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Original Article

Exploring the Wound Healing Activity of Turmeric Oil Based Emulgel through Topical Drug Delivery

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ABSTRACT

Introduction: Wounds may be known as any damage or distortion to the normal structural and functional of skin, if left untreated it can be more dangerous, reaching in subcutaneous tissue and serious harm to other structure. After a wound, subcutaneous tissue exposed, providing a warm, moist, and nutrient-rich condition that is favourable to microbial colonization and growth. Recent research has indicated that the use of emulsion-based gel formulation, topical medication delivery systems may present an appealing treatment alternative for wounds. Therefore, objective of this research was to develop an emulgel containing turmeric oil for the management of wounds. This ground-breaking medication may provide an alternative approach to wound treatment. **Materials and Methods:** The emulgel was developed by various turmeric oil-based emulsions with Smix (surfactant and co-surfactant), which were further incorporated into the gel base. Gel bases were composed of different concentrations of carbopol 940. The prepared emulgel was evaluated for different parameters. **Results and Discussion:** The developed formulations were evaluated on the basis of different parameters such as pH, viscosity, Extrudability, Spreadability, Drug Content, and Anti-microbial studies. the physical properties of emulgel satisfied the necessary standards. These eight emulgel formulation efficaciously inhibit the growth of organism. The present research work indicates the emulgel was effective against gram negative and gram positive bacterial. Zone of inhibition was found between 2.1 to 8.9 μM. The highest ZOI was measured against *Bacillus subtilis.* **Conclusion:** The emulgel of turmeric essential oil showed the most promising results for wound management by inhibiting microorganisms that form biofilm and delaying the wound healing process. These results provide captivating novel possibilities for wound management and emphasize the significance of ongoing research in this field.

Keywords: Essential oil, Turmeric oil, Emulgel, Carbopol 940, Wounds Healing, Topical formulation.

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INTRODUCTION

Any structural and functional damage or distortion to the normal skin is termed as wound. Chronic wounds which are deep to epidermis reaches to dermis layer are more prone to get infection due to presence of microbes near to the wounded area. Any damage to the layers of skin can cause a wound. The organism starts the wound healing process, which is completed in three phases: the inflammatory, proliferation, and remodeling phases (Wang *et al*., 2018; Singer *et al*., 1999; Gushiken *et al*., 2021). All three phases overlapped with each other and completed in with time. Platelet aggregation, blood clotting, fibrin synthesis, inflammation in reaction to damage, changes in the ground substances, angiogenesis, and re-epithelialization are all processes involved in healing (Kokane *et al*., 2009). After a wound or other loss of skin integrity, subcutaneous tissue becomes exposed, providing a warm, moist, and nutrient-rich condition that is favourable to microbial colonization and growth. However, a wound's nature, depth, location, and quality, as well as the degree of tissue perfusion and the host immune response's antimicrobial efficiency, will all have an impact on the quantity and variety of bacteria present (Robson, 1998 and Bowler *et al*., 2001). Any wound has some risk of infection because wound colonization is typically polymicrobial, including a variety of potentially pathogenic microbes. Moreover, the Extracellular Matrix (ECM) and growth factors are often deteriorated by the pathogenic microorganisms that reside in the wound bed. Once the bacteria have taken over the wound sheet, they typically develop biofilms that serve as a barrier, enabling the bacteria to proliferate, thrive, and shield themselves from immune cells or develop antibiotic resistance. A portion of the bacteria are implanted in the extracellular polysaccharide matrix or Extracellular Polymeric Substances (EPS) to form the biofilm architecture. Furthermore, the other skin cells are poisoned by this biofilm, which explains why wound healing is taking longer. The water-based Extracellular

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Polymer Scaffold (EPS) is composed of a protein matrix that facilitates the flow of nutrients, mobility, and communication amongst the bacterial communities within a biofilm (Alavi *et al*., 2007; Demidova *et al*., 2012; Landen, 2016; Rahim *et al*., 2017). The majority of bacterial biofilms that aid in colonization or recolonization are primarily made up of EPS, which sticks to the damaged surface area (Flemming *et al*., 2016; Li *et al*., 2018).Chemotaxis is a mechanism that most bacteria employ to move about, colonize a host, and spread infection. Chemotaxis is the guided movement of cells in a soluble chemical attractant concentration gradient, referred to as a chemoattractant, mediated by receptors. Gram positive and negative bacteria that cause skin infections are not chemo attractants; instead, they adhere to the surface of host tissue or cells using a variety of adhesion mechanisms, using the nutrients that are present to spread their pathogenicity throughout the host (Matilla and Krell, 2018).

The essential oil of turmeric was obtained from the fresh rhizomes of the plant *Curcuma longa* belonging to the Zingiberaceae family (Mohamed, 2004 and Panwar *et al*., 2011). It is commonly grown in China, Sri Lanka, West and East Africa, and other tropical nations. It was first discovered in India. In China, it is referred to as Huangjiang or Jianghuang. Chinese Traditional Medicine (TCM) uses it to cure, prevent, and manage a wide range of conditions, including psoriasis, cancer, hepatobiliary diseases, coughs, diabetes, arthritis, diarrhea, skin problems, gastric ulcers, and peptic ulcers. In addition to acting as a natural flavouring ingredient that significantly alters the color, taste, and nature of food, it increases blood circulation, eliminates stagnation, and alleviates depression (Stanos, 2007 and Syafri *et al*., 2024). A dosage form that obtained from the combination of the gel and emulsion are referred as emulgel. Emulsions are incorporated into the gel with proper mixing. In emulgel both type of emulsions is used to deliver to drugs into skin. Emulsion possesses a ability to easily washed off whenever required. They also have ability to penetrate the skin. Together they provide dual controlled release system so we can say that emulgels provide dual controlled release of drugs. Emulsion helps in deliver the hydrophobic drugs or oils while gels help in prolong the contact of emulgel to the skin so drugs get sufficient time to penetrate into the skin (Barra, 2009; Costa *et al*., 2019; Komakech *et al*., 2019). There is always a need to find more affordable and efficient medication sources for wound healing. Because plants are a never-ending source of active ingredients, bioactive compounds isolated from them are a desirable source for the development of new medications (Chen *et al*., 2004; Shafiq-un-Nabi *et al*., 2007). A terpenoids-rich essential oil is found in the rhizomes of the turmeric plant. Research has indicated that terpenoid molecules possessing astringent and antibacterial properties can facilitate the healing of wounds. These characteristics are thought to speed up the process of epithelialization and aid in wound contraction (Ali *et al*., 2012). However, the chemical profile of essential oils, which is controlled by a number of variables such as light exposure, geographic location, rainfall amount, and soil quality, has a significant impact on the biological activity of these oils (Gajbhiye *et al*., 2023).

MATERIALS AND METHODS

Materials

Turmeric oil was purchased from Yarrowchem Products (Mumbai, Maharashtra), and eugenol acetate was purchased from CDH, Delhi, India. Other chemicals, such as Tween 20, Propylene Glycol (PG), sodium benzoate, and carbopol 940, were supplied by CDH (Delhi, India), and ethanol was supplied by S.D. Fine Chemical Ltd. (Mumbai, India). All other solvents and chemical reagents were of analytical grade and distilled water was used throughout the research work.

Gas Chromatography/Mass Spectrometry (GC/MS) Analysis

10 µL of sample (50 mg/mL) was taken in a separating funnel and shaken by adding 10 mL of water and ethyl acetate in the ratio of 1:4 (add 2.5 µL water to 7.5 µL Ethyl Acetate). Upper layer was collected and concentrated to 1 mL in the rotary evaporator. 50 µL N, O-Bis (trimethylsilyl)trifluoroacetamide (SRL Chem Cat no.-57677) and trimethylchlorosilane (BSTFA+TMCS) was added and then finally 10 µL of Pyridine (Mirck- Cat no.- 132292) was also added. For BSTFA+TMCS, make 100 µL solution of 99 µL of BSTFA and 1 µL of TMCS. Samples were transferred in GC vial and dried using nitrogen gas. Finally, samples were dissolved in methanol (SD-fine Cat no.-10930LC250) before GC-MS analysis and spectra was matched with reported spectra (Bhise, 2021).

Selection of surfactants and co-surfactant

Surfactants and co-surfatants were selected for the development of emulsion by optimal mixing. An adequate amount of turmeric oil was added to 10 mL vials with a stopper containing 5 mL of each surfactant and co-surfactant. The contents were vortexed for 15 min using a vortex. The vials were then kept in a rotating shaker at 25±1°C for 72 hr to improve mixing. The samples were centrifuged at 3000 rpm for 15 min and filtered through Whatman filter paper. After dilution with in methanol, the concentration of the oil was estimated by using a Shimazdu UV spectrophotometer at 280 nm (Ali *et al*., 2020).

Formulation of Emulgel of Turmeric Essential oil

For the development of emulgel, the following steps were followed

Preparation of Gel Base: Different concentrations of polymers were dispersed in distilled water to swell up for 2 hr, and after that, other additives were mixed on a magnetic stirrer till a homogeneous gel base was obtained. A few drops of triethanolamine were added to the gel base to adjust the pH of the gel base (Londhe *et al*., 2013).

Preparation of Emulsion: An emulsion was prepared with the aqueous titration method, in which a mixture of oil and Smix (a combination of surfactant and cosurfactant in a 1:1 ratio) was titrated with distilled water with continuous stirring. Distilled water was added to the mixture with the help of a micropipette on a magnetic stirrer at 700 RPM (Khunt *et al.*, 2012; Aher *et al.*, 2013; Venkataharsha *et al.*, 2015).

Preparation of Emulgel: Emulsion and gel base were mixed properly in a 1:1 ratio with the help of a homogenizer (Dev *et al.*, 2015). The composition of a turmeric oil-containing emulgel is shown in Table 1.

Characterization of Emulgels

Physical examination

All the prepared emulgel formulations were evaluated on the bases of their colour, an appearance, consistency and grittiness. The formulation demonstrating favourable outcomes was subjected to additional analysis and characterization (Abdallah *et al.*, 2021).

pH Determination

The pH values of emulgels were determined by employing a digital pH meter (Hicon, India) by dispersing electrode into a 1% solution of the formulation in distilled water.

Viscosity Determination

Viscosity of prepared emulsion were determined by Brookfield Viscometer. The spindle number 64 was taken and turned at rates of 15 revolutions per minute (Khullar *et al.*, 2012; Ghanbarzadeh and Arami, 2013).

Spreadability

Spreadability of different formulations were determined by apparatus recommended by Mutimer which is appropriately adjusted for the laboratory and was used for the study. A ground slide was fixed on block. 1 g of prepared formulation of emulgel was placed on ground glass slide. The emulgel was sandwiched between the ground glass slide and another glass slide having similar dimensions of ground slide and provide with hook. Placed 5 g of weight on the top of two slides for 5 min to remove air and to provide a uniform film of the emulgels between the slides. Excess amount of emulgels was removed from the edge of slides. The top plate is then subjected to pull of weight with help of string attached to the hook and the time required by the top slide to cover a distance to be noted. The spreading coefficient can be calculated using the following method:

$$S=M\times L /T$$

Whereas, S stands for spreadability in g/cm^2. M represents the weight (g) attached to the second slide.

T denotes the time required to separate two glass sides (in seconds), and L denotes the length of the glass slide (in centimeters) (Said dos Santos *et al.*, 2021).

Extrudability

The purpose of this assessment is to determine the force required to extrude the formulation from the collapsible aluminium tube that has been lacquered. 10 g of emulgel were poured into the tube, and the end was sealed. It was found to be the weight in grams required to extrude the formulations in 10 sec. The extrudability can be calculated using the formula: Extrudability=Applied weight (in gm)/Area (in cm^2) (Shelke *et al.*, 2021).

Drug Content

Drug contents of prepared formulations of emulgel was determined by dissolving 1 g of emulgel in buffer 7.4 and make up the volume up to 100 mL sonicate it. After sonication filter it by the aid of whatman filters paper. Filtrate observed under UV spectrophotometer after appropriate dilution at 280 nm. Drug content of each formulations calculated using the formula: Drug Content: Drug Content = (Concentration× Dilution Factor×Volume taken) × Conversion Factor (Baibhav *et al.*, 2011).

In vitro release of emulgel

In vitro release studies of prepared formulations was performed using a jacketed Franz diffusion cell and egg membrane. The diffusion cell was locally fabricated with a 20 mL volume of the receiver compartment. Phosphate buffer pH 7.4 was used as the receiver medium. The egg membrane was treated with 1 g of emulgel, which was fixed between the receiver and donor compartments. The diffusion medium was continuously agitated at a speed of 50 rpm by a magnetic stirrer and its temperature was kept at 37ºC±0.5ºC by the water in the jacket around it. The absorbance of all samples was observed by a UV-visible spectrophotometer at 280 nm.

Globule size of emulsion

Average globule size of prepared microemulsion was examined by zetasizer. 1 mL of prepared emulsion of turmeric oil was withdrawn and transferred into 10 mL volumetric flask and make up the volume with the help of distilled water after that sample was filtered with whatman filter paper filtrate was collected and observed under zetasizer for its average particle or globule size and for PDI of microemulsion (Tian *et al.*, 2007).

Zeta Potential

Zeta potential is very important parameter because it is helpful for assessing flocculation since electrical charge on particle influence the rate of flocculation. Zeta potential of prepared emulsion of drug was determined by zetasizer. For that 1 mL of prepared emulsion was withdrawn and transferred into 10 mL volumetric flask and make up the volume with the help of distilled water after that sample was filtered with whatman filter paper, filtrate was collected and observed under zetasizer for its zeta potential (Tian *et al*., 2007).

Anti-Microbial Studies

Antimicrobial studies of different gels were done by agar well diffusion method. Microbial strains like Gram Positive bacteria (*Staphylococcus aureus, Bacillus subtilis* MTCC 1430, MTCC 2453) and Gram-Negative strain bacteria (*Escherichia coli* MTCC 1573, *Pseudomonas aeruginosa*) purchased from Institute of Microbial Technology, Chandigarh. Culture media for the activation of microbes were prepared according to the official protocols as given in microbial type culture cultivation protocol. Using micropipettes, test samples with concentrations of 25, 50, and 100 µg/mL were dissolved in dimethylsulfoxide, and then the standard medication and control were added to the respective well. The Petri dish and three inoculated plates were kept at room temperature. Petri dishes containing samples were incubated for 24 hr at the appropriate temperature for each organism to allow for sample diffusion. Millimeters were used to measure the diameter of the zones of inhibition (Upadhyay *et al*., 2023).

RESULTS AND DISCUSSION

Gas Chromatography/Mass Spectrometry (GC/MS) Analysis

In GCMS analysis of Turmeric Oil revealed the presence of many phytochemical compound in plant. In extract of Turmeric oil total 28 phytochemical compounds were identified which was mentioned in Table 2 and shows the chromatogram of GS-MS analysis of turmeric oil. The oil was characterized by relatively high content of benzoic acid that is 29.07%. Ar-Turmerone (19.88%), Turmerone (13.58%), Curlone (9.16%) and α-Curcumene (0.54%) are the main active constituents of the oil. Other chemical constituents are 1,3,3-Trimethyl-2-ox abicyclo[2.2.2]octan-6-ol (0.53%), 1-Isopropyl-4-methyl-3-cyclohexen-1-ol (0.15%), 1R-terpinyl Acetate (0.72%), 1,3,4- Eugenol acetate (0.95%), 4-Tert-Butylcyclohexyl Acetate (3.56%), Neryl acetate (7.24), Bicyclo [7.2.0]undec-4-ene,4,11,1 1-trimethyl-8-methylene (4.11%), alpha-Zingiberene (0.46%), alpha-Longipinene (0.33%), 1,2-Benzenedicarboxylic acid diethyl ester (1.69%), 5-oxatricyclo[8.2.0.0 (4,6)] dodecane 12-trimethyl (1.00%), 7-,ethoxymethyl-2,7-dimethylcyclohepta-1,3,5-triene (0.25%), Methyl (3-oxo-2-pentylcyclopentyl) acetate (0.46%) etc.

Selection of surfactants and co-surfactant

The solubility of turmeric oil in various surfactants and co-surfactants was determined. Among all surfactants and co-surfactants tested, tween 20, ethanol and propylene glycol, possessing higher solubility of oil. On the solubility basis these excipients were selected for the development of formulations.

Physical Examination

Prepared emulgels of turmeric oil with different concentration of Carbopol 940 as a gelling agent having good appearance, smooth on application, homogeneous and have no irritation on application over the skin.

pH measurement

pH value of prepared formulations was ranges from 6.3-7.2 ensuring that it is safe to use without skin irritation.

Viscosity Determination

Viscosity of emulgels were determined by Brookfield viscometer. Results were mentioned in Table 3.

Extrudability

The tubes were filled with prepared emulgels and crimped from one end. It was determined to be the weight in grams needed to extrude the formulation's ribbon in length in 10 sec. Result displayed in Table 3.

Spreadability

Spreadability of different emulgels were determined by apparatus recommended by Mutimer which is appropriately adjusted for the laboratory and was used for the study. Table 3 displayed the result of spreadability of prepared formulations.

Table 1: Composition of Turmeric Essential oil Emulgel Formulation.

Ingredients	F1	F2	F3	F4	F5	F6	F7	F8
Turmeric Essential oil	05	05	05	05	05	05	05	05
Carbopol 940	0.2	0.5	0.7	1	1.2	1.5	1.7	2
Tween 20	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Span 20	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Propylene glycol	5	5	5	5	5	5	5	5
Sodium benzoate	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Distilled water	Quantity Sufficient							
Triethanolamine	Few drops to adjust pH							

*F1: Formulation 1.

Table 2: Chemical composition of the essential oil of turmeric.

Sl. No.	Retention Time	Area%	Name of Compounds
1.	6.708	0.53	1,3,3-Trimethyl-2-oxabicyclo[2.2.2]octan-6-ol
2.	9.110	0.15	1-Isopropyl-4-methyl-3-cyclohexen-1-ol
3.	11.259	1.31	4-Tert-Butylcyclohexyl Acetate
4.	11.460	0.72	1R-Terpinyl Acetate
5.	11.590	0.95	1,3,4,-Eugenol Acetate
6.	11.749	3.56	4-Tert-Butylcyclohexyl Acetate
7.	11.824	7.24	Neryl Acetate
8.	11.922	0.28	15-Copaenol
9.	12.551	4.11	Bicyclo[7.2.0]undec-4-ene,4,11,11-trimethyl-8-methylene-,(1R,4Z,9S)
10.	13.243	0.54	α-Curcumene
11.	13.411	0.46	α-Zingiberene
12.	13.579	0.33	α-Longipinene
13.	14.554	1.69	1,2-Benzenedicarboxylic acid diethyl ester
14.	14.626	1.00	5-Oxatricyclo[8.2.0.0(4,6)]dodecane,12-trimethyl
15.	14.751	0.25	7-Methoxymethyl-2,7-Dimethylcyclohepta-1,3,5-Triene
16.	15.279	0.46	Methyl(3-Oxo-2-pentylcyclopentyl) acetate
17.	15.400	1.48	Tumerone
18.	15.502	19.88	Ar-Turmerone
19.	15.558	13.58	Tumerone
20.	15.743	0.45	(Z)-.Gamma.-Atlantone
21.	15.931	9.16	Curlone
22.	16.020	0.26	(Z)-.Alpha.-Atlantone
23.	16.310	0.20	(6R,7R)-Bisabolone
24.	16.384	0.37	(6R,7R)-Bisabolone
25.	16.534	0.25	1-Methyl-6-(3-methylbuta-1,3-dienyl)-7-oxabicyclo[4.1.0]heptane
26.	16.742	29.07	Benzoic acid
27.	16.931	0.75	Piperityl Tiglate
28.	17.890	0.42	2-Butenoic acid,3-methyl-, 3-Phenylpropyl Ester

Drug Content

Result showed the formulation code F6 gave maximum drug content that is 89.26±0.83. Drug content of prepared formulation was shown in Table 3.

Globule size of emulsion

Average globule size, Zeta potential of optimized turmeric essential oil containing emulsion based emulgel was studied. The emulsion was optimized based on particle size, zeta potential and PDI resulted in emulsion containing Tween 20 and Ethanol in 1:5 ratio showed smaller particle size as compared to other formulations.

In vitro release study

In vitro release analysis of turmeric oil emulgels demonstrated that, in comparison to other formulations, Formulation (F2) exhibited a lesser release of 83.39±1.97%, while Formulation (F3) had a higher release of 92.86±1.99% at 210 min. The cumulative drug release of the developed formulations have been shown in Figure 1.

Anti-microbial studies

The antimicrobial activity of formulations, the Zone Of Inhibition (ZOI) was found to be between 2.1±0.58 to 8.9±0.61 mM, the antimicrobial activity of the emulgel F3 is 2.4±0.56 at the dose of 25 µg/mL, but at the dose of 100 µg/mL it shows the ZOI of about 8.9±0.61 mM against bacterial strains, the formulation F3 at the dose of 100 μg/mL shows the maximum ZOI against the gram-positive strains (*Bacillus subtilis*).

Emulgel is a more recent innovation that offers a better way to administer topical medications by combining the advantages of gel and emulsion. The microbiota on the skin can influence wound healing in both favorable and unfavorable ways (Wolcott *et al*., 2016; Canchy *et al*., 2023; Zielinska *et al*., 2023). Depending on the type of bacteria, there are several ways that the microbes influence the wound healing process (Pastar *et al*., 2013; Arnold *et al*., 2016; Johnson *et al*., 2018). Up to 80% of human infections are thought to be connected to biofilms and poor healing, particularly in chronic wounds (Costerton *et al*., 1995; James *et al*., 2008). Moreover, the ECM and growth factors are often deteriorated by the pathogenic microorganisms that reside in the wound bed. Once the bacteria have taken over the wound sheet, they typically create biofilms that serve as a barrier, enabling the bacteria to proliferate, thrive, and shield themselves from immune cells or develop antibiotic resistance. A portion of the bacteria are implanted in the extracellular polysaccharide matrix or Extracellular Polymeric Substances (EPS) to form the biofilm architecture. Furthermore, the other skin cells are harmed by this biofilm, which explains why wound healing takes so long. The colonization of *S. aureus* can impede the healing of wounds due to increased levels of chemokine ligands, TNF-α, IL-1B, CXCL-1, and keratinocyte cytokines (Wolcott *et al*., 2016; Johnson *et al*., 2018; Canchy *et al*., 2023). In the presence of infection, *Pseudomonas* species stimulates the TAK1/MKK/p38 signalling pathway, causing cell death and preventing tissue regeneration (Robson, 1998; Bowler *et al*., 2001). Toxins that damage tissue and enzymes like penicillinase, which render penicillin inactive, are secreted by *Bacillus subtilis*. These toxins can interfere with antibiotic therapies that use penicillin as their active ingredient (Loggenberg *et al*., 2022). Biofilm was formed by microbes (*P. aeruginosa, E. coli*), which act as obstacles for the wound healing process. Ignorance could lead to infection spreading and biofilm development, which would heighten resistance to chemical, immunological, and antimicrobial agents (Percival *et al*., 2012).

This scientific research unambiguously demonstrated that the emulgel contains turmeric oil that is effective, albeit dose-dependently, against both gram positive and gram-negative bacteria (Negi *et al*., 1999). The minimum ZOI against the gram-negative strain was determined to be 2.1±0.58 at a dose of 25 μg/mL while the maximum ZOI against the gram-positive strain was found to be 8.9±0.69 at 100 μg/mL with the same concentration of turmeric oil present in prepared emulgels. This variation is due to the chemical properties of antimicrobial compounds and other additives present in formulations, such as different concentrations of carbopol 940, which may affect the release of active ingredients from the formulations (Remmal *et al*., 1993; Carson *et al*., 1995; Sivropoulou *et al*., 1996). Although this antimicrobial data provides insight into the formulation, further thorough investigation is necessary to fully explore the antimicrobial emulgel's vast potential.

Stability Studies

Stability study was performed by the chemical and physical parameters and observed results and found formulations stable.

LIMITATIONS

This study used the turmeric oil-based emulgel to treat wounds by showing antimicrobial activity. Additionally, research utilizing the extracted bioactive chemicals is necessary, which is responsible for antimicrobial activity. For the purpose of the

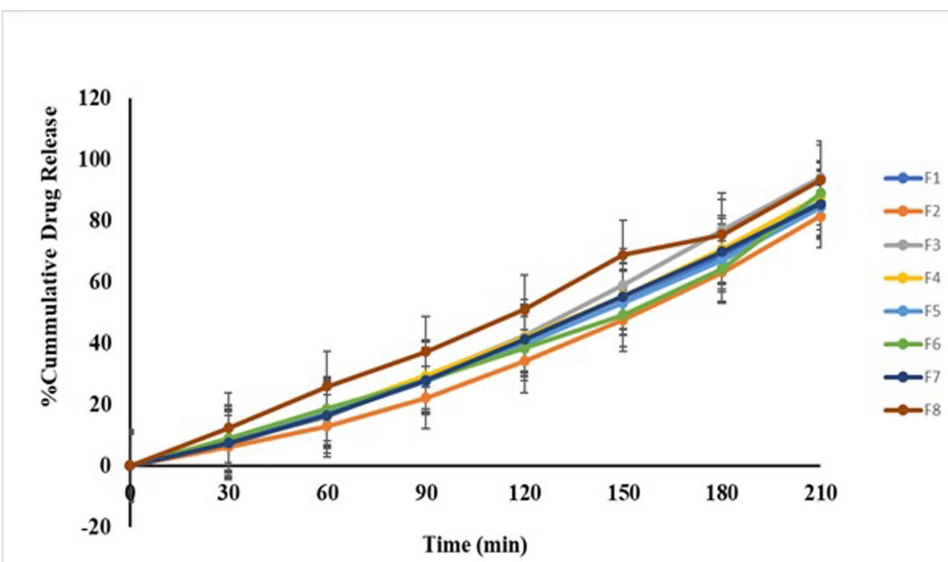

Figure 1: *In vitro* drug permeation study of formulations.

Table 3: Viscosity, spreadability, extrudability, drug content and pH of emulgels of essential oil of turmeric. *n*=3 values in mean±SD.

Formulation code	Viscosity (cP)	Spreadability (g.cm/sec)	Extrudability (10 sec.gm)	pH	Drug Content (%)
F1	1420±14.15	28.33±1.52	1.066±0.11	6.6±0.1	62.70±2.45
F2	1022.66±15.27	39.00±1.00	0.98±0.01	7.1±0.2	65.56±1.45
F3	1071.66±11.50	57.66±2.51	0.91±0.04	6.7±0.1	70.53±2.15
F4	1158±16.09	17.33±2.08	1.07±0.11	7.13±0.20	72.92±1.85
F5	1010.66±12.01	24.33±1.52	0.95±0.02	6.63±0.25	68.37±0.17
F6	1479.66±11.01	22.33±2.08	0.88±0.02	5.93±0.15	89.26±0.83
F7	2193±15.13	25.33±1.52	0.84±0.05	6.00±0.26	60.39±1.55
F8	1117±14.73	27.33±2.51	1.09±0.12	6.6±0.20	70.94±2.51

*SD: Standard Deviation, cP: centipoise.

study, only *Staphylococcus aureus, Bacillus subtilis, Escherichia coli*, and *Pseudomonas aeruginosa* were used. Preclinical and clinical research is required to evaluate several critical safety and efficacy characteristics of the formulations.

CONCLUSION

The results show that the turmeric oil exhibited an antibacterial effect against all the bacteria tested either gram positive or gram-negative bacteria. In this study, a total of eight formulations of emulgel were prepared by using turmeric essential oil as an active pharmaceutical ingredient with different concentrations of Carbopol 940 0.2, 0.5, 0.7, 1,1.2, 1.5,1.7 and 2% (w/v), whereas Tween 20 used as surfactant. Among the eight formulations, F3 showed the best organoleptic properties in terms of homogeneity, colour, consistency, and phase separation. F3 showed the most favourable pH (6.6±0.12), drug content (70.50±2.15%) and show highest drug release that is 92.86±1.99. Among all formulations, F3 shows effectiveness against *Bacillus subtilis* with a maximum zone of inhibition that is 8.9±0.61 as compared with other formulations. The emulgel also exhibited potential antimicrobial properties making it a better alternative of other topical dosage form which affect wound healing process.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

PDI: Polydispersity index; **ZOI:** Zone of Inhibition; **CDH:** Central Drug House; **PG:** Propylene glycol; **g:** Gram; **mL:** Millilitre; **mg:** Milligram; **R.P.M:** Revolution per minutes; **nm:** Nanometre; **mM:** Micrometre; **SD:** Standard deviation; **ECM:** Extracellular matrix; **TNF-α:** Tumor necrosis factor alpha; **IL-1β:** Interleukin -1 beta; ***E. coli:*** *Escherichia coli;* ***P. aeruginosa:*** *Pseudomonas aeruginosa*; ***B. subtilis***: *Bacillus subtilis;* ***S. aureus:*** *Staphylococcus aureus*; **TCM: T**raditional Chinese Medicine.

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