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Antibacterial efficacy evaluation of an in-Situ Gel formulation containing Moxifloxacin: A comparative analysis with a marketed Eye Drop

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ABSTRACT

This study evaluated the antibacterial activity of an optimized in situ gel formulation (OPT-07-1) containing Moxifloxacin against *Staphylococcus aureus*, *Escherichia coli*, and *Bacillus subtilis*. Using the agar diffusion method, the optimized formulation was compared to a marketed eye drop formulation (Moxicip). The in vitro bioassay revealed that OPT-07-1 exhibited slightly superior antimicrobial activity with increased zones of inhibition (ZOI) for all tested microorganisms. The enhanced efficacy of OPT-07-1 was attributed to the prolonged and sustained release of active ingredients facilitated by its high-viscosity gel matrix. The study emphasizes the potential of in situ gel formulations for enhanced antibacterial activity in ophthalmic applications.

Keywords: Antibacterial activity, In situ gel, Agar diffusion, Zone of inhibition, Ophthalmic

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INTRODUCTION

The rising prevalence of microbial infections necessitates the development of advanced formulations that offer superior antibacterial efficacy. In situ gel systems are gaining popularity for their ability to provide prolonged drug release and enhanced therapeutic outcomes.

In ophthalmic formulations, achieving sustained drug delivery is crucial for maintaining drug concentration above the minimum inhibitory concentration (MIC) and ensuring effective microbial inhibition [1-3]. Studies by Kersala et al. (2016), Baig et al. (2016), and Kalam et al. (2010) have demonstrated the antimicrobial potential of nanosuspensions and gelling systems for treating bacterial infections [4-6].

This research aimed to evaluate the antimicrobial efficacy of an optimized in situ gel formulation (OPT-07-1) using the agar diffusion method. Comparative studies were conducted against a marketed formulation (Moxicip) to highlight the potential advantages of OPT-07-1 in ophthalmic applications.

MATERIALS AND METHODS

Preparation of Formulation

In the study we had investigated for the potential of a microemulsion based in situ electrolyte-triggered gelling system for specific delivery of Moxifloxacin to posterior ocular tissue and fluids. Compared to two other formulations, those are in situ gelling system and eye drop solutions, the Moxifloxacin microemulsion based in situ gelling system showed better penetration into ocular tissues, higher Moxifloxacin levels in vitreous humor and prolonged residence in the cornea. The optimized in situ gel formulation (OPT-07-1) was developed using a blend of polymers to achieve prolonged drug release and enhanced antimicrobial activity.

Antibacterial Activity Testing

- **Method**: Agar diffusion using the cup plate technique.
- **Microorganisms**: *Staphylococcus aureus* (MTCC 96), *Escherichia coli* (MTCC 3850), and *Bacillus subtilis* (MTCC 441).
- **Procedure**:
  a) Nutrient agar plates were prepared and seeded with bacterial suspensions (10^4–10^5 CFU/mL).

b) Cups (4 mm diameter) were bored into the agar, and 50 µL of the optimized and marketed formulations were introduced.
c) Plates were incubated at 37°C for 24 hours.
d) Zones of inhibition (ZOIs) were measured in triplicate, and the results were averaged.

RESULTS AND DISCUSSION

The results demonstrated that the optimized formulation (OPT-07-1) exhibited superior antibacterial activity compared to the marketed formulation (Moxicip).

Table 1: Comparative Evaluation of Antibacterial Efficacy

Bacteria	Optimized Formulation (Mean ± SD)	Marketed Formulation (Mean ± SD)	Ratio	p-value
S. aureus	4.56 ± 0.32	4.24 ± 0.47	1.08	0.0684
E. coli	3.71 ± 0.52	3.41 ± 0.41	1.08	0.1322
B. subtilis	3.40 ± 0.67	3.31 ± 0.82	1.03	0.7660

The slight increase in ZOI values for OPT-07-1 indicates its ability to maintain effective drug concentrations over time. This enhanced activity is likely due to the high-viscosity gel system, which facilitates sustained drug diffusion [7-9].

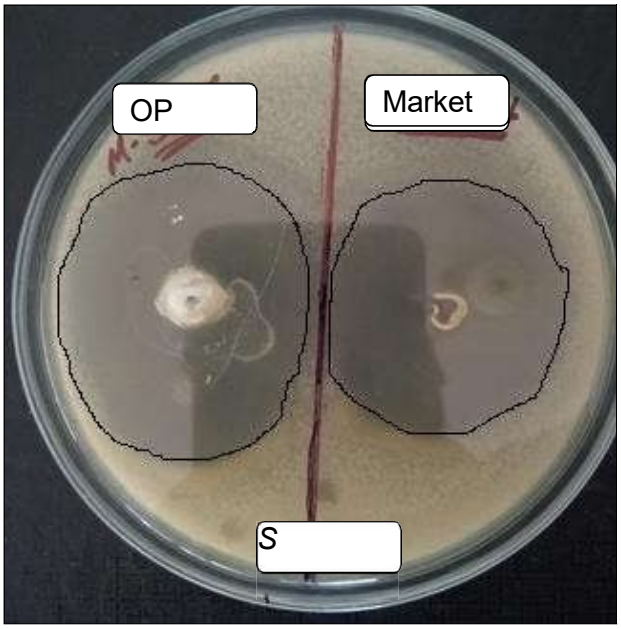

Figure 1: Antibacterial efficacy study optimized formulation OPT-07-1 with respect to marketed eye drops against bacteria S. aureus

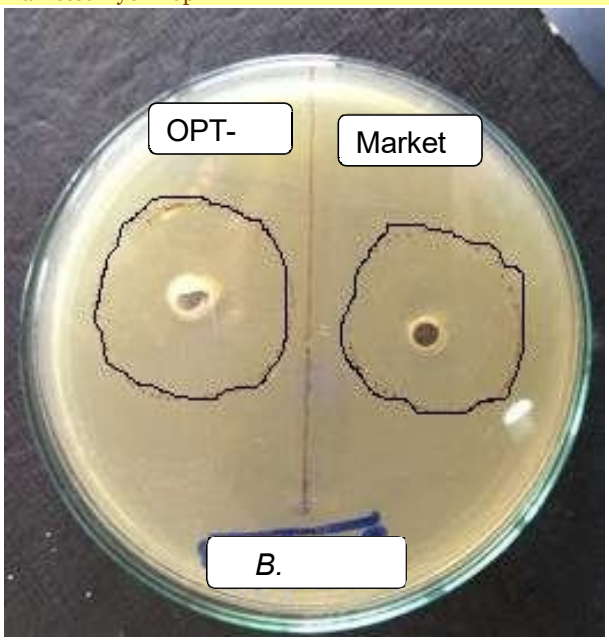

Figure 2: Antibacterial efficacy study optimized formulation OPT-07-1 wrt marketed eye drops against bacteria B. subtilis

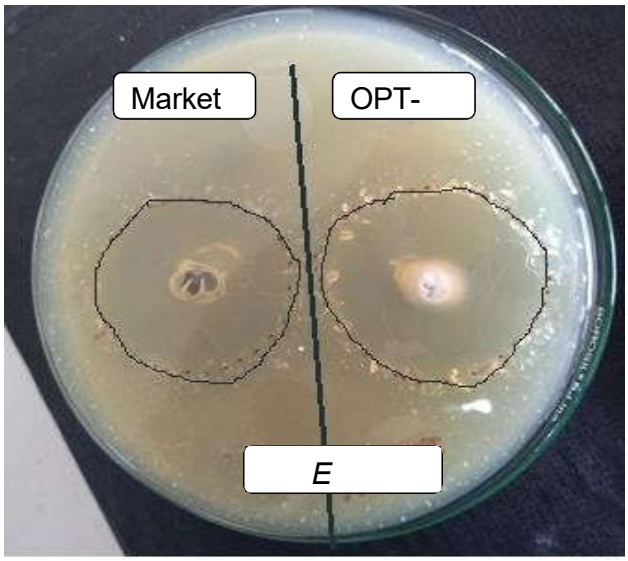

Figure 3: Antibacterial efficacy study optimized formulation OPT-07-1 with respect to marketed eye drops against bacteria E. coli

The in-situ gel formulation demonstrated comparable or slightly superior antibacterial activity across all tested strains. The increased efficacy can be attributed to the hybrid gel matrix's ability to control drug release and maintain therapeutic levels at the site of infection. These findings align with previous studies highlighting the benefits of gelling systems for prolonged antimicrobial action [10-15].

CONCLUSION

The optimized in situ gel formulation (OPT-07-1) exhibited enhanced antibacterial efficacy compared to a marketed product. Its superior performance against *S. aureus*, *E. coli*, and *B. subtilis* demonstrates the potential of in situ gel systems in ophthalmic applications. These findings pave the way for further development and clinical evaluation of advanced drug delivery systems for bacterial infections.

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