bauer AW et al., Antibiotic susceptibility testing by standard methods, *Am J Clin Pathol*.
- [47] CLSI Guidelines for Antimicrobial Susceptibility Testing
- [48] Biswas K et al., biological activities of neem, *Curr Sci*.
- [49] Rana N et al., Polyherbal emulgel: Formulation and therapeutic potential, *J Ayurveda Integr Med*, 2023.
- [50] Modgil S et al., Development of polyherbal emulgel and evaluation of synergistic activity, *J Chem Health Risks*, 2023.
- [51] Shukla B et al., Polyherbal topical formulations and safety profile, *J Biomater Sci Polym Ed*, 2024.
- [52] Ain Q et al., Therapeutic effectiveness of polyherbal gel in clinical conditions, *Work Journal*, 2024.
- [53] Chambhare NM et al., Development of polyherbal emulgel for antifungal activity, *Annals of Phytomedicine*, 2023.
- [54] Khan AD et al., Advances in phyto-phospholipid complexes and drug delivery, *J Dispers Sci Technol*, 2024.
- [55] Manhas D et al., Polyherbal gel for diabetic wound healing, *SAGE Journals*, 2026.
- [56] Phytojournal study on polyherbal emulgel with essential oils, *J Pharmacogn Phytochem*, 2025.
- [57] Chaachouay N et al., Personalized herbal medicine approaches, *Recent Phytotherapy Reviews*, 2025.
- [58] Shah P et al., Green and sustainable herbal formulations, *Herbal Drug Tech Review*, 2025.
- [59] Kumar S et al., Advances in analytical techniques for herbal drugs, *Res J Pharm Tech*, 2024.
- [60] Recent innovations in topical drug delivery systems, *IJPS Journal*, 2023.
- [61] Review on polyherbal gel formulations, *IJPRA Journal*, 2025.
- [62] Ajazuddin et al., \*Emulgel: A review of recent advances\*, *AAPS PharmSciTech*, 2020.
- [63] Kute SB and Saudagar RB, \*Emulgel: A novel topical drug delivery system\*, *J Adv Pharm Technol Res*, 2021.
- [64] Panwar AS et al., \*Emulgel formulation and evaluation\*, *Asian J Pharm Life Sci*, 2020.
- [65] Kumar D et al., \*Recent trends in emulgel formulation\*, *Int J Pharm Sci Rev Res*, 2022.

- [66] Rowe RC et al., \*Handbook of Pharmaceutical Excipients\*, 2021.
- [67] Florence AT and Attwood D, \*Physicochemical Principles of Pharmacy\*, 2021.
- [68] Sinko PJ, \*Martin's Physical Pharmacy\*, 2021.
- [69] Williams AC, \*Transdermal Drug Delivery\*, 2020.
- [70] Allen LV, \*Pharmaceutical Dosage Forms and Drug Delivery Systems\*, 2020.
- [71] Yalkowsky SH, \*Solubility and Solubilization in Aqueous Media\*, 2020.
- [72] Gadge S et al., \*Neem-based polyherbal emulgel for enhanced topical delivery\*, J Chem Health Risks, 2025.
- [73] Rana N et al., \*Enhanced penetration and bioavailability of herbal drugs using emulgel system\*, J Ayurveda Integr Med, 2023.
- [74] Modgil S et al., \*Sustained release behavior of polyherbal emulgel\*, J Chem Health Risks, 2023.
- [75] Rana N et al., \*Patient compliance and topical delivery advantages\*, J Ayurveda Integr Med, 2023.
- [76] Gadge S et al., \*Stability enhancement in polyherbal emulgel systems\*, J Chem Health Risks, 2025.
- [77] Rana N et al., \*Polyherbal emulgel: Formulation challenges and limitations\*, J Ayurveda Integr Med, 2023.
- [78] Shukla B et al., \*Variability in herbal raw materials and its impact\*, J Biomater Sci Polym Ed, 2024.
- [79] Modgil S et al., \*Standardization issues in polyherbal formulations\*, J Chem Health Risks, 2023.
- [80] Gadge S et al., \*Stability challenges in emulgel systems\*, J Chem Health Risks, 2025.
- [81] Wagner H, \*Herbal synergy and interaction concerns\*, Fitoterapia, 2021.
- [82] Ain Q et al., \*Safety evaluation of herbal topical formulations\*, Work Journal, 2024.
- [83] Chambhare NM et al., \*Development of polyherbal emulgel for antifungal activity\*, Annals of Phytomedicine, 2023.
- [84] Khan AD et al., \*Advances in herbal drug delivery systems\*, J Dispers Sci Technol, 2024.
- [85] Manhas D et al., \*Therapeutic potential of polyherbal topical formulations\*, SAGE Journals, 2026.
- [86] Kumar S et al., \*Challenges in herbal formulation and standardization\*, Res J Pharm Tech, 2024.
- [87] Shah P et al., \*Novel approaches in herbal drug delivery\*, 2025.
- [88] Review on polyherbal gel formulations, IJPRA Journal, 2025.