RESEARCH PAPER

Orally Disintegrating Films of Madhulai Manapagu (Punica granatum L.) for Paediatric Emesis and Oncology-Supportive Care: Development, Optimization and Phytopharmaceutical Evaluation

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ABSTRACT

Background: Traditional Siddha herbal formulations are widely used for gastrointestinal disturbances, yet conventional syrup dosage forms may limit patient compliance, particularly among children experiencing emesis and patients undergoing chemotherapy who frequently present with nausea, vomiting, and swallowing difficulties. Madhulai Manapagu, a Punica granatum L.–based formulation, offers therapeutic potential but requires modernization into patient-centric delivery systems.

Purpose: To develop and optimize an orally disintegrating film (ODF) incorporating Madhulai Manapagu and evaluate its physicochemical, analytical, and morphological characteristics as a translational phytopharmaceutical dosage form.

Methods: Lyophilized Madhulai Manapagu was incorporated into polyvinyl alcohol–based films using a solvent casting technique. A statistical experimental design was employed to optimize formulation variables. Films were evaluated for thickness, weight variation, disintegration time, in-vitro dissolution, surface morphology, and phytochemical integrity using UV spectroscopy, Analytical validation of phytoconstituent integrity was supported by λmax determination at 216 nm, HPTLC fingerprint profiling across multiple wavelengths, and FTIR spectral comparison confirming physicochemical compatibility within the polymeric matrix.

Results: Optimized films exhibited rapid disintegration (~40 s), uniform drug distribution, acceptable mechanical properties, and efficient release behavior. Analytical studies confirmed preservation of phenolic and flavonoid constituents without significant interactions between formulation components.

Conclusion: The developed orally disintegrating films provide a patient-friendly phytopharmaceutical platform with potential relevance for pediatric emesis management and supportive care during chemotherapy. These findings support the modernization of Siddha formulations through advanced drug-delivery technologies, while future clinical investigations are required to establish therapeutic outcomes.

Keywords: *Punica granatum; Madhulai Manapagu; orally disintegrating films; pediatric emesis; chemotherapy supportive care; herbal drug delivery*

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1. INTRODUCTION

Herbal and traditional medicine systems continue to contribute significantly to global healthcare, particularly in gastrointestinal disorders [1,2] where patient tolerance and safety are critical considerations. Despite their widespread use, many classical herbal formulations remain confined to conventional dosage forms that limit dosing precision, stability, and patient adherence. The development of modern phytopharmaceutical delivery platforms represents an important strategy to bridge traditional knowledge with contemporary pharmaceutical science, enabling improved usability in sensitive populations such as pediatric patients and individuals undergoing chemotherapy.

Madhulai (*Punica granatum* L.) is a medicinally important plant widely recognized for its antioxidant, gastroprotective, anti-inflammatory, and haematinic properties [3-5]. In the Siddha system of medicine, Madhulai Manapagu, a syrup-based formulation prepared using pomegranate juice along with honey and sugar candy, is traditionally prescribed for iron-deficiency anaemia and gastrointestinal complaints such as nausea

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and vomiting [6]. Despite its therapeutic relevance, the conventional syrup dosage form is associated with drawbacks including high viscosity, poor dose accuracy, reduced stability, and limited acceptability among pediatric and geriatric patients.

Orally disintegrating films (ODFs) have emerged as an advanced solid oral dosage form designed to disintegrate rapidly in the oral cavity without the need for water. ODFs offer several advantages over conventional solid and liquid formulations, including ease of administration, improved patient adherence, accurate dosing, and rapid onset of action [7-9]. These attributes make ODFs particularly suitable for herbal formulations intended for vulnerable patient populations.

The present study was therefore undertaken to develop and optimize orally disintegrating films incorporating Madhulai Manapagu as a novel phytopharmaceutical delivery system. By integrating traditional Siddha medicine with modern formulation science, this work aims to enhance the clinical usability and translational potential of a classical herbal formulation.

The rapid disintegration and ease of administration associated with orally disintegrating films may be particularly advantageous for pediatric populations experiencing emesis, where swallowing conventional dosage forms become difficult. Herbal formulations derived from *Punica granatum* have traditionally been regarded as well tolerated, suggesting potential applicability in sensitive patient groups. Furthermore, patient-friendly dosage systems that do not require water may offer supportive benefits in individuals undergoing chemotherapy who frequently experience nausea, vomiting, and dysphagia, although dedicated clinical studies are required to confirm such applications.

1.1 Translational significance:

The modernization of traditional Siddha formulations into advanced drug-delivery systems represents an important step toward their integration into contemporary phytopharmaceutical practice. By converting Madhulai Manapagu into an orally disintegrating film, the present work explores a patient-centric approach that may improve administration in populations with swallowing difficulties, including children experiencing emesis and patients undergoing chemotherapy. Such dosage platforms have the potential to enhance adherence, enable standardized dosing, and support the development of evidence-based herbal therapeutics. The current investigation therefore provides a translational framework linking traditional medicinal knowledge with modern pharmaceutical design principles, encouraging further clinical and pharmacological validation.

2. MATERIALS AND METHODS

2.1 Materials

Madhulai Manapagu was prepared from an GMP certified Pharmacy. Polyvinyl alcohol was used as the primary film-forming polymer, along with suitable plasticizers and excipients of pharmaceutical grade. All reagents used for analytical studies were of analytical grade.

2.2 Preparation of Lyophilized Madhulai Manapagu

The syrup formulation was subjected to lyophilization to obtain a free-flowing solid suitable for incorporation into film matrices. The resulting powder was stored in airtight containers until further use.

2.3 Formulation of Orally Disintegrating Films

Orally disintegrating films were prepared using the solvent casting technique. Accurately weighed quantities of polymer and excipients were dissolved in distilled water, followed by incorporation of lyophilized Madhulai Manapagu. The homogeneous dispersion was cast onto glass plates and dried under controlled conditions. Dried films were peeled off and cut into uniform dimensions. The overall workflow for preparation and optimization of Madhulai Manapagu orally disintegrating films is illustrated in **Figure 1**.

Figure 1. Schematic representation of preparation and optimization of Madhulai Manapagu orally disintegrating films.

2.4 Response surface methodology (RSM)–based optimization

A response surface methodology (RSM) approach was employed to optimize the formulation variables influencing disintegration performance of Madhulai Manapagu orally disintegrating films. Polymer concentration (polyvinyl alcohol, factor A) and disintegrating agent concentration (mannitol, factor B) were selected as independent variables, while disintegration time was considered the primary response parameter. Experimental runs were generated using Design-Expert® software, and a Box–Behnken experimental design was applied to evaluate interactions between formulation factors. Polynomial regression models were developed to describe the relationship between independent variables and response outcomes. Optimization criteria were defined to achieve rapid disintegration while maintaining acceptable physicochemical properties of the films.

Table 1. Independent variables and response levels used for RSM optimization.

Factor	Variable	Low (−1)	Medium (0)	High (+1)
A	Polyvinyl alcohol (g)	0.5	1.0	1.5
B	Mannitol (g)	0.25	0.50	0.75
Response	Disintegration time (s)	—	—	—

2.5 Statistical analysis and experimental design

A response surface methodology (RSM) approach employing a Box–Behnken experimental design was used to evaluate the combined influence of formulation variables on disintegration performance of orally disintegrating films. Polyvinyl alcohol concentration (factor A) and mannitol concentration (factor B) were selected as independent variables, while disintegration time was considered the primary response parameter. Experimental runs were generated using Design-Expert® software (Version 13.0.2.2, Stat-Ease Inc., USA) [10].

The experimental data were fitted to a second-order polynomial model, and analysis of variance (ANOVA) was applied to determine statistical significance of model terms and interactions. Response surface and contour plots were constructed to visualize the effect of independent variables on formulation performance. Optimization was carried out by numerical desirability function to obtain films with minimum disintegration time and acceptable physicochemical characteristics.

2.5 Evaluation of Films

Prepared films were evaluated for thickness, weight variation, surface pH, drug content uniformity, disintegration time, and in-vitro dissolution behavior using standard pharmacopeial methods. Experimental results obtained from the optimized formulation were compared with predicted values generated through the RSM model. In-vitro dissolution studies were performed using phosphate buffer (pH 6.8) under controlled agitation. Samples were withdrawn at predetermined time intervals and analyzed spectrophotometrically at 216 nm to determine cumulative release.

2.6 Phytochemical and Analytical Characterization

Lyophilized Madhulai Manapagu and optimized orally disintegrating films were subjected to comprehensive analytical characterization to evaluate phytochemical integrity and compatibility with formulation excipients. The absorbance maxima (λmax) of lyophilized Madhulai Manapagu were determined by scanning the formulation in phosphate buffer solution (pH 6.8) over the wavelength range of 200–400 nm using a UV–visible spectrophotometer. The spectrum exhibited a characteristic peak at 216 nm, which was selected for subsequent quantitative analysis and in-vitro dissolution studies.

A standard calibration curve for Madhulai Manapagu was constructed by preparing serial dilutions in phosphate buffer (pH 6.8) and measuring absorbance at 216 nm. A linear relationship between concentration and absorbance was obtained, confirming suitability for spectrophotometric estimation of drug content and release behavior.

Quantitative phytochemical analysis was performed to estimate total phenolic, flavonoid, and tannin content using standard spectrophotometric methods with gallic acid, quercetin, and tannic acid as reference standards, respectively.

High-performance thin-layer chromatography (HPTLC) fingerprinting was carried out on silica gel plates using an optimized mobile phase system. Plates were scanned at 254 nm and 366 nm, followed by derivatization with vanillin–sulphuric acid and scanning at 520 nm to visualize characteristic phytoconstituent bands.

Fourier transform infrared (FTIR) spectroscopy was employed to assess potential interactions between polyvinyl alcohol and phytoconstituents of Madhulai Manapagu by comparing characteristic functional group vibrations of individual components and optimized films.

2.7 Surface Morphology

Surface morphology of the optimized films was examined using scanning electron microscopy.

3. RESULTS

3.1 Physicochemical characteristics of lyophilized Madhulai Manapagu

Lyophilization of Madhulai Manapagu produced a free-flowing hygroscopic powder suitable for incorporation into polymeric film matrices. The lyophilisate retained characteristic phytochemical properties, confirming its stability during processing and suitability for film formulation.

3.2 Film formation and physical evaluation

All orally disintegrating film formulations were smooth, flexible, and translucent, indicating uniform polymer dispersion and successful solvent casting. Film thickness, weight variation, and surface pH were within acceptable limits, suggesting good formulation reproducibility. The composition of various formulations is presented in Table 2, while physicochemical evaluation results are summarized in Table 3 and Figure 2

Table 2. Composition of orally disintegrating film formulations of Madhulai Manapagu (Punica granatum L.)

Ingredient	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
Drug (g)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Polyvinyl alcohol (g)	0.20	0.40	0.50	0.75	1.00	1.25	1.50	1.00	2.00	2.50
Mannitol (g)	0.10	0.13	0.15	0.20	0.25	0.35	0.40	0.50	0.60	0.75
Citric acid (mg)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Glycerine (mL)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Water (mL)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0

Table 3. Physicochemical evaluation of Madhulai Manapagu orally disintegrating film formulations (F1–F10).

Parameter	F1	F2	F3	F4	F5	F6 (Optimized)	F7	F8	F9	F10
Thickness (mm)	0.18 ± 0.01	0.19 ± 0.02	0.21 ± 0.01	0.23 ± 0.01	0.24 ± 0.02	0.22 ± 0.01	0.25 ± 0.01	0.26 ± 0.02	0.27 ± 0.01	0.28 ± 0.02
Weight variation (mg)	48.1 ± 0.7	49.3 ± 0.5	50.6 ± 0.8	52.2 ± 0.6	53.4 ± 0.4	51.8 ± 0.5	54.1 ± 0.6	55.3 ± 0.7	56.8 ± 0.5	58.2 ± 0.6
Folding endurance (times)	112 ± 3	118 ± 4	125 ± 5	132 ± 4	140 ± 3	138 ± 3	142 ± 5	150 ± 4	155 ± 3	162 ± 4
Surface pH	6.4 ± 0.1	6.5 ± 0.1	6.6 ± 0.2	6.6 ± 0.1	6.7 ± 0.2	6.7 ± 0.1	6.8 ± 0.1	6.8 ± 0.2	6.9 ± 0.1	6.9 ± 0.2
Moisture loss (%)	35.88 ± 0.09	37.14 ± 0.21	40.13 ± 0.01	42.34 ± 0.14	41.25 ± 0.17	35.75 ± 0.23	33.85 ± 0.07	31.34 ± 0.06	35.39 ± 0.11	39.89 ± 0.16
Drug content (%)	90.17 ± 1.12	87.14 ± 0.03	86.78 ± 1.07	91.27 ± 0.15	91.75 ± 0.25	98.78 ± 0.07	91.75 ± 0.23	95.95 ± 0.27	94.17 ± 0.15	92.24 ± 0.67
Disintegration time (s)	65 ± 3	58 ± 2	54 ± 2	50 ± 2	45 ± 2	40 ± 1	47 ± 2	52 ± 2	60 ± 3	68 ± 3

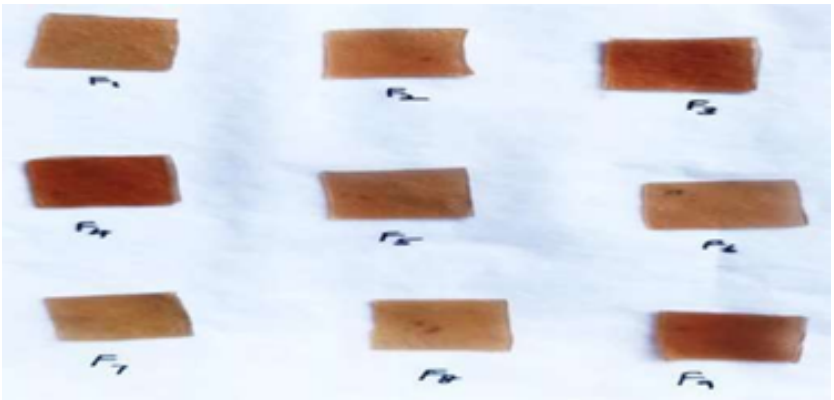


Figure 2. Orally Disintegrating Films (ODF's) of Madhulai Manapagu.

3.3 Optimization of formulation using response surface methodology (RSM)

Response surface methodology was applied to investigate the influence of polyvinyl alcohol concentration (factor A) and mannitol concentration (factor B) on film disintegration behavior. The generated polynomial model indicated that increasing polymer concentration prolonged disintegration time, whereas higher levels of mannitol promoted rapid film hydration and faster disintegration.

The interaction between formulation variables was visualized through response surface and contour plots (**Figure 3** and **Figure 4**). The optimized formulation demonstrated predicted disintegration characteristics consistent with experimental observations, confirming the

reliability of the statistical model. ANOVA results confirmed statistical significance of the developed polynomial model, indicating a strong relationship between formulation variables and disintegration performance.

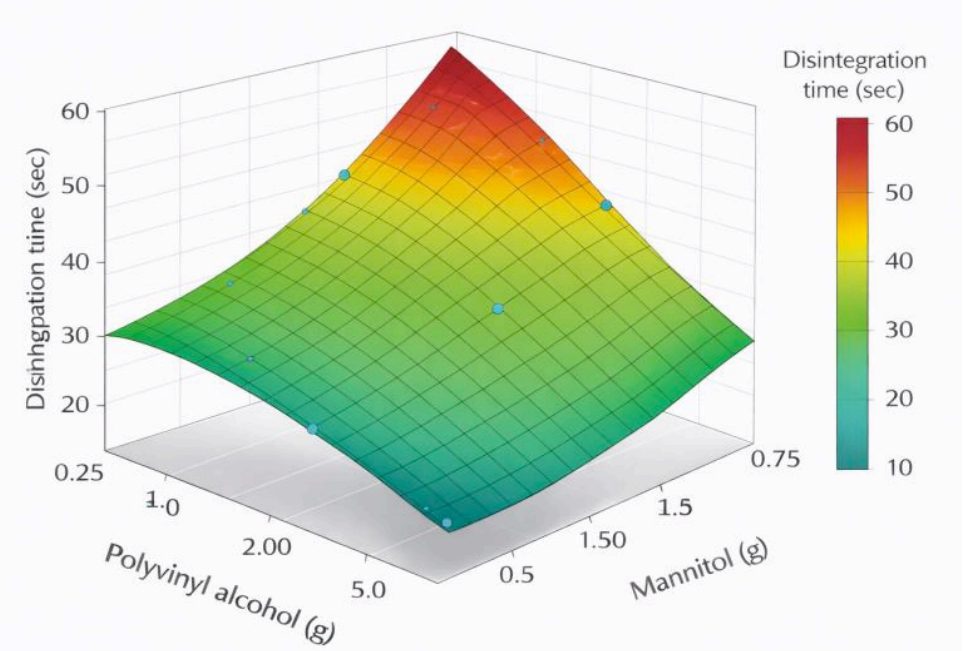


Figure 3. Response surface plot illustrating the effect of polyvinyl alcohol and mannitol concentrations on disintegration time of orally disintegrating films.

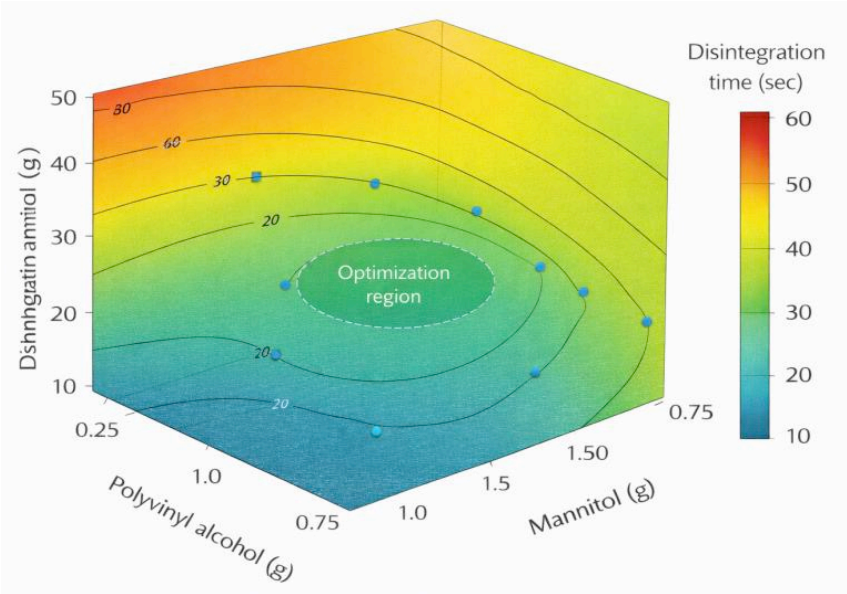


Figure 4. Contour plot showing optimization region for formulation variables influencing disintegration performance.

3.4 Disintegration time and in-vitro release behavior

Disintegration time varied across formulations depending on polymer concentration. Films containing lower polyvinyl alcohol content showed faster disintegration, while higher polymer levels resulted in increased matrix density and slower hydration. The optimized formulation exhibited rapid disintegration (~40 s), meeting criteria for orally disintegrating films. In-vitro dissolution studies demonstrated an initial rapid release phase followed by complete release, indicating efficient matrix erosion. The optimized formulation exhibited rapid release behavior with an initial burst phase followed by complete release, as illustrated in Figure 5.

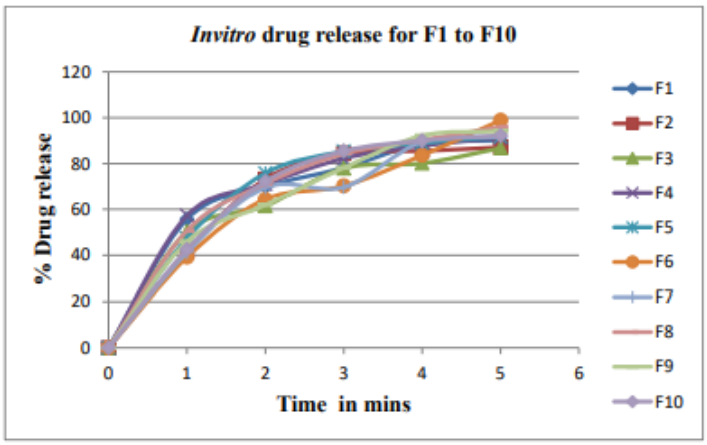


Figure 5. Determination of in-vitro release of Different formulations of Madhulai Manapagu orally disintegrating films (F1-F10)

3.5 Quantitative phytochemical analysis of lyophilized Madhulai Manapagu

Quantitative phytochemical analysis of lyophilized Madhulai Manapagu was performed to determine the concentration of major bioactive constituents prior to film formulation. The total phenolic content and total flavonoid content were estimated using standard spectrophotometric methods. The lyophilized formulation exhibited appreciable levels of phenolic and flavonoid compounds, supporting its antioxidant and gastroprotective potential. The preservation of these phytoconstituents following lyophilization confirmed that the drying process did not adversely affect the chemical integrity of the formulation. The standard calibration curves of quercetin and tannic acid showed strong linear regression behavior, enabling reliable quantification of phytochemical content. The quantitative phytochemical profile is summarized in **Table 4** and **Figure 6,7 & 8.**

Table 4. Quantitative phytochemical constituents of lyophilized Madhulai Manapagu determined using spectrophotometric methods.

Phytochemical parameter	Standard reference	Expression of result	Content
Total phenolic content	Gallic acid	mg GAE/g extract	0.95±0.06
Total flavonoid content	Quercetin	mg QE/g extract	2.77 ±0.12
Total tannin content	Tannic acid	% w/w	0.35±0.05

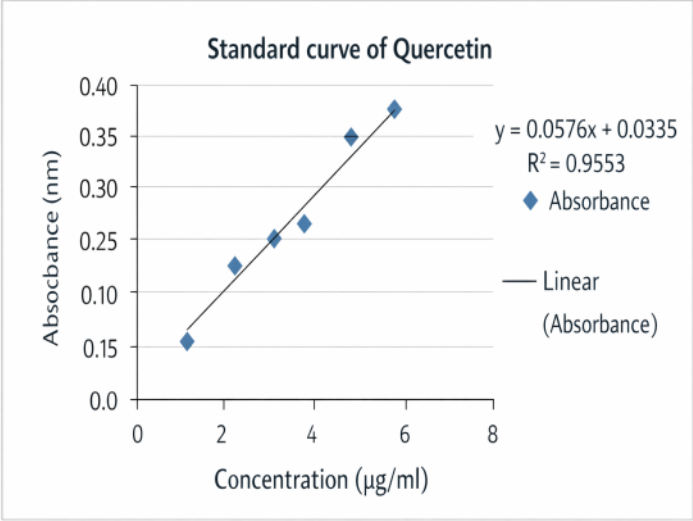


Figure 6. Calibration curve of quercetin used for determination of total flavonoid content.

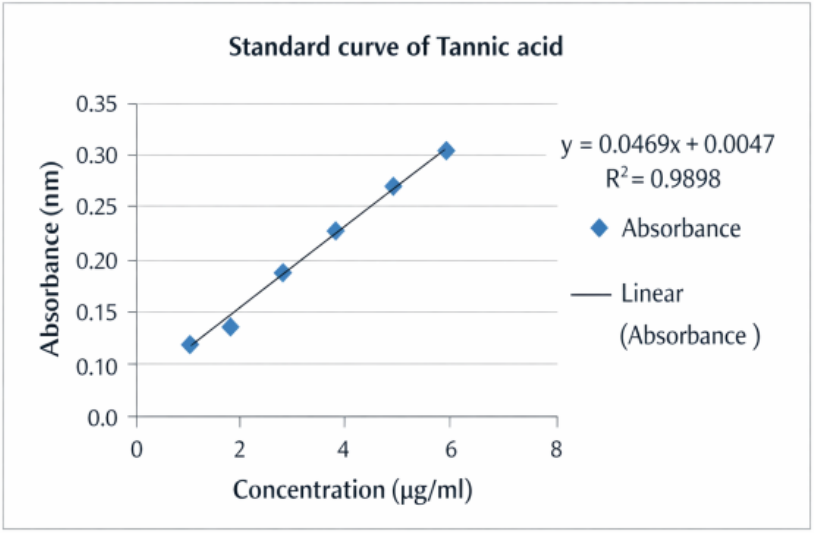


Figure 7. Calibration curve of tannic acid used for estimation of total tannin content.

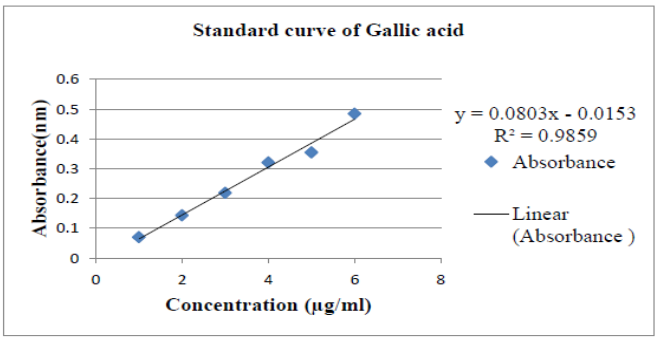


Figure 8. Calibration curve of Gallic acid used for estimation of total phenolic content.

3.6 Analytical characterization

The analytical characterization of lyophilized Madhulai Manapagu and optimized orally disintegrating films was performed using a multi-modal approach to confirm phytochemical integrity following formulation. UV spectrophotometric analysis revealed a characteristic absorption maximum (λmax) at 216 nm, indicating suitability of the formulation for quantitative analysis and dissolution monitoring. The calibration curve constructed at this wavelength demonstrated linearity across the tested concentration range, validating the spectrophotometric method employed for drug content estimation [11]. **Table 5** and **Figure 9 & 10.**

HPTLC fingerprint analysis [12] displayed well-resolved bands at 254 nm and 366 nm, while derivatization with vanillin–sulphuric acid followed by scanning at 520 nm revealed characteristic purple bands corresponding to phenolic constituents. The similarity of banding patterns between standard gallic acid and Madhulai Manapagu extract confirmed phytochemical consistency and absence of significant degradation during formulation **Figure 11**.

FTIR spectral analysis [13] demonstrated retention of key functional group vibrations, including O–H stretching and C=C vibrations, without major peak shifts in the optimized films compared with individual components. This observation indicates compatibility between polyvinyl alcohol and phytoconstituents, suggesting that the solvent casting process did not induce significant chemical interaction. FTIR spectral analysis confirmed the absence of significant chemical interactions between polyvinyl alcohol and Madhulai Manapagu, as summarized in **Table 6** and illustrated in **Figure 12 (a), (b), (c)**.

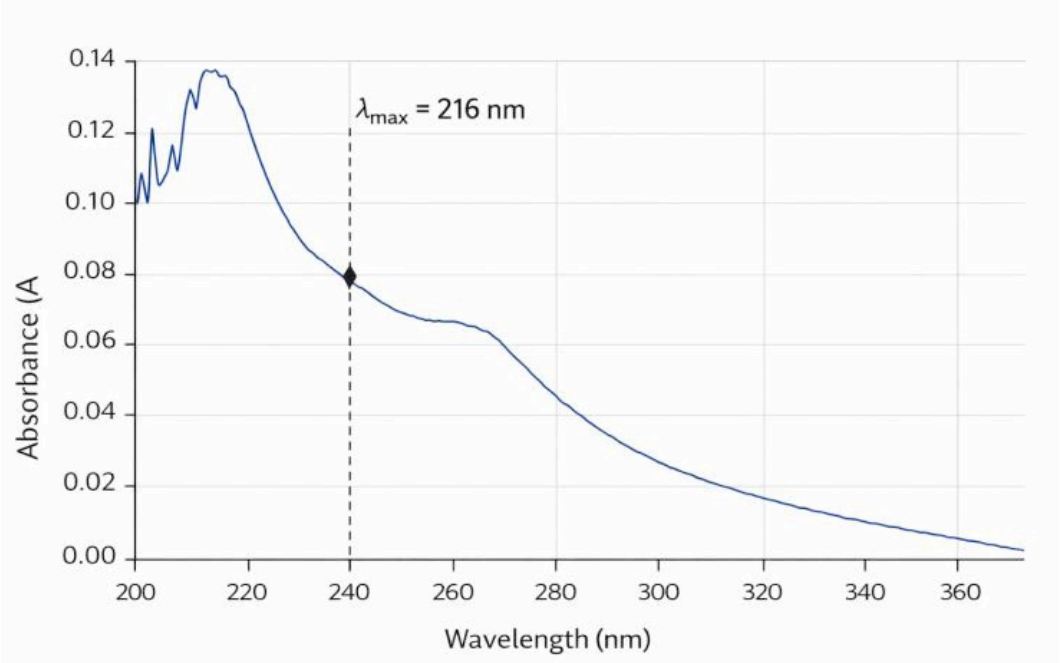


Figure 9. Ultraviolet absorption spectrum of Madhulai Manapagu in phosphate buffer solution (pH 6.8) showing λmax at 216 nm.

Table 5: Estimation of Madhulai Manapagu measured at 216 nm in phosphate buffer (pH 6.8) using UV spectrophotometry

Concentration(µg/ml)	Absorbance(nm)
1	0.032
2	0.044
3	0.059
4	0.067
5	0.1
6	0.107

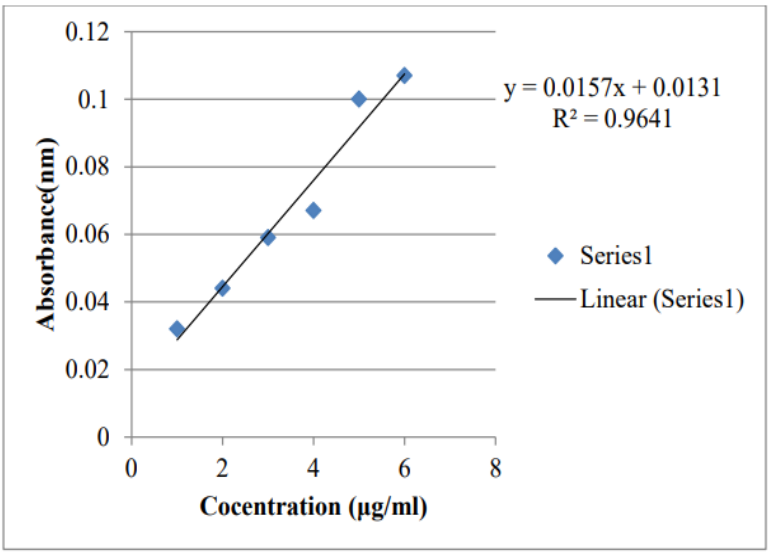
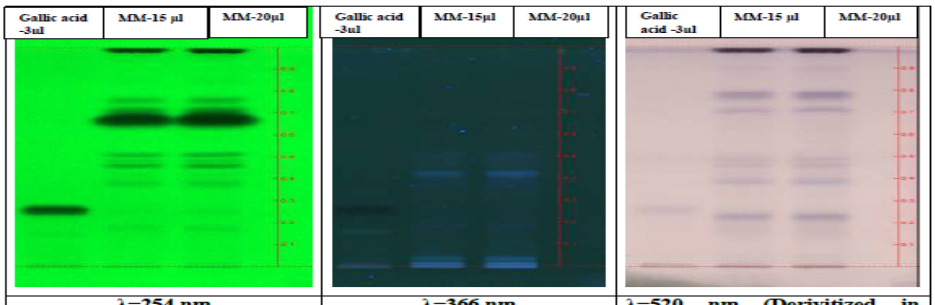
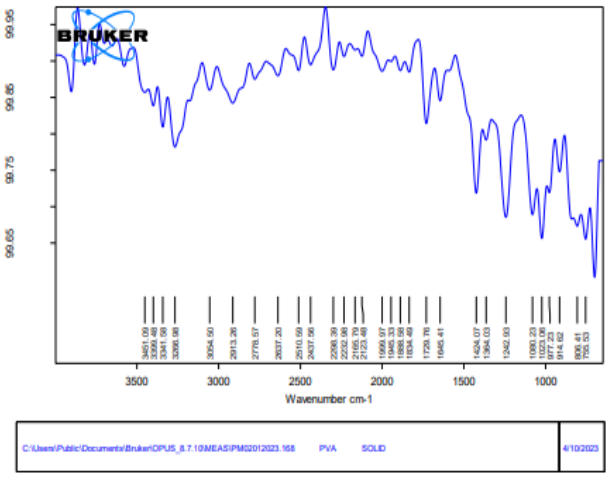


Figure 10. Calibration curve of Madhulai Manapagu in phosphate buffer solution (pH 6.8) at 216 nm showing linear relationship between concentration and absorbance.

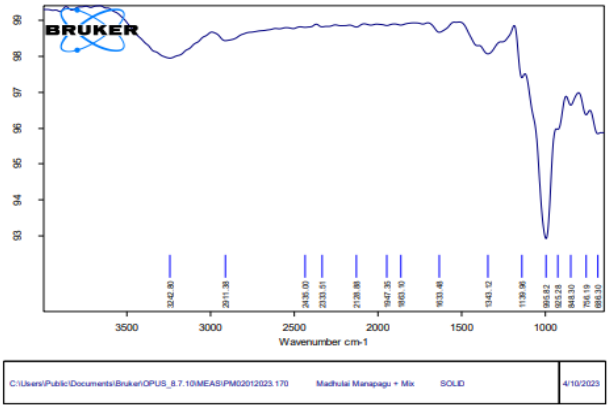


λ=254 nm				λ=366 nm				λ=520 nm (Derivitized in vanillin sulphuric acid)			
Track 1		Track 2 & 3		Track 1		Track 2 & 3		Track 1		Track 2 & 3	
R_f	Colour	R_f	Colour	R_f	Colour	R_f	Colour	R_f	Colour	R_f	Colour
0.25	Dark	0.18	Dark	0.25	Blue	0.04	Blue	0.25	Purple	0.23	Purple
		0.38	Dark			0.42	Blue			0.39	Purple
		0.46	Dark			0.51	Blue			0.46	Purple
		0.49	Dark							0.49	Purple
		0.52	Dark							0.71	Purple
		0.67	Dark							0.78	Purple
		0.72	Dark							0.90	Purple
		0.77	Dark								

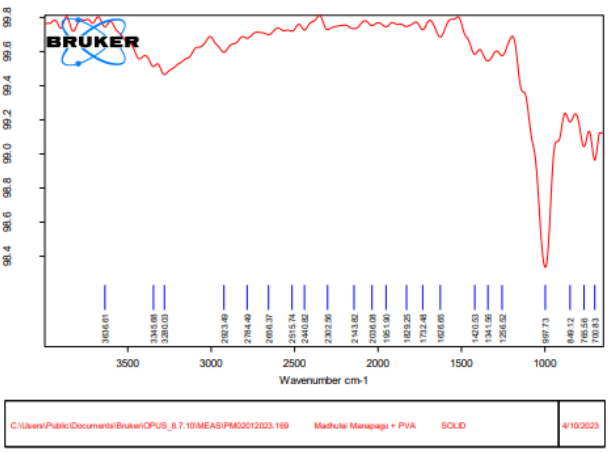
Figure 11. HPTLC fingerprint chromatograms of lyophilized Madhulai Manapagu and gallic acid standard.



12(a) FTIR spectrum of PVA



12(b) FTIR Spectrum of Madhulai Manapagu



12(c) FTIR Spectrum of Madhulai Manapagu + PVA

Figure 12. FTIR spectra of (a) polyvinyl alcohol, (b) lyophilized Madhulai Manapagu, and (c) optimized orally disintegrating film formulation.

Table 6. Characteristic FTIR bands of polyvinyl alcohol, Madhulai Manapagu, and optimized orally disintegrating film formulation.

Functional group / vibration	Polyvinyl alcohol (cm^{-1})	Madhulai Manapagu (cm^{-1})	Optimized film (PVA + Manapagu) (cm^{-1})
O–H stretching	3266.98	3242.80	3280.03
N–H / C–H stretching	2913.26	—	2923.49
C=O stretching	1729.76	—	1732.48
C=C stretching	1645.41	1633.48	1626.65
O–H bending	1424.07	1343.12	1341.56
C–N stretching	1023.06	—	—
C=C bending	—	995.82	997.73

3.7 Surface morphology

Scanning electron microscopy revealed a smooth and homogeneous film surface without cracks or phase separation (**Figure 13 (a) (b) (c)**). The uniform morphology supported rapid disintegration and consistent release behavior observed in optimized formulations.

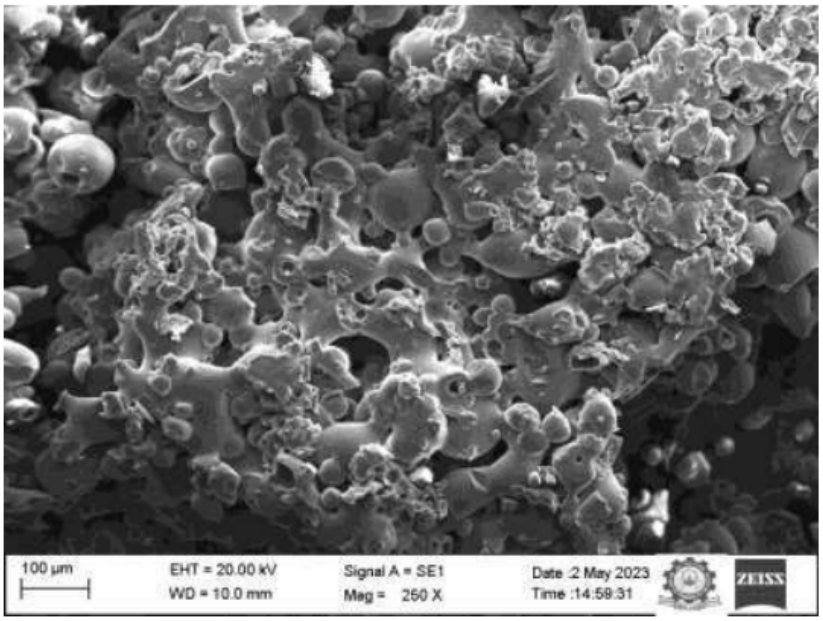


Figure 13(a). Scanning electron microscopy (SEM) image of optimized Madhulai Manapagu orally disintegrating film at 100 µm magnification showing surface morphology.

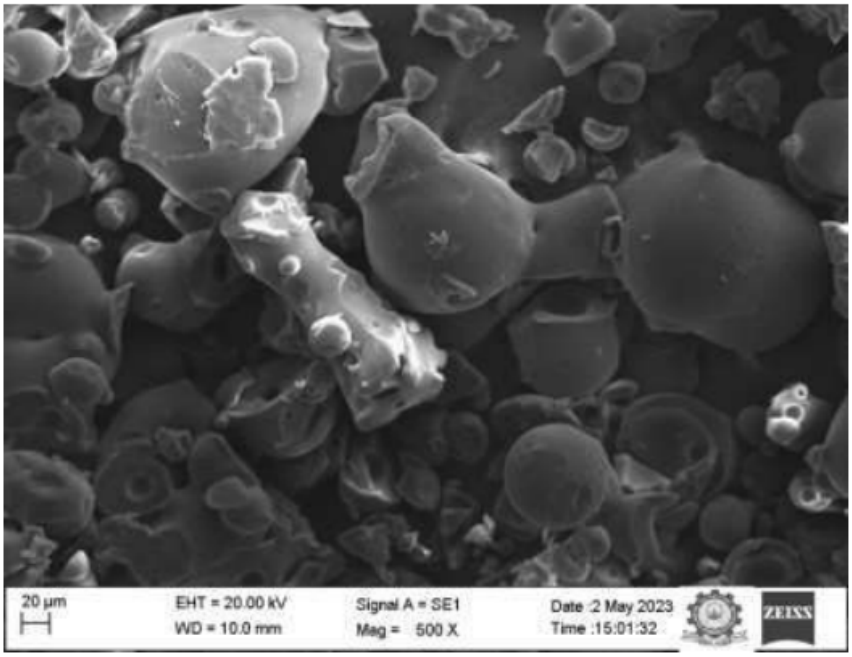


Figure 13(b). Scanning electron microscopy (SEM) image of optimized Madhulai Manapagu orally disintegrating film at 20 µm magnification illustrating surface microstructure.

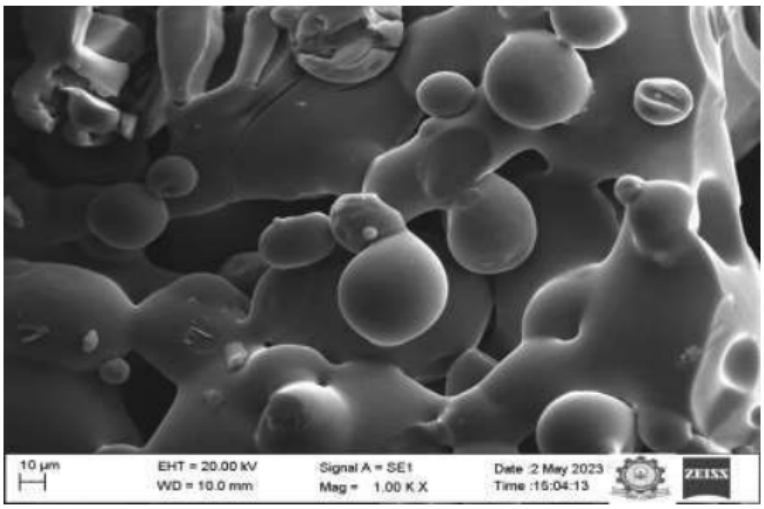


Figure 13(c). Scanning electron microscopy (SEM) image of optimized Madhulai Manapagu orally disintegrating film at 10 µm magnification showing fine surface morphology and polymer matrix distribution.

4. DISCUSSION

The present study demonstrates the successful transformation of Madhulai Manapagu, a classical Siddha formulation derived from Punica granatum, into an orally disintegrating film through a statistically optimized formulation strategy. Conventional herbal syrups are often associated with challenges such as dosing variability, limited stability, and reduced patient acceptability. The development of a rapidly disintegrating film offers a patient-centric alternative capable of improving administration convenience and compliance [7,8] while maintaining phytochemical integrity.

Response surface methodology employing a Box–Behnken design enabled systematic evaluation of formulation variables influencing disintegration performance. The statistical model indicated that increasing polyvinyl alcohol concentration enhanced mechanical strength but prolonged disintegration, whereas mannitol facilitated rapid hydration and matrix erosion. The close agreement between predicted and experimental

responses confirmed the robustness of the optimization approach and highlights the importance of multivariate statistical design in phytopharmaceutical formulation development [14].

Analytical characterization provided strong evidence for preservation of bioactive constituents following lyophilization and film fabrication. The UV absorption maximum observed at 216 nm enabled reliable spectrophotometric quantification and dissolution monitoring, while linear calibration behavior supported the analytical validity of the method. HPTLC fingerprint analysis revealed consistent banding patterns across multiple wavelengths, confirming retention of phenolic markers characteristic of Madhulai Manapagu. Furthermore, FTIR spectra demonstrated minimal shifts in functional group vibrations, suggesting compatibility between polyvinyl alcohol and phytoconstituents without significant chemical interaction. Together, these findings indicate that the solvent casting process preserved the structural and chemical integrity of the herbal formulation.

The optimized films exhibited rapid disintegration and favorable physicochemical properties, which are particularly advantageous for patient populations experiencing difficulty with conventional dosage forms. In pediatric emesis, rapid oral disintegration may enhance administration efficiency and reduce the likelihood of dose rejection. Similarly, patients undergoing chemotherapy frequently encounter nausea, vomiting, and dysphagia, making non-swallowable dosage forms highly desirable [15]. Although the present study does not evaluate clinical antiemetic efficacy, the combination of rapid disintegration, preserved phytochemicals, and patient-friendly design suggests potential utility as a supportive phytopharmaceutical platform.

Overall, the integration of traditional Siddha medicine with modern drug-delivery technology demonstrates the feasibility of translating classical herbal formulations into standardized, scientifically optimized dosage systems. Future investigations should focus on in-vivo performance, mucosal absorption behavior, and patient-centered clinical evaluation to further validate the therapeutic applicability of Madhulai Manapagu orally disintegrating films.

5. CONCLUSION

The present investigation successfully demonstrated the development and statistical optimization of Madhulai Manapagu orally disintegrating films using a response surface methodology approach. The optimized formulation exhibited rapid disintegration, acceptable physicochemical characteristics, and preserved phytochemical integrity, as confirmed through UV spectrophotometry, HPTLC fingerprinting, and FTIR analysis. The absence of significant physicochemical interactions between polyvinyl alcohol and herbal constituents supports the stability of the developed system.

The patient-centric nature of the rapidly disintegrating films highlights their potential as a modern phytopharmaceutical dosage platform, particularly for populations requiring easy-to-administer formulations such as pediatric patients experiencing emesis and individuals undergoing chemotherapy. While clinical efficacy remains to be established, the present work provides a translational framework for integrating classical Siddha formulations into contemporary drug-delivery strategies.

6. LIST OF ABBREVIATIONS

ODF – Orally Disintegrating Film

RSM – Response Surface Methodology

FTIR – Fourier Transform Infrared Spectroscopy

HPTLC – High Performance Thin Layer Chromatography

UV – Ultraviolet Spectroscopy

SEM – Scanning Electron Microscopy

ANOVA – Analysis of Variance

BB Design – Box–Behnken Design

PVA – Polyvinyl Alcohol

λmax – Maximum Absorption Wavelength

GAE – Gallic Acid Equivalent

QE – Quercetin Equivalent

7. HIGHLIGHTS

- Orally disintegrating films of Madhulai Manapagu were successfully developed
- Box–Behnken RSM optimized polymer and mannitol for rapid disintegration
- UV, HPTLC, and FTIR confirmed preservation of phytochemical integrity
- Optimized films showed rapid disintegration (~40 s) and uniform morphology
- Patient-centric phytopharmaceutical platform for pediatric and supportive care

8. DECLARATIONS

Ethics approval and consent to participate
Not applicable. The study did not involve humans or animals.

Consent for publication
Not applicable.

Availability of data and material
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests
The authors declare that they have no competing interests.

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Authors' contributions

Dr. M. S. Shree Devi contributed to the conceptualization of the study, formulation development, analytical evaluation, data interpretation, and manuscript drafting. **Dr. Sathiyarajeswaran P** provided scientific guidance, supervision, critical review of the manuscript, and overall validation of the research work. All authors read and approved the final manuscript.

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Plant authentication and regulatory compliance statement
Punica granatum L. used in this study was authenticated according to institutional pharmacognostic procedures. The research complied with applicable national and institutional guidelines for plant material use and did not involve protected or endangered species.

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