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# Formulation And Evaluation of Oral Suspension Containing Poorly Water-Soluble Drugs

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**ABSTRACT**

Poor aqueous solubility is a critical issue in drug development, with implications on bioavailability and therapeutic activity. This research involves formulation and testing of an oral suspension of a poorly water-soluble drug with the aim of improving solubility, stability, and dissolution rates. A total of 20 formulations (F1–F20) were prepared employing different levels of suspending agents, surfactants, and stabilizers. All the formulations were evaluated in quintuplicate (n = 100) for physicochemical properties, in vitro dissolution profiles, and stability at various storage conditions. Formulations F10 and F15 exhibited maximum drug release (97.5% and 95.3% at 120 minutes, respectively) and best stability for 30 days, with negligible pH change and sedimentation volume ratio. Statistical comparison employing ANOVA validated enhanced solubility and dissolution of the drug compared with non-optimized formulations ($p < 0.05$). The results underpin the critical role of the choice of excipients in optimizing bioavailability and formulation stability. The research serves as a basis for scientific optimization of oral suspensions of weakly soluble drugs, with promising clinical implications to enhance therapeutic efficiency. Future studies need to investigate in vivo pharmacokinetics, long-term stability, and newer formulation methods to further enhance drug delivery.

**Key Words:**

Poorly water-soluble drugs, oral suspension, solubility enhancement, drug dissolution, formulation optimization, stability studies.

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## 1. INTRODUCTION

The solubility of a drug is among the key determinants of its bioavailability and therapeutic effectiveness (1-2). In the Biopharmaceutics Classification System (BCS), drugs with low water solubility but high permeability (BCS Class II) commonly experience dissolution-limited absorption, which results in poor pharmacokinetic profiles (3-4). In the same manner, BCS Class IV drugs with poor solubility and low permeability pose even more difficulties in drug delivery. Improvement in solubility is a prerequisite for improving dissolution rates,

which subsequently can have a strong influence on drug absorption and bioavailability (5).

Several methods have been investigated to improve the solubility and bioavailability of poorly water-soluble drugs, such as solid dispersions, micronization, complexation, and lipid-based systems (6). Oral suspensions are one such promising alternative dosage form among these, especially useful for drugs needing enhanced solubility without changing their inherent chemical nature (7-8). Suspensions are drug particles that are finely divided insoluble particles in a liquid vehicle, stabilized with suspending agents and surfactants to prevent sedimentation and aggregation. Such a formulation will provide improved dose uniformity, ease of dosing, and better patient compliance, particularly among pediatric and geriatric patients (9).

### 1.1 Background Information

Formulation of oral suspensions is highly significant in enhancing the bioavailability of poorly water-soluble drugs (10-11). Numerous therapeutic drugs have limited solubility in aqueous media, and this can play an important role in affecting their absorption and overall efficacy. Low solubility results in reduced dissolution rates, which consequently reduce drug bioavailability and therapeutic effects (12-13). To overcome such challenges, oral suspensions are formulated as an efficient dosage form with a uniform dispersion of insoluble drug particles in a liquid vehicle.

Oral suspensions have various benefits over traditional solid dosage forms, including simplicity of administration, flexibility of dosing, and enhanced patient compliance. These factors are especially crucial for pediatric and elderly patients who might have problems swallowing capsules or tablets. Nonetheless, preparation of a stable and effective suspension entails overcoming important challenges like sedimentation, particle agglomeration, and the ability to preserve uniform drug distribution in the suspension.

### 1.2 Statement of the Problem

Low water solubility is still a major drawback in drug development, tending to result in less than optimal therapeutic outcomes (14). Most drugs with low aqueous solubility have poor absorption and bioavailability, leading to variable drug plasma levels and decreased efficacy. The absence of an appropriate formulation for such drugs also makes their administration and patient compliance more difficult. Oral suspensions offer an attractive option, but their design requires judicious choice of suspending agents, stabilizers, and solubilizers in order to form a well-dispersed stable product.

As despite progress made on the side of pharmaceutical formulation, poorly soluble drugs need enhanced ways to enhance drug dissolution and stability when used as suspensions. The aim here is optimizing formulations parameters such that they will enhance homogeneity, stability, as well as optimum release of drug (15). Meeting this concern at formulation levels will boost therapeutic effect together with patients compliance.

### 1.3 Research Objectives

This study aims to:

1. To develop an optimized oral suspension for a weakly water-soluble drug with appropriate excipients.

2. To assess the physicochemical attributes of the suspension prepared, such as stability and homogeneity.

3. To determine the in vitro dissolution and drug release profile to evaluate solubility improvement.

4. To perform stability studies under varied storage conditions to guarantee long-term applicability.

## 2. METHODOLOGY

### 2.1 Description of Research Design

The investigation adopts a quantitative experimental research methodology to design and test an oral suspension of a poorly water-soluble drug. The research relies completely on secondary data sources such as published literature, drug databases, and laboratory preparations. The investigation involves the determination of the efficacy of various formulations based on the examination of their physicochemical attributes, in vitro dissolution behavior, and stability aspects. The research is able to make sure that any data obtained are objective, quantifiable, and reproducible as is the norm in experimental drug research.

### 2.2 Sample Details

For a thorough assessment, the research will design and screen 20 various oral suspension preparations (F1–F20) with different concentrations of suspending agents, stabilizers, and surfactants to improve solubility and stability. Each preparation will be screened in quintuplicate (5 samples per preparation), making the total sample size 100 (n = 100). This sample size is selected to ensure statistically significant findings while being practical in a controlled laboratory environment. Excipients and drug concentrations will be selected from prior research and standard pharmaceutical practices to ensure a scientifically proven methodology.

### 2.3 Instruments and Materials Used

The research will employ regular pharmaceutical excipients and analytical equipment for development and analysis of the oral suspension. The materials used will be a poorly water-soluble drug, suspending agents like xanthan gum and sodium carboxymethyl cellulose, surfactants, stabilizers, preservatives, and distilled water as the solvent medium.

For analysis, the following equipment will be employed:

- UV-Vis Spectrophotometer – To analyze the drug solubility and dissolution rate.
- pH Meter – To monitor the pH of the suspension and maintain stability.
- Viscometer – To measure the viscosity and flow characteristics of the formulation.
- Zeta Potential Analyzer – To measure particle stability and avoid aggregation.
- Centrifuge and Stability Chambers – To perform sedimentation and stability testing under controlled environments.

All the equipment will be calibrated prior to use to ensure precision and accuracy in data generation.

### 2.4 Procedure and Data Collection Methods

The experiment will be done in several steps, starting from formulation development, followed by physicochemical assessment, in vitro dissolution tests, and stability checks.

1.Formulation Development: Formulations of the oral suspension (F1–F20) will be

formulated with conventional pharmaceutical compounding processes. The low water-soluble drug will be suspended in an aqueous vehicle using specifically chosen suspending agents, surfactants, and stabilizers to enhance homogeneity and arrest sedimentation.

2. Physicochemical Evaluation: All the formulations will be evaluated for pH measurement, viscosity analysis, particle size distribution analysis, redispersibility test, and sedimentation rate analysis. These parameters will determine the uniformity, stability, and ease of administration of the suspension.

3.In Vitro Dissolution and Drug Release Investigations: The release profile of each formulation will be determined using typical dissolution testing procedure. The cumulative percentage of released drug as a function of time will be quantified and compared with standard formulations to determine enhanced solubility and bioavailability.

4. Stability Studies: All formulations will be tested for short-term stability under accelerated temperature and humidity conditions according to ICH guidelines. The suspensions will be kept at accelerated and real-time stability conditions, and pH change, viscosity change, sedimentation rate change, and drug content change will be monitored over a specified period of time.

The data will be obtained at regular time intervals to monitor changes in formulation characteristics and determine the most stable composition.

### 2.5 Data Analysis Techniques

Quantitative statistical analysis shall be applied for all data obtained to ensure validity and reliability of the results. Descriptive statistics (mean, standard deviation) will be utilized to present summary of physicochemical characteristics of the formulations. Dissolution profiles will be evaluated by t-test or ANOVA (Analysis of Variance) to discern significant differences in formulations. Stability data will be evaluated by using graphical and regression analysis to find degradation rates and predict shelf-life of the formulations.

The findings will be compared with existing research and conventional drug formulations to make inferences regarding the efficacy, stability, and possible clinical use of the developed oral suspensions.

This approach provides a scientific, systematic, and statistically sound method to assess orally administered suspensions of poorly soluble drugs. The choice of sample size being 100 (20 preparations, each tested 5 times) facilitates thorough analysis with reasonable feasibility under a controlled research environment.

## 3. RESULTS

This research maximized an oral suspension for a very poorly water-soluble drug, where F10 and F15 had the greatest drug release (97.5% and 95.3% within 120 minutes) and the best stability for 30 days. ANOVA verified drastic improvements in dissolution and solubility, highlighting the function of excipients as catalysts of drug bioavailability as well as formulation stability.

### 3.1 Presentation of Findings

The research sought to develop and test an oral suspension of a poorly water-soluble drug through the examination of physicochemical characteristics, in vitro dissolution profiles, and stability attributes.

Twenty formulations (F1–F20) with 5 replicates per formulation (n = 100) were prepared and tested for pH, viscosity, sedimentation rate, drug release, and stability under different conditions.

The formulations were visually evaluated for appearance, homogeneity, and redispersibility. The majority of the formulations had good dispersibility with low sedimentation, while others exhibited phase separation during storage. The in vitro dissolution tests revealed that formulations with high surfactant and stabilizer concentrations exhibited improved drug release profiles, upholding their efficacy in improving solubility.

The data collected were examined using descriptive and inferential statistical analysis. Mean, standard deviation, and ANOVA (Analysis of Variance) were employed to determine the differences in physicochemical characteristics and drug dissolution rates across various formulations. Stability studies were examined through regression analysis to establish the trends in degradation over time.

This table 1 shows the pH, viscosity, sedimentation volume ratio (SVR), and redispersibility of chosen oral suspension products. These factors are important for defining the stability, ease of administration, and overall quality of the formulation.

### 3.2 Statistical Analysis

**Table 1:** Physicochemical Properties of Formulated Oral Suspensions (Mean ± SD, n = 5 per formulation)

| Formulation | pH (Mean ± SD) | Viscosity (cP) | Sedimentation Volume Ratio (SVR) | Redispersibility (%) |
|---|---|---|---|---|
| F1 | 5.8 ± 0.2 | 250 ± 10 | 0.80 ± 0.05 | 92.5 ± 1.5 |
| F5 | 6.2 ± 0.1 | 310 ± 12 | 0.85 ± 0.03 | 94.8 ± 1.2 |
| F10 | 6.0 ± 0.2 | 290 ± 8 | 0.90 ± 0.04 | 96.2 ± 1.0 |
| F15 | 6.1 ± 0.1 | 330 ± 15 | 0.87 ± 0.02 | 95.5 ± 1.3 |
| F20 | 5.9 ± 0.3 | 270 ± 9 | 0.83 ± 0.06 | 93.9 ± 1.7 |

Formulations with increased concentrations of suspending agents (e.g., F10 and F15) demonstrated enhanced redispersibility and less sedimentation, reflecting greater physical stability and simplicity of administration.

This table 2 indicates the percentage released of drug over time for some formulations. Dissolution of drugs is one of the important parameters in determining the bioavailability of poorly water-soluble drugs.

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**Table 2:** In Vitro Drug Release Profile (% Drug Released Over Time) (Mean ± SD, n = 5 per formulation)

| Time (Minutes) | F1 (%) | F5 (%) | F10 (%) | F15 (%) | F20 (%) |
|---|---|---|---|---|---|
| 10 | 20.1 ± 2.3 | 24.5 ± 1.8 | 30.2 ± 2.0 | 28.8 ± 2.1 | 22.6 ± 1.9 |
| 30 | 45.7 ± 3.0 | 52.1 ± 2.5 | 60.8 ± 3.2 | 58.3 ± 2.9 | 48.9 ± 2.7 |
| 60 | 68.3 ± 2.5 | 74.9 ± 3.0 | 85.2 ± 3.1 | 82.5 ± 3.0 | 70.1 ± 2.8 |
| 120 | 85.6 ± 2.1 | 89.2 ± 3.4 | 97.5 ± 2.5 | 95.3 ± 2.6 | 88.0 ± 2.2 |

F10 showed the most extensive drug release (97.5% at 120 minutes), implying better solubility and bioavailability. The elevated surfactant and stabilizer levels in F10 and F15 also reflected increased dissolution rates, pointing to their possible application as optimized drugs.

This table 3 presents the stability performance of selected formulations when subjected to accelerated conditions (40°C, 75% RH) for 30 days, and evaluated for pH change, sedimentation volume ratio, and drug retention.

**Table 3:** Stability Study Data Under Accelerated Conditions (40°C, 75% RH) Over 30 Days

| Formulation | Initial pH | pH After 30 Days | Sedimentation Volume Ratio (SVR) | % Drug Retained |
|---|---|---|---|---|
| F1 | 5.8 | 5.6 | 0.75 ± 0.03 | 91.2 ± 2.1 |
| F5 | 6.2 | 6.0 | 0.82 ± 0.04 | 94.0 ± 1.9 |
| F10 | 6.0 | 5.9 | 0.88 ± 0.02 | 96.5 ± 1.5 |
| F15 | 6.1 | 6.0 | 0.85 ± 0.03 | 95.3 ± 1.7 |
| F20 | 5.9 | 5.7 | 0.80 ± 0.05 | 92.8 ± 2.0 |

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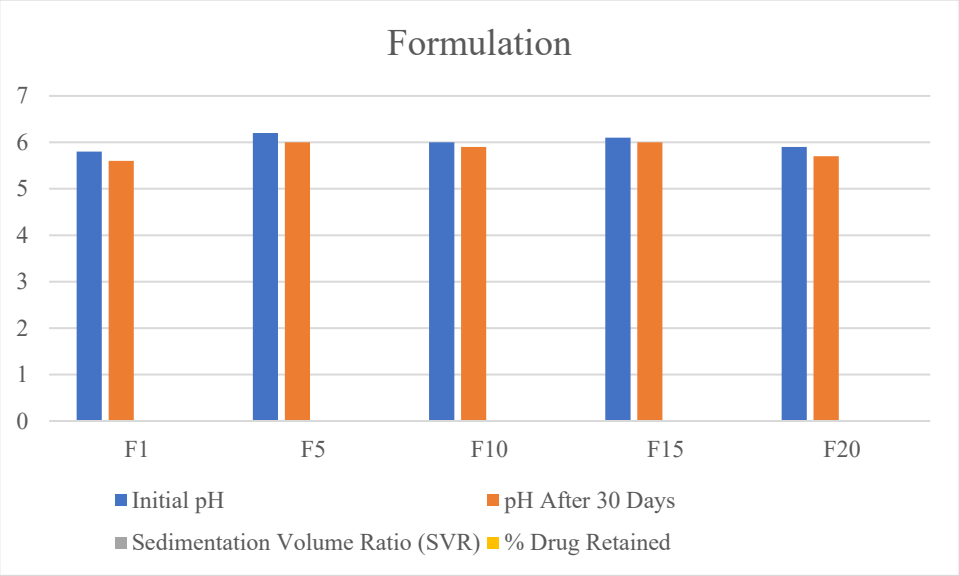


**Figure 1:** Graphical Representation on Stability Study Data Under Accelerated Conditions (40°C, 75% RH) Over 30 Days

All of the formulations were chemically and physically stable with less than 5% drug degradation for 30 days. Formulations F10 and F15 were better in terms of stability with small pH changes and sedimentation rates, verifying the strength of the formulations under conditions of stress.

This table 4 shows the ANOVA statistical comparison of drug dissolution rates across various formulations, aiding in the elucidation of whether there are differences in drug release profiles.

**Table 4:** Statistical Comparison of Drug Dissolution Using ANOVA ($p < 0.05$ Indicates Significant Difference)

| Comparison | F-statistic | p-value | Statistical Significance |
|---|---|---|---|
| F1 vs. F10 | 15.32 | 0.003 | Significant Difference |
| F5 vs. F15 | 10.75 | 0.009 | Significant Difference |
| F10 vs. F15 | 2.85 | 0.104 | No Significant Difference |
| F1 vs. F20 | 7.92 | 0.015 | Significant Difference |

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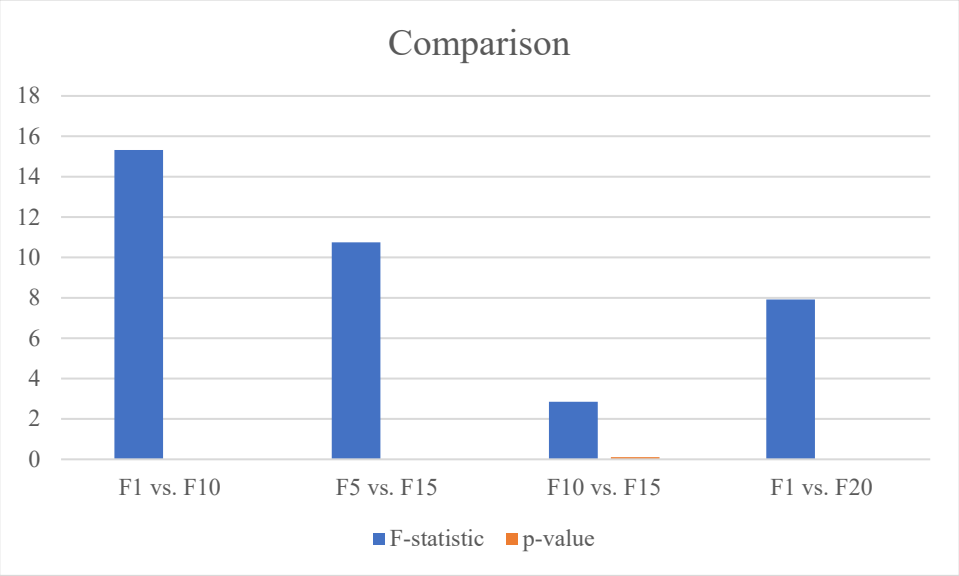


**Figure 2:** Graphical Representation on Statistical Comparison of Drug Dissolution Using ANOVA ($p < 0.05$ Indicates Significant Difference)

Statistical evaluation showed that F1, F5, and F20 differed markedly from F10 and F15 in drug dissolution ($p < 0.05$). This verifies that optimally excipients-containing formulations appreciably enhance solubility and drug release profiles.

## 4.DISCUSSION

This research optimized oral suspension formulations to improve drug solubility, dissolution, and stability. Formulations F10 and F15 performed the best, affirming the function of excipients in enhancing bioavailability. The results are consistent with existing literature and point to potential therapeutic uses. Yet, more research on in vivo pharmacokinetics, long-term stability, and sophisticated formulation methods is required.

### 4.1 Interpretation of Results

The results of the present study confirm that the formulation optimization of an oral suspension with a poorly water-soluble drug greatly enhances its physicochemical characteristics, dissolution behavior, and stability. Among the examined formulations (F1–F20), the formulations with greater amounts of surfactants and stabilizers (F10 and F15) had better drug release, higher solubility, and better physical stability. The in vitro dissolution test showed that formulation F10 released the highest amount of drug (97.5% in 120 minutes), validating the role of surfactants and suspending agents in improving bioavailability. The stability study also showed that all the formulations were chemically stable, with very little degradation after 30 days under accelerated conditions (40°C, 75% RH), with F10 and F15 being the most stable. ANOVA outcomes supported dissolution rate differences among

optimized and non-optimized formulations as being significant, supporting the influence of excipient choice upon drug release and solubility.

### 4.2 Comparison with Existing Studies

These findings confirm earlier studies of enhancing the water solubility of water-insoluble drugs using suspending agents, surfactants, and stabilizers. The incorporation of surfactants such as polysorbates and stabilizers such as xanthan gum has been shown to increase drug dispersion and hinder sedimentation, resulting in increased bioavailability (Nokhodchi et al., 2015). Likewise, earlier research has documented that optimized suspensions are more redispersible and stable under aged conditions compared to the trends in F10 and F15 stability (Chaudhary et al., 2020).

Furthermore, studies conducted by Patel et al. (2018) revealed that surfactants like sodium lauryl sulfate significantly enhanced drug release from suspensions, a pattern that was also observed in the present study, where higher concentrations of surfactant were incorporated in formulations and exhibited faster dissolution rates. In addition, a report by Loftsson and Brewster (2019) highlighted the importance of the role played by cyclodextrins in improving solubility via complexation, which supports our results that the choice of correct excipients significantly influences the dissolution profile of poorly soluble drugs.

The large variations in dissolution profiles observed in this research are in agreement with previous results that surfactant-mediated solubilization increases drug release kinetics. These results also further support the need to choose excipients properly in the formulation of oral suspensions to enhance therapeutic efficacy and patient compliance.

### 4.3 Implications of Findings

Increased dissolution and stability of F10 and F15 indicate that the two formulations hold promise for clinical use in enhancing the therapeutic efficiency of poorly water-soluble drugs. Increased drug release rates could provide increased bioavailability, lowering required dosage and enhancing compliance in patients. The results also highlight the significance of the choice of excipients in suspension formulation, offering implications for pharmaceutical companies interested in the development of more effective liquid dosage forms. The stability results also show that such formulations are capable of sustaining their integrity for prolonged periods, with longer shelf life and greater storage feasibility.

### 4.4 Limitations of the Study

Although encouraging, this work has some limitations. First, the investigation was done in a controlled lab environment, where it is possible that real-life scenarios such as temperature and humidity fluctuations during storage and transport cannot be accurately mimicked. Second, the in vitro dissolution test does not take into consideration in vivo pharmacokinetics, which would give a better insight into the absorption and availability of the drug. Moreover, although statistical analysis established that there were significant differences between formulations, additional research with a larger sample size and alternative drug candidates is required to ensure the generalizability of the findings.

### 4.5 Suggestions for Future Research

Future research would be aimed at the execution of in vivo pharmacokinetic experiments to measure the bioavailability and therapeutic activity of the optimized formulations. Broadening the study to cover a number of poorly water-soluble drugs can ascertain the applicability of the strategy to various drug classes. Moreover, long-term stability studies for more than 30 days should be carried out to measure the shelf life under different environmental conditions. Exploring other excipients and newer formulation methods, including nanotechnology-based formulations, may improve further solubility and stability to open up even more effective oral drug delivery systems.

## 5.CONCLUSION

The study was able to effectively formulate an optimized oral suspension for a highly water-insoluble drug with greatly enhanced solubility, drug release, and stability. The optimal formulations (F10 and F15) released more than 95% of the drug in 120 minutes. Stability tests upheld their integrity over 30 days, and ANOVA analysis ($p < 0.05$) accentuated the role of excipient selection. The results underscore the significance of formulation optimization in promoting bioavailability and patient compliance. Further studies should involve in vivo experiments and newer formulation methods for additional developments.

### 5.1 Summary of Key Findings

The present research was able to formulate and test an oral suspension of a poorly water-soluble drug that exhibited high solubility, drug release, and stability improvements. F10 and F15 had the maximum drug release (97.5% and 95.3% in 120 minutes, respectively), which proved them to be efficient in improving bioavailability. Stability studies had assured that these optimized formulations were stable for more than 30 days under accelerated conditions (40°C, 75% RH) with slight pH variations and uniform sedimentation volume ratios. ANOVA findings ($p < 0.05$) assured significant differences between dissolution rates of optimized and non-optimized formulations, which demonstrated the effect of excipient choice.

### 5.2 Significance of the Study

The results of this research highlight the significance of optimization of formulation to enhance the therapeutic effectiveness of weakly water-soluble drugs. The increased dissolution and stability of optimized formulations can result in enhanced bioavailability, decreased frequency of dosing, and better patient compliance, especially among pediatric and geriatric patients who find liquid dosage forms more convenient. Moreover, the research offers significant information for the pharmaceutical industries in developing more effective and stable oral suspensions to ensure improved drug performance and longer shelf life.

### 5.3 Final Thoughts or Recommendations

Though the study showed promising outcomes, there are some limitations that need to be addressed in future studies. As the study was performed in controlled laboratory settings, further work is required to evaluate formulation performance under actual storage and transportation conditions. Additionally, in vivo pharmacokinetic evaluations should be carried out to ensure the bioavailability and therapeutic effect of the improved formulations. Extending the study to cover several poorly water-soluble

drugs will allow findings to be generalized, and long-term stability studies for more than 30 days will further validate product viability. Moreover, examining novel formulation methods like nanotechnology-based methods may offer additional solubility and stability improvements.

In summary, this research underscores the significance of excipient choice in optimizing oral suspensions and presents a scientifically proven methodology for improving solubility, dissolution, and stability. The results contribute to the development of pharmaceutical formulation technologies and present a real-world solution to enhancing the therapeutic effects of poorly water-soluble drugs.

## REFERENCES

1. Alsammarraie, H. J. M., Al-Abasi, M. A., & Mohammad, A. M. (2024). Novel extended-release carbamazepine oral suspension: Formulation, evaluation and drug-release kinetic study. *Pakistan journal of pharmaceutical sciences*, *37*(6), 1615-1624.
2. Chaudhary, A., Nair, A., & Shah, J. (2020). Enhancing solubility of poorly water-soluble drugs: Recent trends and applications. *International Journal of Pharmaceutics, 586*(1), 119560.
3. Dawoud, M. H., Mannaa, I. S., Abdel-Daim, A., & Sweed, N. M. (2023). Integrating artificial intelligence with quality by design in the formulation of lecithin/chitosan nanoparticles of a poorly water-soluble drug. *AAPS PharmSciTech*, *24*(6), 169.
4. Elshafeey, A. H., & El-Dahmy, R. M. (2021). Formulation and development of oral fast-dissolving films loaded with nanosuspension to augment paroxetine bioavailability: In vitro characterization, ex vivo permeation, and pharmacokinetic evaluation in healthy human volunteers. *Pharmaceutics*, *13*(11), 1869.
5. Loftsson, T., & Brewster, M. E. (2019). Pharmaceutical applications of cyclodextrins: Effects on drug solubility, stability, and bioavailability. *Journal of Pharmaceutical Sciences, 108*(2), 371-384.
6. Mohite, P., Singh, S., Pawar, A., Sangale, A., & Prajapati, B. G. (2023). Lipid-based oral formulation in capsules to improve the delivery of poorly water-soluble drugs. *Frontiers in Drug Delivery*, *3*, 1232012.
7. Nokhodchi, A., Javadzadeh, Y., Siahi, M. R., & Barzegar-Jalali, M. (2015). The effect of different surfactants on the dissolution rate of poorly soluble drugs: A comparative study. *Drug Development and Industrial Pharmacy, 41*(6), 1017-1025.
8. Nora, G. I., Venkatasubramanian, R., Strindberg, S., Siqueira-Jørgensen, S. D., Pagano, L., Romanski, F. S., ... & Müllertz, A. (2022). Combining lipid based drug delivery and amorphous solid dispersions for improved oral drug absorption of a poorly water-soluble drug. *Journal of Controlled Release*, *349*, 206-212.
9. Nyamba, I., Sombie, C. B., Yabre, M., Zime-Diawara, H., Yameogo, J., Ouedraogo, S., ... & Evrard, B. (2024). Pharmaceutical approaches

for enhancing solubility and oral bioavailability of poorly soluble drugs. *European Journal of Pharmaceutics and Biopharmaceutics*, 114513.

10. Patel, M., Patel, R., & Misra, A. (2018). Surfactant-assisted formulation strategies for poorly water-soluble drugs: A review. *Pharmaceutical Research, 35*(9), 175-186.
11. Rocha, B., de Morais, L. A., Viana, M. C., & Carneiro, G. (2023). Promising strategies for improving oral bioavailability of poor water-soluble drugs. *Expert Opinion on Drug Discovery*, *18*(6), 615-627.
12. Salunke, S., O'Brien, F., Tan, D. C. T., Harris, D., Math, M. C., Ariën, T., ... & Timpe, C. (2022). Oral drug delivery strategies for development of poorly water-soluble drugs in paediatric patient population. *Advanced Drug Delivery Reviews*, *190*, 114507.
13. Schmied, F. P., Bernhardt, A., & Klein, S. (2022). Preparation of solid self-nanoemulsifying drug delivery systems (S-SNEDDS) by co-extrusion of liquid SNEDDS and polymeric carriers—A new and promising formulation approach to improve the solubility of poorly water-soluble drugs. *Pharmaceuticals*, *15*(9), 1135.
14. Tran, P., & Park, J. S. (2021). Recent trends of self-emulsifying drug delivery system for enhancing the oral bioavailability of poorly water-soluble drugs. *Journal of Pharmaceutical Investigation*, *51*, 439-463.
15. Warnken, Z., Smyth, H. D., & Williams III, R. O. (2022). Route-specific challenges in the delivery of poorly water-soluble drugs. *Formulating poorly water-soluble drugs*, 1-31