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FORMULATION, OPTIMIZATION AND EVALUATION OF POVIDONE-IODINE AND TURMERIC CREAM FOR ANTISEPTIC ACTIVITY

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ABSTRACT

Background: Skin wounds and superficial infections require topical formulations that can control microbial load while supporting tissue repair. Povidone-iodine is a broad-spectrum antiseptic, but repeated application may cause irritation and may not provide sufficient wound-healing support. Turmeric (Curcuma longa), rich in curcumin, offers antimicrobial, antioxidant, anti-inflammatory and wound-healing activity. Objective: The present work aimed to formulate, optimize and evaluate an oil-in-water topical cream containing povidone-iodine and turmeric for antiseptic activity. Methods: Preformulation studies included organoleptic evaluation, solubility testing, UV-visible spectrophotometry, FTIR and DSC compatibility analysis. Creams were prepared by the emulsification method using stearic acid and cetyl alcohol as critical formulation variables. A factorial design was used to evaluate the effects of these variables on viscosity, spreadability and drug release. The formulations were evaluated for appearance, homogeneity, phase separation, pH, viscosity, spreadability, drug content, in-vitro drug release, antimicrobial activity and stability. Results: Prepared creams were smooth, homogeneous and physically stable. The optimized formulation contained povidone-iodine 70 mg, turmeric 30 mg, stearic acid 80 mg, cetyl alcohol 50 mg and other excipients in a suitable cream base. The optimized formulation showed drug content of 96%, cumulative drug release of 96% at 8 h and zones of inhibition of 24 mm against Staphylococcus aureus and 22 mm against Escherichia coli. Stability testing for three months showed no visible change, no microbial contamination and only minor changes in pH, viscosity and spreadability. Conclusion: The povidone-iodine and turmeric cream demonstrated acceptable physicochemical quality, sustained drug release, antimicrobial activity and short-term stability, indicating its potential as a topical antiseptic formulation for wound and skin-infection management.

KEYWORDS: Povidone-iodine; turmeric; Curcuma longa; antiseptic cream; topical formulation; antimicrobial activity; factorial design.

1. INTRODUCTION

The skin is the largest organ of the body and forms a primary barrier against physical injury, chemical exposure and microbial invasion. Disruption of this barrier through cuts, burns, abrasions, surgical wounds or dermatological disorders can allow bacteria and fungi to colonize damaged tissue, delaying healing and increasing the risk of local or systemic infection. Topical therapy is therefore an important approach because it delivers the active agent directly to the affected site, minimizes systemic exposure and improves patient convenience.

Povidone-iodine (PVP-I) is a well-established iodophor antiseptic that gradually releases free iodine after topical application. The released iodine oxidizes microbial proteins, enzymes and nucleic acids, thereby producing broad-spectrum activity against Gram-positive bacteria, Gram-negative bacteria, fungi, viruses and protozoa. PVP-I is widely used for wound cleansing, surgical disinfection and treatment of minor cuts and abrasions. However, prolonged or repeated application may produce local irritation, staining, dryness, hypersensitivity or cytotoxic effects on cells involved in wound repair. These limitations justify the development of modified topical formulations that retain antimicrobial efficacy while improving skin compatibility.[1-3]

Turmeric (Curcuma longa) is a traditional medicinal plant with curcumin as its principal bioactive constituent. Curcumin has been reported to possess antimicrobial, anti-inflammatory, antioxidant and wound-healing properties. It helps reduce oxidative stress and inflammatory mediator production and may support collagen deposition and tissue remodeling during healing. Combining turmeric with PVP-I can therefore provide complementary effects: rapid broad-spectrum microbial control from PVP-I and additional healing support from turmeric. This herbo-synthetic strategy also responds to the increasing preference for safer and multifunctional topical preparations.[4-7]

Creams are among the most acceptable semisolid dosage forms for dermal application because they are non-greasy, washable, cosmetically acceptable and capable of distributing active ingredients uniformly over the skin surface. The performance of a topical cream depends on pH, viscosity, spreadability, homogeneity, drug content, release rate, antimicrobial activity and stability. The present study was designed to develop and evaluate a povidone-iodine and turmeric topical cream and to optimize the concentration of key excipients using design of experiment methodology.

2. MATERIALS AND METHODS

2.1 Materials

Povidone-iodine was used as the synthetic antiseptic agent and turmeric extract was used as the herbal antimicrobial and wound-healing agent. Stearic acid, cetyl alcohol, triethanolamine, liquid paraffin, glycerin, methyl paraben, propyl paraben and purified water were used for preparation of the oil-in-water cream base. The materials and instrumental methods were selected to support formulation, characterization and evaluation of the topical cream.

Table 1: Optimized composition of povidone-iodine and turmeric cream.

Ingredient	Optimized batch quantity (mg)	Role
Povidone-Iodine	70	Active antiseptic agent
Turmeric extract	30	Herbal antimicrobial and wound-healing agent
Stearic acid	80	Fatty acid base and emulsifying/stiffening agent
Triethanolamine	30	pH adjuster/emulsifying aid
Cetyl alcohol	50	Thickener/co-emulsifier
Liquid paraffin	80	Emollient/oil phase
Glycerin	50	Humectant

Methyl paraben	1.5	Preservative
Propyl paraben	0.5	Preservative
Purified water	q.s.	Aqueous phase/vehicle

2.2 Preformulation studies

Organoleptic properties of povidone-iodine and turmeric extract were evaluated by observing color, odor, texture and presence of foreign matter. Solubility studies were carried out in distilled water, propylene glycol, ethanol and liquid paraffin to identify a suitable dispersion strategy for the formulation. Povidone-iodine showed good solubility in water and alcohol-based media, whereas turmeric showed better solubility in ethanol and oil phase components. These observations guided the selection of aqueous and oil-phase addition steps during cream preparation.

UV-visible spectrophotometry was used to determine the analytical wavelength and calibration response of povidone-iodine. A stock solution was prepared in methanol and serial dilutions were analyzed at 350 nm. The calibration data were linear over 2-12 µg/mL with the equation y = 0.0566x + -0.0070 and R^2 = 0.9903.

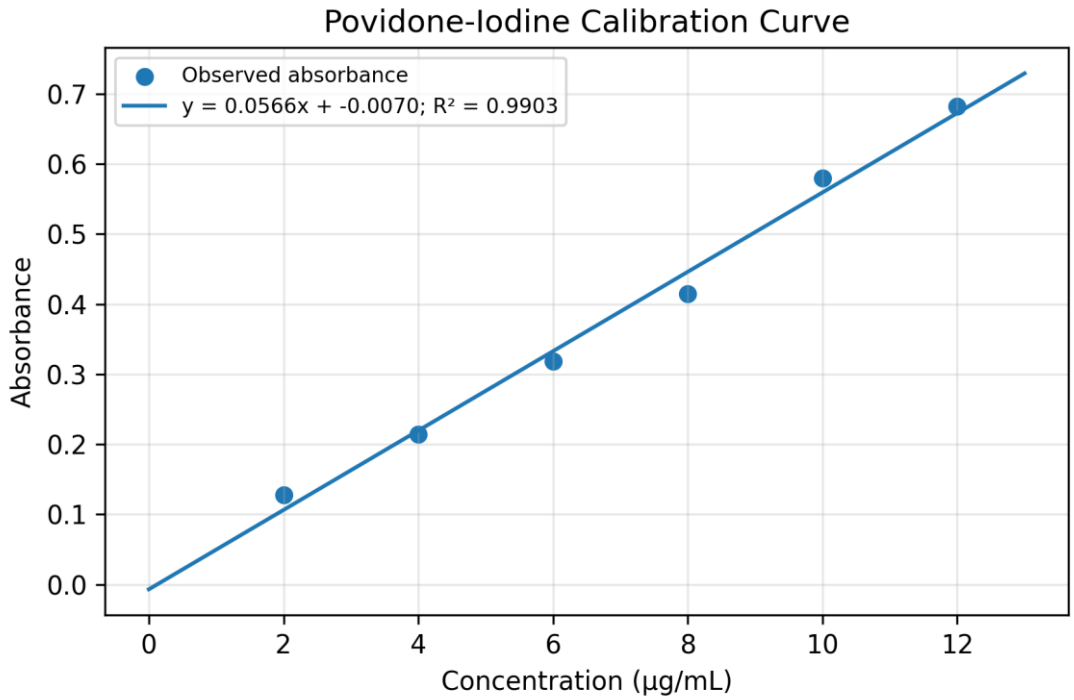
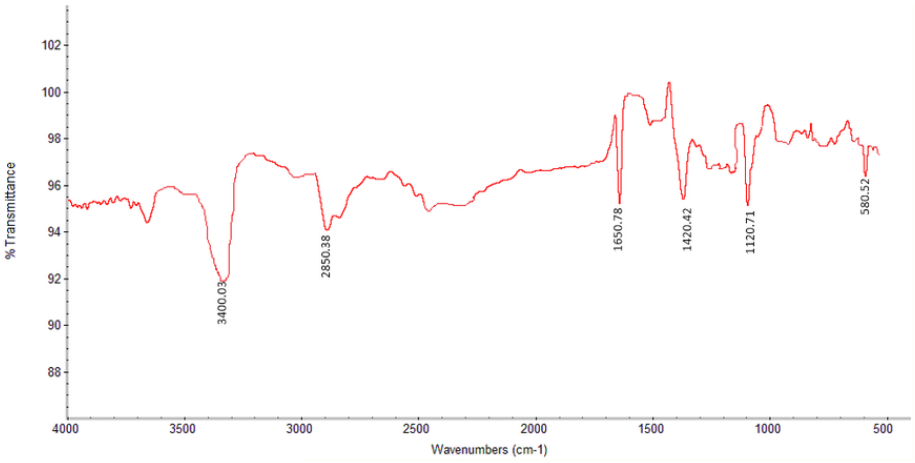


Figure 1: Calibration curve of povidone-iodine in methanol.

2.3 Compatibility studies

Drug-excipient compatibility was assessed using FTIR spectroscopy and DSC. FTIR spectra of pure povidone-iodine and the physical mixture with selected excipients were compared in the range of 4000-400 cm^{-1}. Characteristic peaks attributed to O-H stretching, aliphatic C-H stretching, lactam C=O stretching, methylene bending and C-N stretching were retained in the mixture, indicating absence of major chemical interaction. DSC thermograms were used to compare thermal behavior of the drug and drug-excipient mixture. The broad endothermic behavior around the reported peak region showed no major incompatibility between the drug and excipients.

A. Povidone-Iodine FTIR spectrum



B. Povidone-Iodine + excipients FTIR spectrum

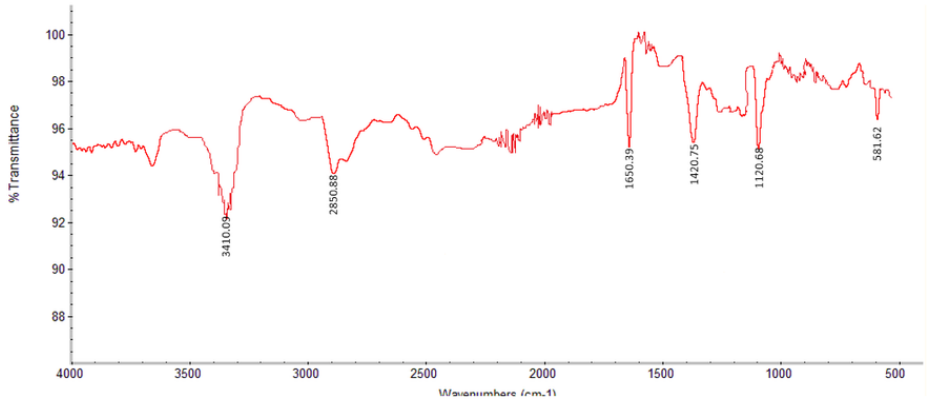


Figure 2: FTIR spectra of povidone-iodine and povidone-iodine with selected excipients.

2.4 Experimental design and optimization

Preliminary trials indicated that stearic acid and cetyl alcohol markedly influenced cream consistency and release behavior. These two variables were selected as independent factors in a factorial design. Stearic acid was evaluated from 50 to 80 mg and cetyl alcohol from 10 to 50 mg. The dependent responses were viscosity, spreadability and percentage drug release. Experimental batches were prepared according to the design and the observed responses were analyzed through ANOVA and response surface plots.

Table 2: Factorial design batches and observed responses.

Run	A: Stearic acid (mg)	B: Cetyl alcohol (mg)	Viscosity (cPs)	Spreadability (gm/sec)	Drug release (%)
1	50	10	22000	16	88
2	50	30	23000	17	89
3	50	50	23600	18	91
4	65	10	24000	18	90
5	65	30	26000	19	91
6	65	50	27000	20	92
7	80	10	27500	21	90
8	80	30	27800	20	91
9	80	50	28000	19	96

2.5 Preparation of cream

The cream was prepared by the oil-in-water emulsification method. Stearic acid, cetyl alcohol and liquid paraffin were accurately weighed and melted in a water bath at 70-75°C to form the oil phase. Povidone-iodine was dissolved in measured distilled water, and glycerin and other aqueous ingredients were incorporated. The aqueous phase was also heated to 70-75°C. The hot aqueous phase was slowly added to the hot oil phase with continuous mechanical stirring at approximately 1000-1200 rpm for 15-20 min to obtain a uniform emulsion. Turmeric extract was pre-dispersed in a small quantity of oil or ethanol to prevent clumping and was added after cooling the emulsion to about 40-45°C. The pH was adjusted using triethanolamine and the cream was cooled to room temperature with gentle stirring before packing in sterile airtight containers.

2.6 Evaluation parameters

Physical evaluation included observation of color, texture, homogeneity and phase separation. Homogeneity was checked visually and by rubbing a small amount of cream between the fingers to detect grittiness, lumps or aggregates.

The pH was determined by dispersing 1 g of cream in distilled water and measuring the dispersion with a calibrated digital pH meter. Viscosity was measured at 32°C using a Brookfield viscometer with a suitable spindle. Spreadability was assessed by the glass slide method using a known weight, and the time required for the upper slide to move over the lower slide was recorded.

Drug content was estimated by accurately weighing 1 g of cream, extracting with methanol, filtering, suitably diluting and measuring absorbance at 350 nm. In-vitro drug release was studied using a Franz diffusion cell. A cellophane membrane soaked in phosphate buffer pH 7.4 was mounted between donor and receptor compartments. One gram of cream was placed in the donor compartment, the receptor medium was maintained at 37 ± 0.5°C with stirring, and samples were withdrawn at predetermined time intervals and analyzed spectrophotometrically.

Antimicrobial activity was evaluated by the agar well diffusion method against Staphylococcus aureus and Escherichia coli. Plates were incubated at 37°C for 24 h and the zone of inhibition was measured in millimeters. Stability was studied for three months by observing appearance, pH, viscosity, spreadability and microbial contamination.

3. RESULTS AND DISCUSSION

3.1 Preformulation and compatibility

Povidone-iodine was observed as a brown, fine powder with characteristic iodine odor, while turmeric extract was yellow-orange with mild aromatic odor. The absence of foreign matter confirmed suitability of both active ingredients for formulation. Solubility results supported the use of water/alcoholic phase for povidone-iodine and oil/ethanolic dispersion for turmeric. The UV method showed a consistent concentration-absorbance relationship, allowing estimation of drug content and release samples. FTIR and DSC studies did not show significant incompatibility, supporting the selected excipient system.

3.2 Effect of formulation variables

ANOVA of the viscosity response showed a significant model effect with F-value 74.67 and $p < 0.0001$. Stearic acid had a prominent influence on viscosity ($p < 0.0001$), and cetyl alcohol also contributed significantly ($p = 0.0134$). The interaction term AB was significant ($p = 0.0054$), indicating that simultaneous variation of both fatty components

affected the consistency of the cream. Viscosity increased from 22,000 cPs in the lowest stearic acid/cetyl alcohol batch to 28,000 cPs in the optimized high-level formulation. This increase is attributed to enhanced structuring of the semisolid matrix and improved emulsion rigidity.

For spreadability, the model was significant with F-value 3.23 and p = 0.0331. Stearic acid was the only significant factor (p = 0.0482), while cetyl alcohol and interaction terms had comparatively lower effects. The response varied between 16 and 21 gm/sec, suggesting that changes in the lipidic matrix altered ease of spreading. An appropriate balance between viscosity and spreadability is necessary because excessively fluid creams may have poor residence time, whereas overly viscous creams may be difficult to apply uniformly.

Drug release was strongly influenced by cetyl alcohol. The ANOVA model was significant with F-value 135.88 and p < 0.0001. Cetyl alcohol showed a highly significant effect (p < 0.0001), whereas stearic acid had a comparatively minor effect. The drug release increased from 88% to 96% over 8 h across the design space. The optimized formulation achieved the highest release value, indicating that the selected ratio of stearic acid and cetyl alcohol produced a suitable matrix for sustained but adequate release of povidone-iodine.

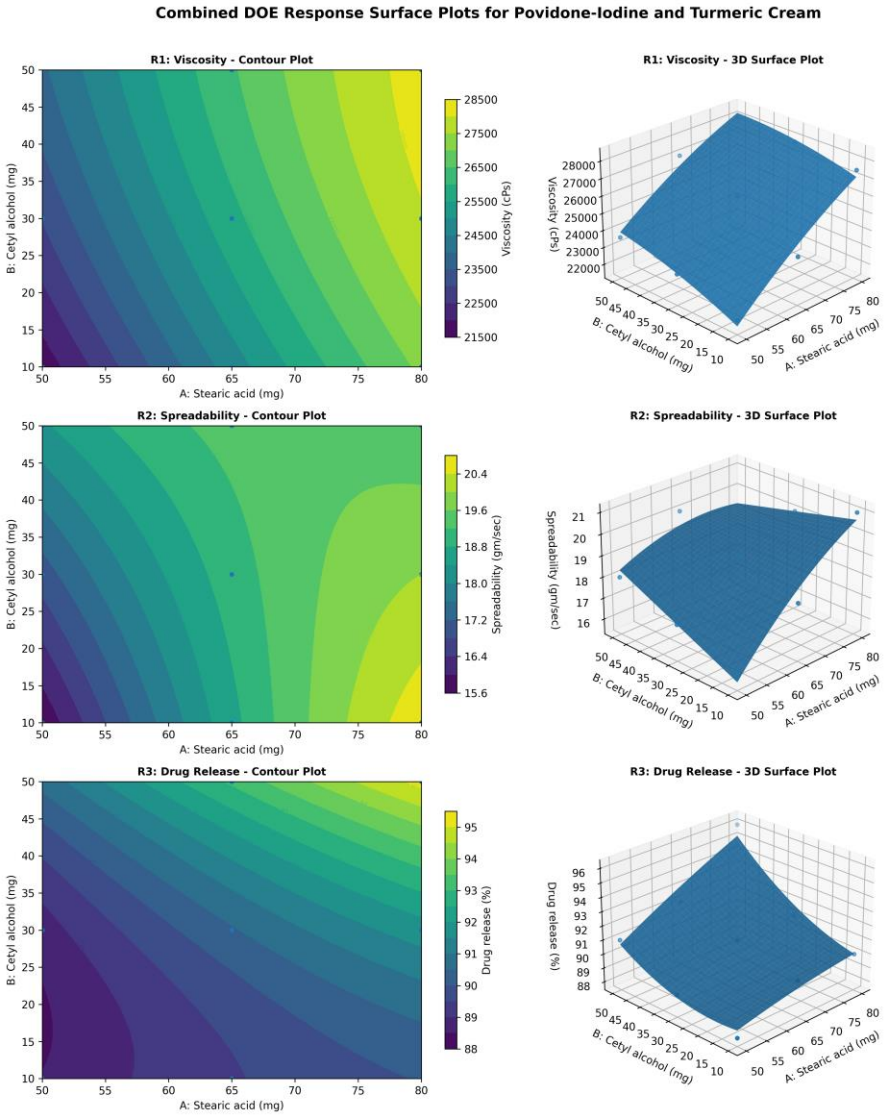


Figure 3: Combined DOE contour and 3D response surface plots for viscosity, spreadability and drug release.

3.3 Evaluation of cream formulations

Table 3: Physicochemical evaluation of cream formulations.

Batch	pH	Viscosity (cPs)	Spreadability (gm/sec)	Drug content (%)	Physical observation
F1	5.42	22000	16	90	White, smooth, homogeneous
F2	5.48	23000	17	91	Pale yellow, smooth, homogeneous
F3	5.51	23600	18	90	White, creamy, homogeneous
F4	5.55	24000	18	93	Pale yellow, smooth, homogeneous
F5	5.60	26000	19	91	White, creamy, homogeneous
F6	5.63	27000	20	92	Pale yellow, smooth, homogeneous
F7	5.68	27500	21	90	White, creamy, homogeneous
F8	5.72	27800	20	91	Pale yellow, smooth, homogeneous
Optimized F9	6.90	28000	19	96	Pale yellow, smooth and creamy; excellent homogeneity

All formulations showed smooth texture, acceptable homogeneity and absence of phase separation. The pH values of the experimental batches were generally in the skin-compatible range and the optimized batch showed a balanced semisolid consistency. The viscosity profile suggested that the cream matrix became more structured as stearic acid and cetyl alcohol concentrations increased. Drug content was satisfactory for all batches, and the optimized formulation showed the highest value of 96%, indicating uniform distribution of povidone-iodine within the cream base.

3.4 In-vitro drug release

The in-vitro release study showed gradual diffusion of povidone-iodine from the cream matrix over 8 h. All batches displayed progressive release without abrupt dumping. The optimized batch released 15% at 0.5 h, 42% at 2 h, 68% at 4 h, 86% at 6 h and 96% at 8 h. This profile indicates a controlled release pattern that can maintain local antiseptic availability over a prolonged period after topical application.

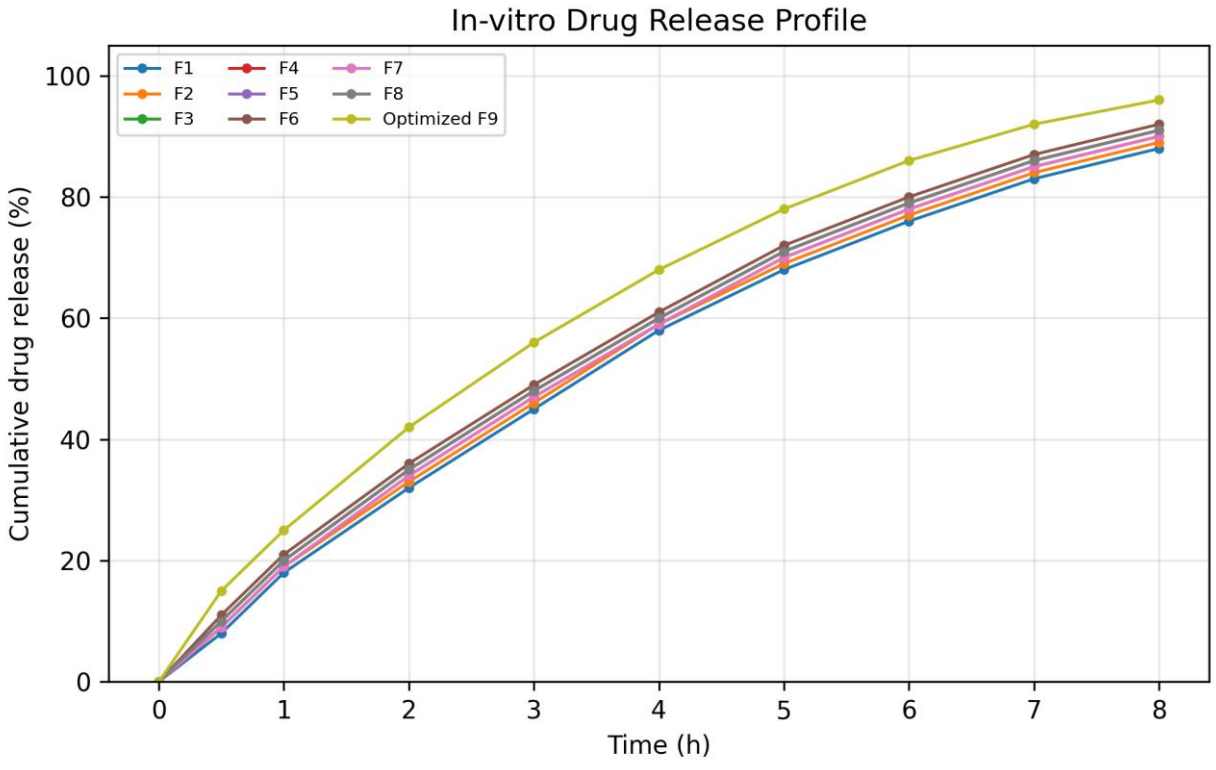


Figure 4: In-vitro cumulative drug release profile of cream formulations.

3.5 Antimicrobial activity and stability

Table 4: Antimicrobial activity and stability summary of optimized cream.

Test parameter	Result
Staphylococcus aureus zone of inhibition	24 mm
Escherichia coli zone of inhibition	22 mm
Appearance during stability	Smooth, pale yellow and homogeneous; no visible change over 3 months
pH during stability	5.60 initially, 5.58 at 1 month, 5.56 at 2 months and 5.55 at 3 months
Viscosity during stability	35,000 cPs initially and 34,500 cPs after 3 months
Spreadability during stability	19 sec initially and 17 sec after 3 months
Microbial contamination	Absent throughout the study

The optimized cream produced clear zones of inhibition against both test organisms, confirming that povidone-iodine and turmeric retained antiseptic activity within the cream base. The larger zone against Staphylococcus aureus suggested strong activity against Gram-positive skin pathogens, while the 22 mm zone against Escherichia coli confirmed relevant activity against Gram-negative bacteria. Stability observations showed no phase separation, discoloration or microbial contamination during three months. Minor reductions in pH and viscosity were within acceptable limits, indicating short-term physical and microbiological stability.

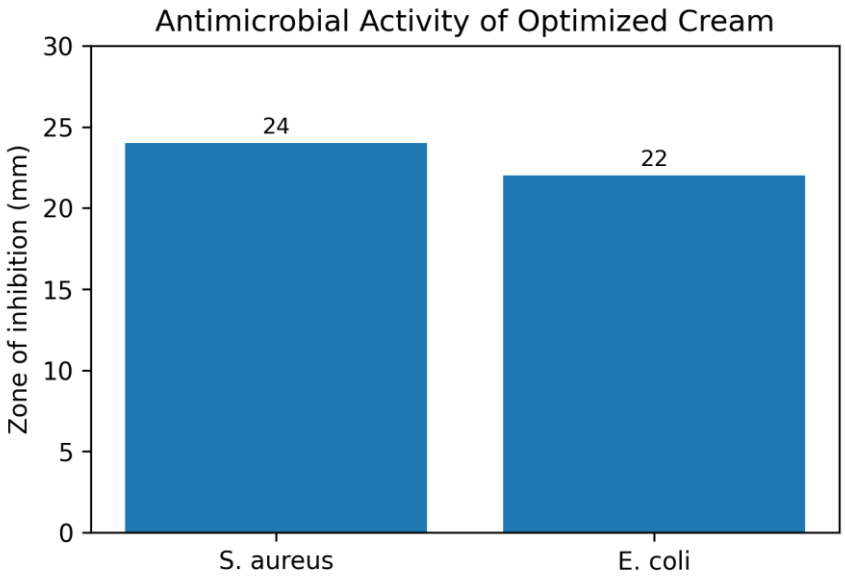


Figure 5: Zone of inhibition of optimized cream against selected microorganisms.

4. CONCLUSION

The study successfully developed a povidone-iodine and turmeric topical cream using an oil-in-water emulsion base. Stearic acid and cetyl alcohol were identified as critical formulation variables influencing viscosity, spreadability and drug release. The optimized formulation showed smooth appearance, excellent homogeneity, absence of phase separation, acceptable pH, balanced viscosity, suitable spreadability, 96% drug content and 96% cumulative drug release at 8 h. Antimicrobial testing demonstrated inhibition zones of 24 mm against Staphylococcus aureus and 22 mm against Escherichia coli, supporting the antiseptic potential of the formulation. Three-month stability testing indicated no visible physical instability and no microbial contamination. Overall, the combination of povidone-iodine with turmeric in a semisolid cream base appears promising for topical antiseptic application, with the potential advantage of combining broad-spectrum antimicrobial action with herbal anti-inflammatory and wound-healing support.

5. Future Scope

Further work should include expanded antimicrobial testing against additional bacterial, fungal and resistant strains; skin irritation and sensitization studies; ex-vivo skin permeation and retention studies; in-vivo wound-healing evaluation; long-term and accelerated stability studies according to ICH guidelines; comparative evaluation with marketed povidone-iodine products; and scale-up studies for reproducibility and commercial feasibility. Advanced delivery approaches such as nanoemulsion, liposomal cream, hydrogel and microsponge-based systems may also be explored to improve retention, controlled release and patient acceptability.

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CONFLICT OF INTEREST

The author declares no conflict of interest.

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