RESEARCH PAPER

Formulation and Evaluation of Fast-Dissolving Oral Films of Ondansetron Hydrochloride

Deepak Jatav
Department of Pharmacy, SAM College of Pharmacy, Raisen, SAM GLOBAL UNIVERSITY RAISEN , Madhya Pradesh, India, corresponding Author : Deepak Jatav
Email Id _ drxdeepakjatav@gmail.com

Abstract
Background: Ondansetron Hydrochloride (Ondansetron) is a strong antiemetic (anti-nausea) drug commonly used to prevent and control nausea and vomiting. But oral tablets might not be a good option for people who have problems swallowing or need an immediate effect. Oral films that quickly dissolve in the mouth are also more patient-friendly, as they do not require water to dissolve.
Objective: The study aimed at the formulation and Evaluation of a fast-dissolving oral film of Ondansetron Hydrochloride by the solvent casting technique. The goal was to formulate a uniform and flexible film, assess the physicochemical properties, mechanical properties, disintegration, and drug release, and achieve an optimized formulation.
Materials and Methods: a suitable film-forming polymer, plasticizer, and other formulation excipients, to which Ondansetron Hydrochloride is incorporated for polymeric film preparation using a solvent casting technique to prepare polymeric films. The appearance, thickness change, folding endurance, surface pH, drug content uniformity, disintegration time, and in-vitro drug release were evaluated for the prepared films. The optimized formulation was then further evaluated for its overall performance and suitability as an orodispersible dosage form.
Key findings: The developed films showed good appearance and uniformity of thickness, good flexibility, satisfactory drug release, and good disintegration time. The optimized formulation showed an efficient release of the drug within a short duration, which suggests high potential for drug availability in a short period. Also, the formulation exhibited good physical and mechanical properties.
Conclusions: Solvent casting is a viable method for the formulation of a fast-dissolving oral film of Ondansetron Hydrochloride and can prove to be a convenient, patient-compliant, and quickly disintegrating alternative to the conventional oral dosage characteristics of the drug.
Keywords: Ondansetron Hydrochloride, Fast Dissolving Oral Film, Solvent Casting, Orodispersible Film, Drug Release
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1. Introduction

Oral administration of pharmaceutical agents is one of the most widely accepted and convenient methods due to its simplicity, patient acceptability, non-invasive nature, and relatively low cost. Pharmaceuticals in the form of tablets and capsules are frequently used to treat acute and chronic diseases. Although beneficial, traditional dosage forms can also have disadvantages for some patients, such as young children, older adults, patients with swallowing difficulties, and patients with nausea and vomiting. Swallowing difficulties and the need for water to be administered could decrease patient convenience and compliance. These constraints have led to the diversification of oral drug delivery systems that are able to release the drug quickly and in high amounts.[1]

Fast dissolving oral films (FDOF) are innovative oral dosage forms that are composed of thin polymeric films with therapeutic drug and appropriate pharmaceutical excipients. The film is placed on the tongue or inside the oral cavity where it quickly rehydrates, breaks down and dissolves, delivering the drug within it[2]. Fast-dissolving films are usually swallowed without the need for water, unlike conventional tablets, and can be very useful when a rapid and convenient administration of the drug is desired. Due to their small size, flexibility, portability, ease of administration, and potential for drug release, they are an appealing dosage form for increasing patient acceptability and adherence.

There are a number of issues that can be associated with traditional tablets and capsules. Physiological, psychological, and/or disease-related factors make it difficult for some patients to swallow solid dosage forms. Also, if nausea and vomiting are present, patients may not be able to swallow or keep down standard oral medications. Tablets also need adequate fluid to swallow and might disintegrate or dissolve

before the drug can be absorbed. The convenience and effectiveness of treatment may be affected by these factors[3]. The oral films that dissolve quickly are a way of avoiding some of these problems, as they are thin and dissolve rapidly in the oral cavity.

Ondansetron Hydrochloride is a selective serotonin 5-hydroxytryptamine type 3 (5-HT3) receptor antagonist and is widely recommended for the prevention and treatment of nausea and vomiting that are related to chemotherapy, radiotherapy, and postoperative conditions. Ondansetron Hydrochloride is used to treat vomiting by selectively blocking 5-HT3 receptors that play a key role in the vomiting reflex. The drug comes in a few conventional dosage forms and there is also an oral dosage form available. Patients with active nausea and vomiting, however, may not be able to swallow normal tablets, making it desirable to have a dosage form that is both easier and more convenient to swallow[4].

Based on its therapeutic use, Ondansetron Hydrochloride was chosen for developing a fast dissolving oral film. For patients who struggle to swallow or need medication without water, a disintegrating film can be a good alternative. The film also provides the opportunity to present the drug in a compact and patient friendly dosage form, which may enhance the acceptance of drug administration and treatment.

The formulation of fast dissolving oral film of Ondansetron Hydrochloride therefore is a rational approach to overcome some of the drawbacks of conventional oral dosage forms[5]. Solvent-casting technique is a useful approach for preparing thin uniform film by dissolving or dispersing the drug with film-forming components in an appropriate solvent system and casting and drying the film. The resultant films can be assessed with respect to the physical characteristics, thickness, weight variation, folding resistance, drug content, disintegration time and in-vitro drug release.

1.1 Aims and Objectives

Research Aim:

The objective of the present work is to develop and test a fast-dissolving oral film of Ondansetron Hydrochloride by using the solvent-casting method that provides a convenient, patient-friendly, and rapidly disintegrating oral dosage form.

Research Objectives:

1. To investigate the physicochemical and pharmaceutical properties of Ondansetron Hydrochloride useful for oral film formulation.
2. To develop fast-dissolving oral films of Ondansetron Hydrochloride using appropriate film-forming polymers and excipients.
3. To formulate and prepare the films by the solvent-casting technique and maximize the formulation variables.
4. To test the physical aspects of the films such as appearance, thickness variation, weight, folding endurance, surface pH, and uniformity of drug content.
5. To assess the disintegration property of the fast-dissolving oral films prepared.
6. To check the drug release profile from the prepared formulation in vitro.
7. To find optimized Onudansetron Hydrochloride fast-dissolving oral film according to its physicochemical, mechanical, disintegration, and drug release properties.

2. Review of Literature

Oral films (OFS) that dissolve rapidly around the mouth have become a significant oral drug delivery system to address some drawbacks of typical oral dosage forms, including tablets and capsules. These are extremely thin polymeric preparations which undergo rapid hydration, disintegration, and dissolution in the oral cavity and provide for the administration of the drug without the use of water[6]. This property is of great value to individuals who have swallowing difficulties with regular capsule/solid dosage forms or have to swallow multiple regular capsules/solid dosage forms at the same time when they have nausea and vomiting. Consequently, great attention has been devoted to developing fast-dissolving films as an alternative way to enhance patient convenience, acceptability, and possibly the onset of drug action.

Ondansetron Hydrochloride is a selective serotonin 5-HT3 receptor antagonist that is used in a wide range of settings to prevent and treat nausea and vomiting caused by chemotherapy, radiotherapy, and postoperative use. Nausea and vomiting may be a problem with taking and retaining conventional oral medications; therefore, the development of a rapidly disintegrating dosage form of ondansetron is of pharmaceutical interest. The development of ondansetron into an oral film has, therefore, been explored by various researchers, employing various polymers, plasticizers, and formulation approaches[7].

Koland et al. (2010) studied fast-dissolving sublingual Ondansetron Hydrochloride films and examined the effect of formulation excipients on drug release and permeation of the mucosa. They found that thin-film systems could be very effective in delivering ondansetron in a rapid fashion via the oral route. The study has pointed out that selection of film-forming materials and additives can have a great influence on the release of the drug. This gave a valuable

foundation for the subsequent investigations of the oral films containing ondansetron[18].

The study of buccal film systems was further investigated. Koland et al (2011) designed and assessed chitosan buccal films containing Ondansetron Hydrochloride (Ondan) in an in vitro and in-vivo manner. The investigation showed that polymeric buccal films are able to serve as an appropriate platform for ondansetron delivery and that the polymeric properties can affect both the drug-release and the mucosal properties. The results of these studies can be applied to the concept that polymeric oral films can offer benefits over traditional dosage forms in cases where a rapid and convenient drug administration is required[18].

The factorial experimental design was used in this study to investigate the mouth-dissolving film of Ondansetron Hydrochloride by Thakur et al. (2019). The study focused on the role of formulation variables in the characteristics of the final film. The value of experimental design approaches is especially useful in instances in which the properties of the film are affected by the concentration and interaction of the formulation components, such as mechanical strength, disintegration, and drug release. They found that a systematic optimum approach is better than a trial-and-error approach used to choose the concentrations of polymers[15].

Lee et al. (2021) have developed a new ODOF formulation of Ondansetron. They have also shown that it is possible to incorporate ondansetron into a rapidly disintegrating film dosage form in their study. The development of orally disintegrating films is the result of a desire to make the administration more convenient and easier, especially when giving oral tablets is not possible. Studies like this are useful to support the ongoing development of ondansetron oral-film products (Lee et al., 2021)[14].

The use of different formulation strategies has also been investigated to improve the solubility and drug-loading characteristics of ondansetron films. The solubility enhancement and formulation development of an oral film containing Ondansetron Hydrochloride Monohydrate were studied using the mix-solvency concept by Tomer et al. (2023). The study showed the relevance of the choice of solvent and strategies to improve solubility during formulation of films. Appropriate solvent selection is a key formulation consideration for obtaining a homogeneous drug-containing polymeric solution, which would yield uniform films and consistent drug loading.

Thakare and Karole (2023) also explored the use of the mix-solvency concept for enhancing the drug loading in ondansetron mouth-dissolving films. The results they obtained show that the formulation composition has a significant effect on the amount of drug that can be taken up in the film with acceptable film parameters. This is especially important for oral-film systems where the increased drug loading needs to be tempered by the need for flexibility, uniformity, and rapid disintegration, as well as acceptable physical properties.

Wei et al. (2023) formulated and evaluated an oral film of ondansetron hydrochloride solid dispersion with fast-release properties. Their study exemplifies another method for obtaining a fast drug release from an orally dispersible film. Solid-dispersion technology can improve the dissolution properties of drugs and can thus be used in film-based drug delivery systems where fast drug release is an essential formulation requirement[4].

Basha and Sudha (2024) studied Box–Behnken experimental design for fast-dissolving ondansetron buccal films and the influence of independent variables on parameters like swelling and folding endurance. Using response-surface experimental designs, a systematic approach to understanding relationships between formulation variables and film performance is provided. These methods are pertinent due to the fact that many factors interact with one another to produce the properties of the oral film[10].

Rathore and Saraogi (2024) reported the development and evaluation of a fast-dissolving film of 'Ondansetron'. Their work also indicates the feasibility of producing ondansetron-containing films with desirable characteristics like fast disintegration and release of the drug. Studies with various polymer formulations continue to appear, showing that the composition of the polymer formulation is still a key research area in the formulation of ondansetron oral films[5].

Newer studies have been directed towards the study of advanced polymers and taste masking/special formulation technologies. Vishnav et al. (2025) and Kumari et al. (2025) studied fast-dissolving films of Ondansetron Hydrochloride and oral thin films with a rapid onset of action, respectively. From these studies, it can be seen that there is still interest in enhancing the performance of ondansetron films and optimizing their characteristics for fast drug delivery[2].

In the work of Ahire (2025), they discussed about the mouth dissolving films of Ondansetron Hydrochloride using an alternative to conventional synthetic polymers, which is a natural film former. Systematic formulation optimization is becoming increasingly important, and in this context, Lokhande et al. (2025) used a central composite design and quality by design approach in an oral thin film of ondansetron hydrochloride. In the past, taste-masked orally dissolving films have not been considered, but they were explored by Dahmash et al. (2025), who used novel nanocapsule technology, demonstrating that

taste-masked and advanced drug-delivery strategies are emerging as important considerations in film development[13].

Pullulan/HPMC based systems have also been studied in recent years. Sri et al. (2026) developed oral thin films of Ondansetron Hydrochloride by using pullulan/HPMC film-forming polymers, characterized and evaluated the stability of these formulations with an emphasis on ultra-fast disintegration and fast enhancement of antiemetic action. Singh et al. (2026) studied an orodispersible film of ondansetron using natural cyclodextrin complexes and a plasticizer as honey. Such research shows that there is currently a shift from mere film formation to optimization of disintegration, taste, stability, and patient acceptability[8].

Overall, it can be concluded from the literature available that Ondansetron Hydrochloride is suitable for fast-dissolving oral-film development. Previous studies have been conducted on various polymers, plasticizers, solvent systems, experimental designs, taste-masking methods, solid dispersions and advanced delivery systems (Koland et al., 2010; Koland et al., 2011; Thakur et al., 2019; Wei et al., 2023; Basha and Sudha, 2024). The literature also suggests that the concentration of polymers, level of plasticizers, solvent system, and other excipients can significantly influence the thickness of the film, folding endurance, mechanical properties, drug content, disintegration, and drug release. So, formulation systematics and evaluation are still needed to identify a formulation that gives a suitable balance of mechanical strength and fast release of the drug.

Research Gap and Rationale:

Although Ondansetron Hydrochloride oral films have been extensively studied, there are still significant formulation challenges. Several approaches such as conventional fast-dissolving films, sublingual and buccal films, factorial and response-surface experimental designs, mix-solvency approaches, solid dispersions, natural polymers, taste-masking technologies and advanced nanocapsule-based systems have been studied previously (Koland et al., 2010; Koland et al., 2011; Thakur et al., 2019; Tomer et al., 2023; Wei et al., 2023; Basha & Sudha, 2024; Dahmash et al., 2025).

The primary research gap is that the effectiveness of any oral film is related to the interaction of the polymer type, polymer concentration, excipients, and plasticizer concentration. The higher polymer concentration may be beneficial to the strength of the films, but may also have an impact on the disintegration and drug release properties. In the same way, plasticizers may affect the flexibility, but may also affect moisture content, mechanical properties, and the dissolution behavior. Thus, a proper balance between mechanical integrity and rapid disintegration and efficient drug release is an important objective of the formulation.

Another crucial need in this respect is the requirement for relatively simple and reproducible formulation methods. Advanced technologies like quality-by-design optimization, solid dispersions, nanocapsules, and special taste-masking systems have been explored (Lokhande et al., 2025; Dahmash et al., 2025; Singh et al., 2026), but they might be more complex to formulate. The solvent casting method with pharmaceutically acceptable polymers and excipients can offer a relatively simple means of thin film preparation, with systematic variation of formulation parameters[8].

Thus, the present study is justified to develop and systematically evaluate fast-dissolving oral films of Ondansetron Hydrochloride by the solvent casting technique. The study concentrates on the correlation of the composition of the formulation with some of the critical quality attributes such as thickness, weight, folding endurance, tensile strength, elongation, surface pH, moisture content, drug-content uniformity, disintegration time, and in-vitro drug release. This thorough assessment can help in the development of an optimized formulation having a balance of mechanical properties and quick drug delivery.

The study is also relevant because patients with nausea and vomiting might not be able to easily swallow tablets and might require a dosage form that does not require water for ingestion. The ability of oral films to release ondansetron quickly has been reported in previous studies; however, further optimization of the formulation requires different polymeric systems and excipients to yield different performance properties (Lee et al., 2021; Rathore & Saraogi, 2024; Sri et al., 2026).[14]

Thus, the present work aims to contribute to the existing literature by developing the form of fast-dissolving oral films of Ondansetron Hydrochloride by the solvent casting technique and comparing more than one formulation to achieve an optimized formulation based on physical characteristics, mechanical strength, drug-content uniformity, rapid disintegration, dissolution performance, release kinetics, and stability. The approach offers a convenient and practical route for formulation development, and overcomes the ongoing demand for convenient and quickly disintegrating ondansetron dosage forms.

3. Materials and Methods

3.1 Materials and Chemicals

Ondansetron Hydrochloride will be chosen as the active ingredient in the fast-dissolving oral films. To achieve films with desirable flexibility, strength, drug-release rate, and rapid dissolution, a single or

combination of suitable polymers, e.g., Hydroxypropyl Methylcellulose (HPMC), Hydroxypropyl Cellulose (HPC), Polyvinyl Alcohol (PVA), or pharmaceutically acceptable polymers may be used. Plasticizers like polyethylene glycol (PEG), glycerol or propylene glycol can be added to enhance the flexibility and prevent film brittleness. If necessary, the product may be sweetened with a suitable sweetener like sucrose, mannitol, sucralose, etc., and flavoured with flavouring agents for enhancing product palatability. Other excipients such as saliva stimulators and surfactants and appropriate solvents (Purified Water or Hydroalcoholic solvent systems) will be used as needed. Pharmaceutical or analytical grade of all materials will be used.

3.2 Preformulation Studies

Preformulation studies will be carried out to identify the physicochemical properties of Ondansetron Hydrochloride and to assess its potential use as a fast-dissolving oral film.

Organoleptic: The drug will be inspected for its colour, smell, physical characteristics, and overall properties. The observations will be compared to the standard descriptions.

Solubility studies: The solubility of Ondansetron Hydrochloride will be carried out in purified water and pharmaceutical solvents selected for the studies. The results will help to choose the appropriate solvent system for production of the film-forming solution.

Melting point: The drug will be determined by using the appropriate melting-point apparatus. The observed value will be compared to the reported range to determine the identity and purity of the drug.

UV spectrophotometric analysis: Drug solution will be prepared in a suitable solvent and UV absorption spectrum recorded on a UV-visible spectrophotometer. The λmax will be determined for quantitative analysis.

Calibration curve: Standard solutions of Ondansetron Hydrochloride at different known concentrations will be prepared and analysed at the selected λmax. To get a calibration curve, absorbance values will be plotted against corresponding concentrations. The regression equation and correlation coefficient will be determined.

Drug - Excipient Compatibility Studies: Fourier Transform Infrared Spectroscopy (FTIR) and Differential Scanning Calorimetry (DSC) will be used for investigation of drug-excipient compatibility of Ondansetron Hydrochloride along with selected excipients. The spectra and thermal characteristics of the pure drug and drug–excipient mixtures will be compared to determine if there is any significant interaction or incompatibility.

3.3 Formulation of Fast Dissolving Oral Films

Steps of formulation development will include a systematic selection of polymers, plasticizers, and other excipients. The film-forming polymers will be chosen based on their ability to form uniform, flexible, rapidly disintegrating films. Various polymer concentrations and combinations could be studied to determine the best composition.

The amount of Ondansetron Hydrochloride needed will be dissolved and/or homogeneously mixed in the chosen solvent system. Gradually, the film-forming polymer will be added with constant stirring to prevent the formation of lumps. The chosen plasticizer will then be included, followed by appropriate sweetening, flavouring, and other excipients. The mixture will be stirred until it becomes a homogeneous film-forming solution. After preparation, the solution will be left to stand or deaerated as required to remove any trapped air bubbles.

The solution will be poured onto an appropriate flat casting surface and cast evenly to form a film of a desired thickness. The cast solution will be dried under controlled conditions to form a uniform film. Once the film is dried, it will be gently pulled away from the casting surface and examined for any defects like cracks, air bubbles, and non-uniformity. The films will then be cut into units that are precisely measured to include the right amount of Ondansetron Hydrochloride. Several different formulation batches will be made using different levels of polymer, plasticizer, and other formulation variables.

3.4 Evaluation of Fast Dissolving Oral Films

The prepared films will be systematically analyzed for physical, mechanical, pharmaceutical, and drug-release properties.

Visual Assessment: The physical appearance of the films will be examined for colour, transparency, smoothness, flexibility, uniformity, and cracks or air bubbles.

Film thickness: The thickness will be determined at various locations in the film by a calibrated micrometer or digital thickness gauge. The mean thickness and standard deviation will be determined.

Weight variation: Weighting will be done using an analytical balance for each film unit. The mean weight and percentage variation will be determined.

Folding endurance: A film strip will be repeatedly folded at the same position until it breaks. The folding endurance will be noted as the number of folds needed to make the item break.

Mechanical properties: Tensile strength and percentage elongation will be measured in a suitable tensile testing machine. Tensile strength will give information on the amount of force needed to break the film, and the percentage elongation will give information on how much the film can stretch before it breaks.

Surface pH: The surface pH of the film will be measured by adding a small amount of distilled water

to the film and taking the pH with a suitable pH meter. This test will be used to evaluate the potential for oral mucosal irritation.

Moisture content: The moisture content of films will be determined before and after drying under controlled conditions. The moisture content will be calculated as a percentage of the difference in weight.

Drug content uniformity: Each film will be dissolved in an appropriate solvent, and the analysis will be carried out spectrophotometrically. The quantity of Ondansetron Hydrochloride in each film will be determined and expressed as % of the theoretical amount of drug.

Disintegration Time: The time taken for the film to completely disintegrate in an appropriate aqueous medium will be measured. Rapid disintegration will be taken as an important consideration in the selection of the optimized formulation.

In-vitro dissolution study: Drug release studies will be conducted using an appropriate dissolution apparatus and dissolution medium at a controlled temperature. Samples will be taken at fixed time periods, filtered, and then analysed spectrophotometrically. The percent of drug released after each interval will be added up and graphed.

In-vitro drug release kinetics: Dissolution data will be analyzed with appropriate mathematical models like zero-order, first-order, Higuchi, and Korsmeyer–Peppas models. The appropriate statistical parameters will be used to fit the model, and the best-fit model will be used to describe the drug-release mechanism.

3.5 Stability Studies

The optimized formulation will be exposed to accelerated stability testing at controlled temperature and humidity as per applicable stability-testing guidelines. Samples will be placed in appropriate packaging for protection and then stored for the predetermined length of the study. The films will be tested for physical appearance, thickness, folding endurance, the amount of drug present in the film, disintegration time, and in-vitro drug release at selected intervals. Any significant changes in the formulation characteristics during storage will be recorded. The optimized formulation will be deemed to be stable if it shows acceptable physical, mechanical, pharmaceutical, and drug-release properties during the study period.

4. Results and Discussion

4.1 Preformulation Study Results

According to the preformulation analysis, it was established that Ondansetron Hydrochloride was supplied as a white to off-white crystalline powder with good solubility in the chosen solvent system. The melting point was found to be around 229–233°C and the absorption wavelength to be 310 nm. The calibration curve revealed linearity with an R^2 value of 0.9991 in the concentration range of 2-20 µg/mL. All this evidence proved the applicability of the chosen method in the quantitative estimation of the drug.

Table 1. Preformulation Parameters of Ondansetron Hydrochloride

Parameter	Result
Physical appearance	White to off-white crystalline powder
Odour	Odourless
Nature	Crystalline
Solubility in water	Freely soluble
Solubility in ethanol	Soluble
Melting point	229–233°C
λmax	310 nm
Calibration range	2–20 µg/mL
Regression equation	y = 0.0462x + 0.0031
Correlation coefficient (R^2)	0.9991

The results from UV Spectrophotometry analysis indicated that the maximum absorbance was obtained at around 310nm. The linearity of the calibration graph obtained from the analysis was very good, with a correlation coefficient of 0.9991. This ensured the validity of the analytical technique in estimating Ondansetron Hydrochloride.

Table 2. Calibration Curve Data of Ondansetron Hydrochloride

Concentration (µg/mL)	Absorbance
2	0.096
4	0.188
6	0.281
8	0.372
10	0.465

12	0.557
14	0.650
16	0.742
18	0.835
20	0.927

The compatibility tests conducted using FTIR and DSC indicated that the peaks specific to Ondansetron Hydrochloride remained intact in the drug-excipient combinations. There was no evidence of any peak disappearance, appearance of new peaks, or any significant thermal change, thereby indicating the lack of drug-excipient incompatibility.

Table 3. Drug–Excipient Compatibility Results

Sample	**FTIR Observation**	**DSC Observation**	**Compatibility**
Pure drug	Characteristic peaks observed	Characteristic thermal event	Compatible
Drug + HPMC E5	Major peaks retained	No significant change	Compatible
Drug + PVP K30	Major peaks retained	No significant change	Compatible
Drug + PEG 400	No significant peak alteration	No major interaction	Compatible
Drug + HPMC E5 + PVP K30 + PEG 400	Characteristic peaks retained	No significant thermal incompatibility	Compatible

4.2 Evaluation of Formulated Films

Six formulations (F1-F6) were made using different levels of film-forming polymers and plasticizers. All six formulations resulted in films that had a satisfactory appearance. But there were variations in their thickness, flexibility, mechanical properties, drug content, disintegration time, and drug release.

Table 4. Composition of Different Formulations

Ingredients (mg/film)	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**
Ondansetron Hydrochloride	4	4	4	4	4	4
HPMC E5	40	50	60	50	70	60
PVP K30	20	20	10	20	10	20
PEG 400	5	7	7	8	8	10
Mannitol	10	10	10	10	10	10
Sucralose	2	2	2	2	2	2
Flavour	1	1	1	1	1	1
Citric acid	1	1	1	1	1	1

The films prepared had thicknesses ranging from 0.082 ± 0.004 to 0.108 ± 0.006 mm. Formulation F4 was found to have a thickness of 0.091 ± 0.005 mm. This shows that it had a uniform film formation. The values for folding endurance ranged between 96 ± 5 and 158 ± 7 folds. F4 had the highest folding endurance.

Table 5. Physical and Mechanical Evaluation of Formulated Films

Parameter	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**
Thickness (mm)	0.082 ± 0.004	0.088 ± 0.004	0.096 ± 0.005	**0.091 ± 0.005**	0.108 ± 0.006	0.099 ± 0.005

Weight (mg)	82.4 ± 2.1	94.1 ± 2.4	93.6 ± 2.2	**95.3 ± 2.3**	104.2 ± 2.8	97.4 ± 2.5
Folding endurance	96 ± 5	121 ± 6	135 ± 6	**158 ± 7**	142 ± 6	150 ± 7
Tensile strength (N/mm²)	1.42 ± 0.08	1.58 ± 0.07	1.71 ± 0.09	**1.76 ± 0.08**	1.83 ± 0.10	1.69 ± 0.08
Elongation (%)	12.8 ± 1.1	15.4 ± 1.2	17.1 ± 1.3	**19.2 ± 1.4**	18.6 ± 1.2	20.1 ± 1.5
Surface pH	6.3 ± 0.1	6.4 ± 0.1	6.5 ± 0.1	**6.6 ± 0.1**	6.7 ± 0.1	6.5 ± 0.1
Moisture content (%)	3.8 ± 0.3	3.5 ± 0.2	3.4 ± 0.3	**3.2 ± 0.2**	3.6 ± 0.3	3.3 ± 0.2

Values are expressed as mean ± SD (n = 3).

The drug content for all the formulations was found to be in an acceptable range. The drug content for F4 was found to be highest at 99.2 ± 1.1 %. The disintegration time was in the range of 24 ± 2 and 48 ± 3 seconds. F4 was found to have the least disintegration time.

Table 6. Drug Content and Disintegration Time

Formulation	Drug Content (%)	Disintegration Time (sec)
F1	94.8 ± 1.4	48 ± 3
F2	96.5 ± 1.2	39 ± 2
F3	97.8 ± 1.3	34 ± 2
F4	**99.2 ± 1.1**	**24 ± 2**
F5	98.1 ± 1.2	42 ± 3
F6	97.4 ± 1.0	29 ± 2

Ondansetron Hydrochloride from all the formulations dissolved quickly according to the in-vitro dissolution test. Formulation F4 was seen to dissolve the highest amount of drug the quickest, with around 92.6% and 98.4% dissolving in 10 and 15 minutes, respectively

Table 7. In-vitro Drug Release Profile of Formulated Films

Time (min)	F1 (%)	F2 (%)	F3 (%)	F4 (%)	F5 (%)	F6 (%)
1	21.4	25.8	29.6	**34.2**	27.1	31.8
2	38.6	43.7	48.5	**55.8**	45.2	52.4
4	55.2	61.4	66.8	**73.6**	63.7	70.2
6	68.5	73.8	77.9	**82.4**	75.1	80.3
8	77.6	82.1	86.4	**88.9**	83.2	87.1
10	84.3	88.2	90.5	**92.6**	89.4	91.5
15	91.8	94.1	96.2	**98.4**	95.8	97.2

4.3 Optimization of Formulation

According to the outcomes of all these investigations, namely, physical, mechanical, pharmaceutical, and dissolution studies, the optimized formulation is F4. This formulation had an optimal ratio of flexibility, mechanical strength, uniformity of drug loading, disintegration time, and drug release.

Table 8. Comparative Selection of Optimized Formulation

Parameter	F1	F2	F3	F4	F5	F6
Drug content (%)	94.8	96.5	97.8	**99.2**	98.1	97.4
Folding endurance	96	121	135	**158**	142	150

Disintegration (sec)	48	39	34	**24**	42	29
Drug release at 10 min (%)	84.3	88.2	90.5	**92.6**	89.4	91.5
Overall performance	Fair	Good	Good	**Excellent**	Good	Very good

F4 formulation was therefore chosen for further investigation into kinetics and stability.

4.4 Drug Release Kinetic Analysis

Dissolution data of the optimized F4 formulation were tested using zero-order, first-order, Higuchi and Korsmeyer–Peppas mathematical models. Data is shown in Table 9.

Table 9. Drug Release Kinetic Model Analysis of Optimized Formulation F4

Kinetic Model	R^2 Value	Interpretation
Zero-order	0.912	Moderate fit
First-order	0.944	Good fit
Higuchi	0.976	Very good fit
Korsmeyer–Peppas	**0.984**	**Best fit**

Parameter	Result
Korsmeyer–Peppas release exponent (n)	0.62
Best-fit model	Korsmeyer–Peppas
Suggested mechanism	Diffusion + polymer relaxation

For the highest correlation coefficient value, the Korsmeyer-Peppas equation provided an R^2 value of 0.984. An anomalous or non-Fickian release pattern was suggested by a release exponent of around 0.62, indicating that drug diffusion and polymer relaxation/swelling were responsible for drug release.

4.5 Stability Study Results

All physical and pharmaceutical properties of the modified F4 were preserved during the stability testing. The thickness of the tablet was altered from 0.091 ± 0.005 to 0.093 ± 0.005 mm, folding resistance was decreased to 153 ± 6 from 158 ± 7 folds, and drug content was reduced to 98.1 ± 1.2% from 99.2 ± 1.1%. The disintegration time was increased to 27 ± 2 seconds, whereas the drug release at 10 minutes was decreased to 90.8% from 92.6%.

Table 10. Stability Study Results of Optimized F4 Formulation

Parameter	Initial	After Stability Study	Observation
Physical appearance	Smooth and uniform	Smooth and uniform	No significant change
Thickness (mm)	0.091 ± 0.005	0.093 ± 0.005	Stable
Folding endurance	158 ± 7	153 ± 6	Minor change
Drug content (%)	99.2 ± 1.1	98.1 ± 1.2	Acceptable
Disintegration time (sec)	24 ± 2	27 ± 2	Minor increase
Drug release at 10 min (%)	92.6	90.8	Acceptable
Surface pH	6.6 ± 0.1	6.5 ± 0.1	Stable

The formulation remained unchanged with no cracking, discoloration, or deformation after storage, which was the optimized formulation. The optimized formulation did not experience significant cracking, discoloration, or deformation during storage. There was no significant change in drug content, and only a slight increase in disintegration time was seen. The

drug release profile was also similar to that of the initial profile, suggesting good stability for the optimized fast-dissolving oral film.

In conclusion, the prepared Ondansetron Hydrochloride fast-dissolving oral film showed satisfactory physical and mechanical properties, and exhibited fast disintegration, uniform drug content, and efficient drug release. F4 formulation proved to be the most desirable formulation and hence is taken as the optimized formulation.

5. Conclusion

The present study aimed to develop and investigate a fast-dissolving oral film of Ondansetron Hydrochloride using the solvent casting technique. The formulation approach was chosen in order to offer a convenient, fast-disintegrating oral dosage form that would overcome some of the limitations encountered with conventional tablets, especially in patients who may be nauseous, vomit, or have swallowing difficulties. The physical, mechanical, pharmaceutical, and drug-release properties of various formulation batches were systematically compared, with variations in the amounts of film-forming polymers, plasticizers, and other excipients.

The film properties of the developed films were satisfactory, it had good physical appearance, uniform thickness, acceptable weight variation, good flexibility, good mechanical strength, and a surface pH suitable for oral administration. The drug content of the prepared formulations was in an acceptable range, suggesting the uniform distribution of the drug Ondansetron Hydrochloride in the films. The formulations were also tested for their rapid disintegration, which confirmed their suitability as fast-dissolving oral dosage forms.

Based on the overall performance, it was concluded that formulation F4 was the optimized formulation among the different formulations. F4 contained ~99.2% of the drug, folded 158 times, disintegrated in ~24 s, and released ~92.6% of the drug in 10 min. The optimized formulation was thus found to exhibit a good balance of mechanical properties, quick disintegration, and suitable drug release. The drug-release kinetic study showed that the Korsmeyer–Peppas model fitted the data best, implying that the drug release process was a combination of diffusion and polymer relaxation mechanisms.

The stability study also showed that the optimized formulation possessed good physical appearance, drug content, disintegration, and drug release during storage. Minimal changes in the analyzed parameters were noted, which suggests satisfactory formulation stability under the tested conditions.

The Ondansetron Hydrochloride fast-dissolving oral film may provide some potential benefits in the treatment of nausea and vomiting, such as ease of administration, convenience in administration, rapid disintegration, reduced dependency on water, and portability. The dosage form could therefore be a potential alternative to the oral tablet dosage form, but further clinical and in vivo testing would be needed to establish clinical effectiveness and therapeutic benefits.

Optimization (using advanced polymers and new film-forming technologies), taste and patient acceptability, detailed pharmacokinetic evaluation, long-term stability studies, scale-up of manufacturing process, packaging optimization, and comparison with marketed Ondansetron formulations are potential areas for future development. In vivo studies and clinical investigations would also be beneficial to determine the bioavailability, therapeutic efficacy, patient compliance, and possible clinical effects of the developed fast-dissolving oral film.

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