Original Article

Formulation Development and Optimization of Famotidine Mucoadhesive Tablets by Central Composite Design

Haranath Chinthaginjala[1,*], Mousami Bhavasar Telkar[1], Abdul Ahad Hindustan[2], Pradeepkumar Bhupalam[3]

[1]Department of Pharmaceutics, Raghavendra Institute of Pharmaceutical Education and Research, Chiyyedu, Andhra Pradesh, INDIA.
[2]Department of Industrial Pharmacy, Raghavendra Institute of Pharmaceutical Education and Research, INDIA.
[3]Department of Pharmacology, Raghavendra Institute of Pharmaceutical Education and Research, INDIA.

ABSTRACT

Objectives: The intention of present study is to formulate and optimize the famotidine mucoadhesive tablets y using Central Composite Design. **Materials and Methods:** The concentrations of *Cordia dichotoma* fruit mucilage powder (X_1) and Polyvinyl pyrrolidone (X_2) were demonstrated as independent variables. Whereas, the dependent variables were selected such as an *in vitro* Mucoadhesion Time and percentage Drug Release. The model was considered to be nonlinear and the curvature effect was significant. Hence, the study reported to Central Composite Design. By using wet granulation method, the tablets were prepared and all the formulated tablets were evaluated for its post compression parameters. **Results:** The drug and the excipients had no interaction, according to FT-IR and DSC analyses. All formulations showed Mucoadhesion Time ranging from 5 hr to 9 hr and % Drug Release in the range of 96.4% to 99.69%. The association amongst the dependent variable and independent variables was judge by using Contour plots. **Conclusion:** The outcomes indicated the efficacy of the proposed design for famotidine Mucoadhesive tablets development.

Keywords: Optimization, Central Composite Design, Drug Release, Famotidine, Muco adhesive.

INTRODUCTION

The interaction of drug delivery system with the mucous coat casing mucosal epithelial superficial and mucin fragments which can improve the continuance of dosage form at the spot of absorption is known as Mucoadhesive drug delivery system (MDDS).[1] It is a component of controlled release drug delivery systems CDDS, which falls under the category of novel drug delivery systems. For systemic and local effects, a MDDS has been designed for countless routes. It is the optimum delivery strategy for hydrophilic compounds with a high molecular weight and low solubility, such as peptides. At the site of application or absorption, extended residence time of dosage form can be achieved by the MDDS.[2] It will enhance the drug's therapeutic performance.[3] Famotidine, an anti-ulcer agent which is a selective H_2 blocker. Its absorption is rapid from stomach but on the other hand incomplete with less bioavailability. The poor bioavailability along with the less biological half-life necessitates the development of mucoadhesive formulations as a controlled release to build up its time of residence in the stomach, which can ultimately improves its bioavailability.[4] For the process or formulation optimization, one of the extensively used statistical method is Central Composite Design (CCD) which is based upon the multivariate non-linear model and it can also be used to ascertain the operating conditions and regression model equations from the suitable experiments. The

Submission Date: 10-02-2022;
Revision Date: 27-04-2022;
Accepted Date: 08-08-2022.

DOI: 10.5530/ijper.56.4.185

Correspondence:
Dr. Haranath Chinthaginjala
Department of Pharmaceutics, Raghavendra Institute of Pharmaceutical Education and Research, Chiyyedu-515721, Andhra Pradesh, INDIA.
E-mail: haranathriper@gmail.com

www.ijper.org

interactions of several variables affecting the process can also studied by using CCD.[5] It has emerged in view of optimization and detecting the finest feasible product from the ongoing batches. The current study's main goal is to use CCD to develop mucoadhesive famotidine tablets and to investigate the impact of various parameters on the responses. The independent variables were the concentrations of *Cordia dichotoma* (CDT) and Polyvinyl pyrrolidone (PVP). *In vitro* Mucoadhesion Time (MT) in addition to the percentage Drug Release (DR) was decided as responses.

MATERIALS AND METHODS

Famotidine was put forward by way of gifted sample from Waksman Selman Pharma Pvt Ltd, Anantapur, Andhra Pradesh. From SD fine chemicals, Mumbai, Polyvinyl pyrrolidone was acquired. Microcrystalline cellulose (MCC), Talc, Magnesium stearate and further elements were obtained from Loba Chemicals, Mumbai. All the above-mentioned chemicals utilized were of analytical mark.

Extraction procedure of CDT dried mucilage powder

The fruits were collected from the tree *cordia dichotoma* G. Forst in the month of June 2019 from local area of Anantapur, Andhra Pradesh, India. and was authenticated by Prof. J. Raveendra Reddy, Head, Dept of Pharmacognosy, Raghavendra institute of pharmaceutical education and research, (RIPER), Anantapur and wad identified as *Cordia dichotoma* G. Forst. Belongs to family *Boraginaceae.*

CDT dried mucilage powder was made as delineated by Pawar *et al.*, 2018.[6] The collected fruits were washed and outer covering as well as the seeds were removed and mixed with water. The mixture was stirred for 3h and was passed through muslin cloth. The resultant was precipitated by using equal volume of HCl. The obtained mucilage was dried in tray dryer overnight at 40°C. The dried mucilage was powdered with mortar and pestle and passé through sieve no.100. Dried mucilage was stored in a container.

FT-IR studies

To discover the interactions from the drug to the excipients, FT-IR spectroscopy was used. The drug and natural polymer as well as PVP are taken in small amounts and blend with KBr, compressed to form thin pellets. These are analysed using FT-IR spectrophotometer, (Bruker- alpha T, Germany) scanning from range 4000 cm^{-1} to 400 cm^{-1}.[7]

DSC studies

DSC instrument (Venchal scientifics, 412105, USA) was used to perform the DSC studies and to investigate whether the drug is compatible with the excipients. 3 mg of pure drug was gauged precisely and the combination of drug and excipients were transferred into the instrument containing aluminium crucible and operated ranging from 50°C to 300°C with an accrual of 10°C / min.[8]

Optimization by the CCD

Sigma Tech software Version 3.1 (Swaroop tech, Hyderabad, India) was used in the current research, for the design of experimentation of FMT, executing 2^2 full factorial design. The significant curvature effect was obtained and the model was noticed to be nonlinear which demonstrated to use CCD for optimization. The CDT concentration (X_1) and PVP concentration (X_2) were identified as nondependent factors and Mucoadhesion time (MT) and % Drug release (DR) were designated as outcomes were charted in Table 1 and the investigational trials were denoted in Table 2.

Preparation of FMT

The FMT were prepared by using wet granulation method. In the present composition, CTD is used as mucoadhesve polymer, PVP is used as binder, MCC is used as diluent, Talc as glidant and Magnesium stearate

Table 1: Coded variables with responses.

Factors	Actual values (mg)					Response
	-2	-1	0	+1	+2	
X1 (CDT)	25	37.5	50	62.5	75	Y1= Mucoadhesion time Y2= %Drug release
X2 (PVP)	12.5	15.625	18.75	21.875	25	

Table 2: Investigational strategy layout.

	Formulation code	Combinations	CDT (X_1) (mg)	PVP (X_2) (mg)
Factorial Design	F1	I	37.5	15.625
	F2	X_1	62.5	15.625
	F3	X_2	37.5	21.875
	F4	$X_1 X_2$	62.5	21.875
Mid point Central Composite Design	F5	Mid point	50.0	18.750
	F6	X_1 at -2L	25.0	18.750
	F7	X_1 at+2L	75.0	18.750
	F8	X_2 at -2L	50.0	12.500
	F9	X_2 at +2L	50.0	25.000

Table 3: Composition of famotidine mucoadhesive tablets (F1 – F9).

Ingredients (mg)	F1	F2	F3	F4	F5	F6	F7	F8	F9
Famotidine	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
CDT	37.5	62.5	37.5	62.5	50.0	25.0	75.0	50.0	50.0
PVP	15.625	15.625	21.875	21.875	18.75	18.75	18.75	12.5	25.0
Talc	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Mg. Stearate	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
MCC	151.875	126.875	145.625	120.625	136.250	161.250	111.250	142.50	130.0
Total weight(mg)	250	250	250	250	250	250	250	250	250

as lubricant. The required quantity of famotidine, natural polymer and other excipients were taken as per the composition tabulated in Table 3 and moved across sieve no 60. With the usage of a mortar and pestle, the drug, natural polymer, MCC were well combined. PVP (dissolved Isopropyl alcohol) was added to the above mass and mixed well to get wet mass. The obtained mass was passed through sieve no.16 to produce wet granules. The granules was subjected to drying in tray dryer at 40°C for 1hr. The dried granules were passed through sieve no.22. Magnesium stearate and talc were added to the dried granules and mixed. Finally, by employing tablet compression machine (Rimek mini press - II MT, India), the granules were compressed into tablets.[9]

Pre compression parameters

Bulk density (BD)

weighed sample was transferred into a 100mL graduating cylinder and estimated the BD.[10] The initial volume and weight are noted. It was expressed as g/cm^3.

Tapped density (TD)

TD apparatus (Electrolab ETD-1020, India) was used to measure the TD. The proportion between entire mass to the tapped volume is called as TD and is ascertained by placing a graduated cylinder containing known mass.[11] It was expressed as g/cm^3.

Angle of repose (AR)

It is defined as the maximum angle possible between the surface of the pile of the powder and the horizontal plane. It is deliberated using a formula.[12]

$$\text{Tan } \theta = h/r$$

$$\theta = \tan^{-1} h/r$$

where h is height and r is radius

Carr's index (CI)

This property in addition known as Compressibility index which is circuitously associated with the rate of flow and size of element and is determined by using following formula.[13]

$$CI = \frac{TD - BD}{TD} \times 100$$

TD is Tapped density and BD is Bulk density

Hausner's ratio (HR)

It refers to the ratio of tapped to bulk density.[14]

$$HR = \frac{TD}{BD}$$

TD is Tapped density and BD is Bulk density

Post Compression Parameters

Weight Variation test

The test was performed as per the procedure mentioned in Indian Pharmacopoeia. 20 tablets were selected at random from each formulation and weighed individually, calculated the average weight (AV) and compared the individual weight to the average weight followed by estimation of percentage deviation. Not more than two individual tablet weights deviate from the average weight by more than the percentage limit and none deviates by more than twice the percentage.[15]

Hardness (HD)

5 tablets were selected randomly and by the assistance of monsanto hardness tester (Dolphin, India) its hardness was measured.[16] It is intimated in kg/cm^2.

Friability (FR)

20 tablets were chosen and weighed before being sited in a Roche friabilator apparatus (Electrolab EF-2, India) for 4 min at 25rpm. Dedusted and reweighed the gathered tablets. The % friability was measured by via the formula.[17]

$$\%FR = \frac{w_1 - w_2}{w_1} \times 100$$

W1 and W2 are the initial and final weights

Thickness (TK)

Vernier callipers is used to measure the thickness of five tablets taken from each formulation.[18]

Drug content (DC)

10 tablets were balanced and grounded. Powder corresponding to 40mg of famotidine was liquefied in 100ml of 0.1N HCl. The content was shaken for the period of 30 min and filtered through Whatmann's filter paper. The absorbance was estimated at 265nm by using UV spectrophotometer.[19] (Shimadzu UV-1800, Japan)

Analytical Method Development

100mg of pure drug was dissolved in 100ml of 0.1N HCl which gives a concentration of 1000µg/ml. From the above solution, 10ml of solution was taken and was adjusted to 100ml with 0.1N HCl (100µg/ml). From the resulting solution, serial dilutions were made to acquire the concentrations of 2, 4, 6, 8 and 10µg/ml. The absorbance of dilutions was estimated at 265nm by using UV spectrophotometer using 0.1N HCl as blank.

Mucoadhesion Time studies

Fresh goat gastric mucosa was obtained from the slaughter house at local market of Anantapur city and cut into 3×3cm^2. Tablets were placed on mucosa by applying gentle pressure and were placed in a beaker. 100ml of 0.1N HCl was added to it, maintained at 37°C and stir up continuously for a period of 10h by magnetic stirrer at 100 rpm. The tablet detachment time was noted.[20]

Dissolution studies

The *in vitro* dissolution investigations were executed for 12 hr using 0.1N HCl as the media and a USP type 2 apparatus (Electrolab TDT-08L, India) maintained at 37±0.5°C with 50 rpm. At defined time intervals, 5ml of the sample was withdrawn and replaced with fresh dissolution medium. The samples were filtered through Whatmann filter paper and its absorbance was measured by UV spectrophotometer at 265nm and estimated the DR.[21]

Statistical Analysis and Optimization

The data collected from all of the formulations was evaluated using Sigma Tech software (version 3.1) in order to generate the research design. The best-fit model was chosen by a comparison of many statistical limitations delivered by the Sigma Tech programme. ANOVA was utilised to find notable variables' properties on response regression co-efficients. The relationship between the reliant and non-reliant limitations was further explored using contour designs. A graphical optimization method with contour plots (CP) was used to create unique formulations with the expected reports, and the MT, DR results were analysed to corroborate the theoretical prediction. For each individual responses, the relative errors (RE) (percent) were determined between the projected and investigated outcomes.

RESULTS AND DISCUSSION

As flourished in Figure 1, FT-IR study indicated no significant variations in the peaks of the medication and excipients employed in the formulation. IR bands of major functional groups of pure drug and drug with excipients were identified from the FT-IR studies. The characteristic IR bands of famotidine includes the presence of peaks at 3504 cm $^{-1}$ (N-H stretching), 1638 cm^{-1} (C=N stretching), 2935 cm $^{-1}$ (C-N stretching), 2933 cm^{-1} (C-H stretching) and 1596 cm^{-1} (C=C stretching) which remained unaltered in IR spectrum of drug with excipients. Thus, IR studies showed that there compatibility between drug with the excipients employed. The DSC studies revealed that there is no major changes in the thermograms of drug and excipients that are used in the formulation. DSC was performed to determine the interaction of drug entity with excipients. Figure 2 shows the thermal behaviour of drug and drug with excipients. Famotidine exhibited an exothermic peak at 170.3°C which is associated with the melting point of the drug and indicates the crystalline

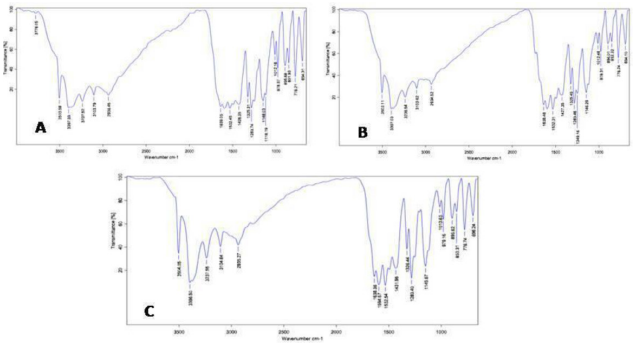


Figure 1: FT-IR spectra of A) Famotidine B) Famotidine with CDT C) Famotidine with PVP.

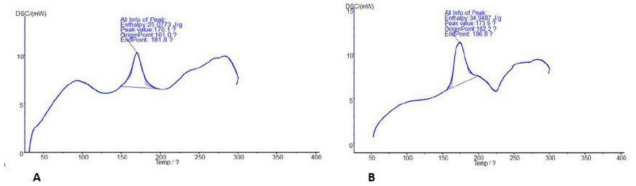


Figure 2: DSC thermograms A) Famotidine B) Famotidine with excipients.

Table 4: Precompression parameters of F1-F9 formulations.

Formulation	BD±SD*	TD±SD*	AR±SD*	CI±SD*	HR±SD*
F1	0.483±0.02	0.490±0.01	23.2±0.11	14.44±0.21	1.01±0.06
F2	0.432±0.01	0.441±0.02	24.5±0.05	12.01±0.05	1.02±0.05
F3	0.561±0.15	0.565±0.17	24.62±0.03	11.40±0.18	1.007±0.01
F4	0.496±0.13	0.498±0.03	25.01±0.08	11.65±0.14	1.004±0.02
F5	0.418±0.05	0.442±0.10	22.45±0.12	12.48±0.17	1.05±0.03
F6	0.468±0.11	0.504±0.09	24.56±0.10	11.25±0.20	1.09±0.05
F7	0.442±0.09	0.497±0.16	25.47±0.09	12.54±0.15	1.12±0.01
F8	0.412±0.07	0.426±0.10	23.45±0.05	10.56±0.08	1.03±0.07
F9	0.465±0.12	0.472±0.01	24.65±0.01	11.36±0.03	1.01±0.06

*n=3 Entire values are stated as mean±SD.

Table 5: Post compression constraints of formulations F1 – F9 formulations.

Formulation	AV±SD*	HD (kg/cm2) ±SD*	FR±SD*	TK±SD*	DC±SD*	MT (h)
F1	249±0.01	6.9±0.10	0.31±0.12	4.1±0.07	99.1±0.12	8.0±0.02
F2	252±0.04	6.0±0.15	0.42±0.19	4.5±0.06	97.5±0.55	6.0±0.10
F3	248±0.02	5.8±0.21	0.49±0.20	4.3±0.03	95.9±0.26	5.2±0.05
F4	251±0.05	6.6±0.19	0.38±0.11	4.8±0.01	98.6±0.35	7.5±0.12
F5	247±0.02	6.1±0.20	0.27±0.21	4.6±0.02	96.8±0.44	6.5±0.04
F6	252±0.01	6.8±0.17	0.34±0.12	4.1±0.05	97.1±0.19	9.0±0.01
F7	249±0.03	6.0±0.22	0.45±0.18	4.5±0.07	96.9±0.22	5.5±0.12
F8	251±0.05	5.9±0.19	0.41±0.26	4.7±0.03	95.8±0.32	5.0±0.06
F9	248±0.04	6.7±0.21	0.33±0.10	4.3±0.01	98.9±0.43	7.8±0.13

*Entire values are stated as mean±SD.

nature. The thermogram of drug with excipients showed an exothermic peak at 173.9°C revealing that there is compatibility between drug and excipients.

The AR of entire batches was differing from 23 to 25°, which indicates that the flow property was excellent. The CI of all formulations was varying from 10.56 to 12.61%, which suggests that the flow was good. HR of all formulations discovered in the series of 1.01 to 1.18, demonstrates that the flow property was good. All formulations had a percentage friability of less than 0.5 percent, indicating that the tablets were stable, and were determined to be in the interval of 0.27 to 0.49 percent, as shown in Table 4.

All the formulations were qualified the weight variation test and were within the standard limits of ±5% deviation. The DC of the manufactured tablets was measured and was originate to be between 95.8% and 99.1%. Thickness of all formulations was realized ranging from 4.1mm to 4.8mm. All formulations had a hardness of 5.8 to 6.9 kg/cm^2, confirming the satisfactory handling qualities listed in Table 5.

Table 6: Statistical investigation of DOE experimental annotations for Y_1 (MT).

Sl. No	Combination	Name of variable	Coefficient values	SS ratio
1	b_o	-	6.675	-
2	b_1	CDT	0.075	0.444%
3	b_2	PVP	-0.325	8.337%
4	b_1b_2	CDT, PVP	1.075	91.218%

SS is Sum of squares.

Mucoadhesion time (Y1)

MT (Y1) as shown in Table 6, the interaction of X1 and X2 was the most significant, with an SS ratio of 91.218 percent and a positive co-efficient sign of 1.075.

Ultimate Polynomial equation in respect of encrypted elements

$$MT\ Y_1 = 6.511 - 0.558X_1 + 0.3583X_2 + 1.075X_1X_2 + 0.1854X_1^2 - 0.0271X_2^2$$

Ultimate polynomial equation in respect of factual elements

$$MT\ Y_1 = 6.511 - 0.558CDT + 0.3583PVP + 1.075CDTPVP + 0.1854CDT^2 - 0.0271PVP^2$$

Table 7: Outcomes of ANOVA for MT

Sl. No	Source of variance	SS	DF	MS	F-value	F std at 0.1p	F std at 0.05p	F std at 0.01p
1	Model	5.0675	3	1.6892	9.22337203	4.19	6.59	16.7
2	Error	0.0	4	0.0				
3	Total	5.0675	7	-				

Standard Deviation (SD) : 0.05 F Standard Value (SV) at 0.05 p: 10.3
Curvature Effect (CE): -5.6239 F Standard Value (SV) at 0.01 p: 41.9
95% Confident Level of Curvature Effect (CLCE) FROM: -6.8725 TO: -5.0132 (Non Linear)
DF is Degrees of freedom, MS is mean squares, P is probability.

After determining the mathematical sign and magnitude of the co-efficient, as well as the mathematical sign it acquires, polynomial equations were employed to induce inferences (i.e., positive or negative). As indicated in Table 7, the attained F(Fisher's) value is more than the crucial F value, and at the probability level (p 0.05), the outcome seemed to be significant. The crucial value of F is 6.59, and the acquired F value (i.e. 10.3) is greater than the critical value, implying that the gained F value is expected to arise via fate with a p 0.05. As a result, as revealed by Sigma Tech software, the relationship between Y_1 and X_1X_2 is nonlinear, and the CCD has remained instigated. Analysis of Multiple linear regression findings shown that diminution in sum of X_1(CDT) and increase in amount of X_2(PVP) leads to enhance in MT. R^2 of this quadratic model was originate to be 0.839, suggesting this model is reliable, which is used to demonstrate the predictions and contour/design space. All formulations showed MT of 5-9 h which is due to cross-linking in the polysaccharide chain leads to better enlargement with mucin molecule confirming a stronger bondage over a prolonged period of time.[22]

In vitro DR (Y_2)

Ultimate equation in respect of encrypted elements

In vitro DR $Y_2=97.87-0.3167X_1+0.1017X_2+0.1X_1X_2+0.3556X_1^2+0.1294X_2^2$

Ultimate equation in respect of factual elements

In vitro DR $Y_2=97.87-0.3167CDT+0.1017PVP+0.1CTDPVP+0.3556CDT^2+PVP^2$

In vitro drug release

The interaction of X_1 and X_2 was found to be the most prominent with an SS ratio of 61.945 percent and a positive development of the co-efficient (0.1) represented in Table 8.

The results of multiple linear regression analysis were showed reduce in amount of X_1 (CDT) and increase in amount of X_2 (PVP) leads to improve in percentage of DR.[23] R^2 value of this quadratic model was identified to be 0.896, suggesting this model is reliable, which is used to indicate predictions and contour/design space.

Table 8: Statistical investigation of DOE experimental annotations for Y2 (% DR).

Sl. No	Combination	Name of variables	Coefficient values	SS ratio
1	b 0	-	99.09	-
2	b 1	CDT	-0.185	18.9457%
3	b 2	PVP	-0.105	19.9548%
4	b 12	CDT, PVP	0.1	61.9457%

Table 9: Outcomes of ANOVA for Y2 (% DR).

Sl. No	Source of variance	SS	DF	MS	*F*-value	Fstd at 0.1p	F std at 0.05p	F std at 0.01p
1	Model	5.472	3	1.7292	9.4482361	4.39	6.72	17.1
2	Error	0.0	4					
3	Total	5.472	7					

SD: 0.0641 F SV at 0.05 p: 10.2
CE:-8.3841 F SV at 0.01 p: 43.9
95% CLCE FROM: -9.6328 TO: -6.9637(NL).

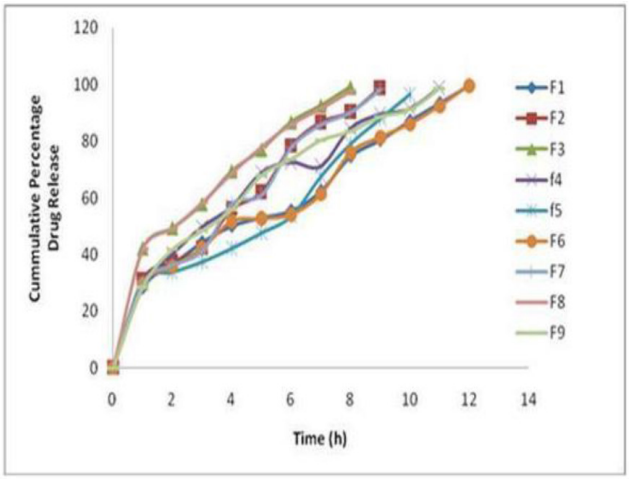


Figure 3: *In vitro* DR outline of F1 – F9

All formulations showed DR about 96.4% to 99.69%. The outcomes were represented in Table 9 and the drug release outline was shown in Figure 3.

A viable design space for DR between the coded values was discovered using contour plots as illustrated

Table 10: Comparison of investigational outcomes with prophesied responses of FMT.

Ingredients	Composition (mg/tab)	Response	Prophesied value	Investigated value	SE
CDT	37.5	Y_1(Mucoadhesion time in h)	8	7.9	1.09%
PVP	15.625	Y_2(%drug release)	99.50	99.10	1.21%

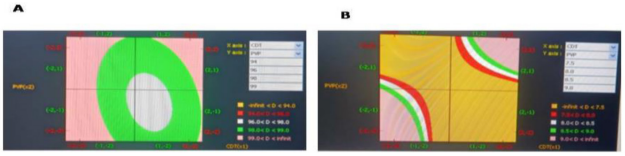


Figure 4: Contour plots A) Drug release B) Mucoadhesion time.

in Figure 4. From a multidimensional combination of mucoadhesion, the study leads to a design space and DR that leads to the operating ranges acceptable for mucoadhesive tablets. The response to the formulation was developed and examined by considering the predicted values. Contour plots made it possible to create a variety of different designs. CDT as 37.5mg (-1) and PVP as 15.625(-1) and for an optimal formulation, all other constituents were kept the same. The RE for each individual outcome was computed using the predicted and investigational values, and the results were found to be and results was noticed to be 1.09%, 1.21% as seen in the Table 10. The investigative values matched the predicted values, indicating the model's predictability and strength.

CONCLUSION

The wet granulation technology was used to successfully synthesise FMT. The concentration of variables CDT and PVP was observed to have effect on the MT and %DR as shown by the model obtained using CCD. It may be concluded that CCD can be used to improve the quality of mucoadhesive tablets by reducing the number of trails.

ACKNOWLEDGEMENT

The authors are grateful to the management of RIPER Raghavendra Institute of Pharmaceutical Education and Research (RIPER), Andhra Pradesh, India. –Autonomous.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

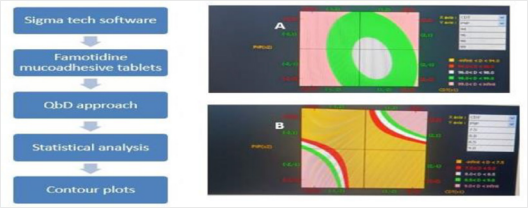
DOE: Design of Experiments; **CCD:** Central Composite Design; **CDT:** *Cordia Dichotoma*; **PVP:** Polyvinyl pyrrolidone; **FTIR:** Fourier-transform infrared spectroscopy; **DSC:** Differential scanning calorimetry; **IP:** Indian Pharmacopoeia; **UV:** Ultraviolet; **HCl:** Hydrochloric acid; **RPM:** Revolutions per minute; **ANOVA:** Analysis of variance; **SS:** Sum of squares; **MT:** Mucoadhesion time; **DR:** Drug release; **TD:** Tapped density; **BD:** Bulk density. **F- value:** Fisher's value; **SS:** Sum of squares; CDDS: Controlled release drug delivery systems

REFERENCES

1. Priya M, Amanpreet K, Geetha A, Hari Kumar SL. Mucoadhesive drug delivery system: A review. Int J Drug Dev Res. 2013;5(1):11-20.
2. Tangri P, Khurana S, Madhav NVS. Oral mucoadhesive drug delivery system. Int J Pharm Biol Sci. 2011;2(1):34-46.
3. Carvalho FC, Bruschi ML, Evangelista RC, Gremião MPD. Mucoadhesive drug delivery systems. Braz J Pharm Sci. 2010;46(1):1-17. doi: 10.1590/S1984-82502010000100002.
4. Alexander A, Sharma S, Ajazuddin KM. Junaid, Swarna. Theories and factors affecting mucoadhesive drug delivery system: A review. Int J Res Ayurveda Pharm. 2011;2(4):1155-61.
5. Sadhukhan B, Mondal NK, Chattoraj S. Optimisation using central composite design (CCD) and the desirability function for sorption of methylene blue from aqueous solution onto Lemna major. Karbala Int J Mod Sci. 2016;2(3):145-55. doi: 10.1016/j.kijoms.2016.03.005.
6. Pawar HA, Gavasane AJ, Choudhary PD. Extraction of polysaccharide from fruits of *Cordia dichotoma* G. Forst using acid precipitation method and its physicochemical characterization. Int J Biol Macromol. 2018;115(146):871-5. doi: 10.1016/j.ijbiomac.2018.04.146, PMID 29715558.
7. Chinthaginjala H, Ahad HA, Bhargav E, Pradeepkumar B. Central composite design aided formulation development and optimization of Clarythromycin extended-release tablets. Indian J Pharm Educ Res. 2021;55(2):395-406. doi: 10.5530/ijper.55.2.77.
8. Chidambaram M, Krishnasamy K. Drug-drug/drug-excipient compatibility studies on curcumin using non-thermal methods. Adv Pharm Bull. 2014;4(3):309-12. doi: 10.5681/apb.2014.045, PMID 24754017.
9. Chowdary KPR, Suresh B, Sangeetha B, Kamalakara Reddy G. Design and evaluation of diltiazem mucoadhesive tablets for oral controlled release. Saudi Pharm J. 2003;11(4):201-5.
10. Vikas S, Mithun B, Vaishali R, Jagdish R. Precompression parameter evaluation of tablets. Int J Pharm Biol Chem Sci. 2017;7(1):55-70.
11. Alagumanivasagam G, Srinivasu CH. Formulation and evaluation of atorvastatin film coated tablets. Int J Pharm Health Care Res. 2018;6(3):55-66.
12. Keshari Sahoo C, Satyanaryana K, Venkata Ramana D, Kahnu Charan P. Formulation and evaluation of controlled release tablets of aspirin. Asian J Pharm Technol. 2017;4(4);5713:2231.
13. Arunachalam A, Avijit M. The outcome of formulation and *in vitro* release studies of levothyroxine tablets. Asian J Pharm Technol. 2011;1(1):33-9.
14. Balasahb Karab B, Ajay Shinde D. Formulation and evaluation of immediate release tablets of levonorgestrel. Indo Am J Pharm Res. 2017;7(8):471-9.
15. Jain AA, Barhate SD. Formulation optimization and evaluation of mouth dissolving tablet of rizatriptan benzoate by using natural superdisintegrant. Asian J Res Pharm Sci. 2019;9(4):245-52. doi: 10.5958/2231-5659.2019.00038.9.

16. Chinthaginjala H, Ahad HA, Pradeepkumar B, Gandhi KS, Kalpana K, Pushpalatha G, *et al*. Formulation and *in vitro* evaluation of gastroretentive ofloxacin floating tablets using natural polymers. Res J Pharm Technol. 2021;14(2):851-6. doi: 10.5958/0974-360X.2021.00151.7.
17. Ravi K, Patil MB, Patil SR, Paschapur MS. Formulation and evaluation of famotidine mucoadhesive tablets. Int J Pharm Technol Res. 2011;54(2):293-300.
18. Davinder K, Mamta A, Virender K. Quality control of tablets: A review. Int J Univers Pharm Bio Sci. 2016;5(4):53-67.
19. Raval JA, Patel MM. Formulation and characterization of gastroretentive discs containing famotidine. Braz Arch Biol technol. 2011;54(2):293-300. doi: 10.1590/S1516-89132011000200010.
20. Arora G, Malik K, Singh I. Formulation and evaluation of mucoadhesive matrix tablets: Assessment of *Myrrh oleo* gum resin as a natural pharmaceutical excipient. Int J Pharm Sci Drug Res. 2011;41(2):23-34.
21. Kumar Upadhyay N, Kumar Gupta R. Formulation and *in-vitro* Evaluation of Mucoadhesive Tablet of Famotidine. Int J Adv Res. 2019;7(10):1223-6. doi: 10.21474/IJAR01/9945.
22. Lohithasu D, Sarada A, Hema Naga Durga D, Rajya Lakshmi T. Assessment of film forming potential of *Cordia dichotoma* fruit mucilage (Boraginaceae): Alfuzosin hydrochloride as a drug of choice. J Appl Pharm Sci. 2016;6(5):36-43.
23. Andrews GP, Laverty TP, Jones DS. Mucoadhesive Polymeric platforms for Controlled Drug Delivery. Eur J Pharm Biopharm. 2009;71(3):505-18. doi: 10.1016/j.ejpb.2008.09.028, PMID 18984051.

PICTORIAL ABSTRACT



SUMMARY

- The study summarizes the preparation of the mucoadhesive tablets loaded by famotidine using natural polymer like CDT powder and PVP as a binder.
- The independent variables selected were CDT, PVP and the dependent variables were MT and percentage DR.
- The concentration of independent factors had a profound influence on MT and percent DR, as per the research findings.
- CP were being used to describe the correlation amid private and reliant variables.

About Authors

Dr. C. Haranath is Associate Professor and Head, Department of pharmaceutics, at Raghavendra Institute of Pharmaceutical Education and Research (RIPER), Andhra Pradesh, India. He is the recipient of best researcher award for the year 2019. He has published one patent and four books. He has published 80 papers in reputed national and international journals. He is the invited resource person for UGC sponsored Medical formulations programme and also speaker for several AICTE sponsored FDP and STTP. His research interest is towards the development of novel drug delivery systems.

Dr. Hindustan Abdul Ahad is Professor & Head in the Department of Industrial Pharmacy, at Raghavendra Institute of Pharmaceutical Education and Research (RIPER), Anantapur, Andhra Pradesh, India. Dr. Hindustan Abdul Ahad has 20 years of Academic, administrative & research experience. He has published 300 papers in reputed national and international journals in the wide range of areas. His research interest is towards natural excipients and novel drug delivery systems. He was awarded as Best Educationist award-2015 by International Institute for Education and Management- New Delhi.

Telkar Mousami Bhavasar is a PG student at Department of pharmaceutics, at Raghavendra Institute of Pharmaceutical Education and Research (RIPER), Andhra Pradesh, India. She has participated in several seminars and conferences.

Bhupalam Pradeepkumar is working as an Associate Professor in Dept. of Pharmacology at Raghavendra Institute of Pharmaceutical Education and Research, Anantapur. He has organized AICTE sponsored short term training program (STTP) as coordinator. He received grant from UGC. He has published 2 books, 2 patents & 40 research papers in various National & International journals. He is invited as resource person in various seminars, conferences, short-term training programs, faculty development programs and quality improvement programs.

Cite this article: Chinthaginjala H, Telkar MB, Hindustan AA, Bhupalam P. Formulation Development and Optimization of Famotidine Mucoadhesive Tablets by Central Composite Design. Indian J of Pharmaceutical Education and Research. 2022;56(4):1044-51.