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Development and Evaluation of Mucoadhesive Tablet of Cefuroxime Axetil using Mallow-Leaved Crossberry Mucilage Powder

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ABSTRACT

This study investigates the potential of mucilage extracted from Mallow-Leaved Crossberry (*Grewia asiatica*) fruit as a mucoadhesive polymer for formulating gastro-retentive tablets of Cefuroxime axetil. The mucilage was isolated using acetone, yielding 28.98 ± 1.90% w/w, with favorable physicochemical and phytochemical properties. Characterization showed excellent swelling indices in distilled water (380.67 ± 6.27%) and phosphate buffer pH 6.8 (353.67 ± 10.41%), revealing its hydrophilic nature and high-water retention capacity. Rheological analysis demonstrated shear-thinning behaviour, and thermal studies indicated stability across varying temperatures. Mucoadhesive strength was comparable to Carbopol 934P, supporting prolonged gastric retention. Pre- and post-compression evaluations of the formulated tablets showed uniform weight, satisfactory mechanical strength, low friability (0.18–0.66%), and consistent drug content (99.61–100.12%). The optimized batch exhibited sustained drug release (99.68% over 12 hours) and demonstrated gastric retention for 10 hours in in-vivo studies. The mucilage was non-toxic, with no observable adverse effects during acute toxicity studies. Stability studies confirmed the robustness of the optimized formulation. These results suggest Mallow-Leaved Crossberry mucilage as a promising natural polymer for developing gastro-retentive drug delivery systems, improving the bioavailability of Cefuroxime axetil.

Keywords: Mallow-Leaved Crossberry, Mucoadhesive tablets, Cefuroxime axetil, Gastro-retentive drug delivery, Natural polymer, Sustained release.

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INTRODUCTION

The development of gastro-retentive drug delivery systems (GRDDS) represents a promising approach to improving the bioavailability of drugs with narrow absorption windows in the gastrointestinal tract (GIT) [1]. By prolonging the gastric residence time, such systems enhance the solubility and therapeutic efficacy of drugs like Cefuroxime axetil, a broad-spectrum cephalosporin antibiotic with pH-dependent solubility and absorption [2][3].

Natural polymers have gained increasing attention for GRDDS due to their biocompatibility, biodegradability, and lower cost compared to synthetic polymers [4]. Mallow-Leaved Crossberry (*Grewia asiatica*) fruit mucilage is a novel, plant-derived polymer with promising physicochemical and mucoadhesive properties, yet its potential in drug delivery remains underexplored [5][6].

This research aimed to isolate and characterize Mallow-Leaved Crossberry mucilage for its mucoadhesive properties and develop a sustained-release tablet of Cefuroxime axetil. The mucilage exhibited hydrophilic, high-swelling, and matrix-forming characteristics, making it a suitable candidate for GRDDS. Mucoadhesion studies demonstrated its ability to form strong bonds with the gastric mucosa, enhancing retention at the absorption site [7][8].

The formulated tablets were evaluated for pre- and post-compression properties, dissolution profiles, and in-vivo gastric retention using X-ray imaging. Additionally, stability and safety were assessed through accelerated stability and acute toxicity studies [9][10]. This work provides a basis for the use of Mallow-Leaved Crossberry mucilage as a functional excipient for mucoadhesive drug delivery systems.

MATERIALS AND METHODS

Spectroscopic Characterization of Cefuroxime axetil

Determination of λ max of Cefuroxime axetil

Accurately weighed Cefuroxime axetil (10 mg) was transferred to 100 ml volumetric flask and dissolved in 100 ml of 0.1 N HCl solutions to obtain a standard stock solution of concentration 100 µg/ml. For the preparation of working standard of 10µg/ml concentration was prepared by taking 1 ml aliquots of stock solution and diluted up to 10 ml to get solution of 10µg/ml concentration. The Ultra-Violet spectrum of Cefuroxime axetil was obtained by scanning from 200 to 400 nm at a medium scan rate.

Preparation of calibration curve of Cefuroxime axetil

Standard stock solution of concentration 100 µg/ml was prepared by transferring 10 mg Cefuroxime axetil to 100 ml volumetric flask and dissolved in 100 ml of 0.1 N HCl solutions (pH 1.2). Then .5, 1, 2, 3, 4 and 5 ml aliquots of stock solution were pipette out and diluted up to 10 ml to prepare standard solutions of drug with concentration 5, 10, 20, 30, 40 and 50 µg/ml respectively. Absorbance of these samples was noted at determined λ max (280 nm) and a calibration curve absorbance vs. concentration was plotted.

Compatibility study by using FT-IR spectroscopy

In the present investigation the compatibility between drug and formulation excipients was determined by the FTIR spectroscopy studies and the spectrum was recorded in the wavelength region of 4000 to 400cm-1, Sample was placed in the light path and the spectrum was obtained. The peaks of pure drug are checked with drug- excipient combination spectrum.

Formulation of Gastro-retentive mucoadhesive tablet of Cefuroxime axetil using Mallow-Leaved Crossberry mucilage powder

The Mucoadhesive tablets were formulated by direct compression, it always first choice method as it is economical and reduces time. The Gastro retentive Mucoadhesive Tablet of Cefuroxime axetil was prepared using Mallow-Leaved Crossberry Mucilage powder as novel mucoadhesive agent and dibasic calcium phosphate, magnesium stearate and aerosil as diluent, lubricant and glidant respectively. Mucoadhesive performance of Mallow- Leaved Crossberry Mucilage powder was compared with carbopol 934P by formulating the tablets containing carbopol 934 P as mucoahesive agents. The level/concentration of all the functional excipients was optimized by preparing several batches. The pre–compression powder blends of 250 mg cefuroxime axetil and selected concentrations of functional excipients were subjected to evaluation of micromeritic properties, then optimized powder blends of different batches as shown in table no. 1 (a) and 1 (b) were subjected to the tablet compression. Cefuroxime axetil, Grewia abutifolia, and dibasic calcium phosphate were sifted through standard 40 mesh sieve then mixed followed blending for 5 minutes; Lubrication of powder blend was done by addition 1.5 mg of magnesium stearate. Finally, the prepared powder blends were compressed by Tablet compression machine using 12 mmround concave punches marked with VISTA 115 and score line to prepare tablet of 500mg weight.

Table No. 1: Formulation Batches (T1-T7) containing Mallow-Leaved Crossberry mucilage and Formulation Batches (T8-T14) containingCarbopol 934P

Ingredient/Batch code	Formulation batches with quantity in mg													
	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
Cefuroxime axetil	250	250	250	250	250	250	250	250	250	250	250	250	250	250
Mallow-Leaved Crossberry mucilage	130	150	170	190	210	230	250	-	-	-	-	-	-	-
(% w/w)	(26)	(30)	(34)	(38)	(42)	(46)	(50)							
Carbopol 934P (% w/w)	-	-	-	-	-	-	-	130 (26)	150 (30)	170 (34)	190 (38)	210 (42)	230 (46)	250 (50)
Dibasic calciumphosphate	118	98	78	58	38	18	00	118	98	78	58	38	18	00
Magnesium stearate	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Aerosil (ColloidalSilicon dioxide)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total weight (mg)	500	500	500	500	500	500	500	500	500	500	500	500	500	500

Evaluation of Mucoadhesive Tablet of Cefuroxime axetil using *Mallow-Leaved Cross berry* Mucilage Powder

Evaluation of pre-compression powder blend

The pre-compression powder blends were subjected to evaluation of micromeritic properties such as Bulk density, tapped density, Compressibility index, Hausner's ratio and Angle of repose were determined in triplicate with reference to standard procedures in accordance with Indian Pharmacopeia and reported methods.

Evaluation of post-compression powder blend

The prepared mucoadhesive gastroretentive tablets of cefuroxime axetil were evaluated for;

Weight variation test

Twenty tablets were collected and were weighed collectively and individually. From the collective weight, average weight was calculated.

Thickness and diameter

The thickness of the tablets was determined using a Vernier caliper. Five tablets from eachformulation were used and average values were calculated.

Hardness Test

Hardness of the tablet was determined using the pifzer hardness tester. The lower plunger was placed in contact with the tablet and a zero reading was taken. The lower plunger wasthen forced against a spring by tuning threaded bolts until the tablet fractured. Then the final reading was recorded. The hardness was calculated by deducting the initial pressure from the final pressure. The results were expressed as an average of 5 readings in terms ofkg/cm2.

Friability

This test was performed to know the effect of friction and shock on tablets. Twelve tablets from each formulation were collected and accurately weighed. Then the tablets were collected and placed in Roche friabilator and operated for 100rpm (25 rpm speed). Tabletswere dusted and reweighed. The test complies if tablets not lose more than 1% of their weight. Friability Percentages of the tablets were calculated.

Drug content uniformity

Ten tablets were weighed individually, crushed and the drug was extracted in 0.1N HCl. The solution was filtered through a cellulose acetate membrane (0.45 µm) and the drug content was determined by UV spectrophotometer at a wavelength of 281 nm after a suitable dilution

Swelling index

The swelling index of tablets was determined in 0.1 N HCl (pH1.2) at ambient temperature. The tablet was immersed in 100 ml of the medium. The tablet was removed periodically from medium. After draining from water by blotting paper, it was measured for weight gain. The swollen weight of the tablet was determined at different time intervals for a period of 6 hrs. The % swelling index (SI) was calculated from the following equation

Where,

$$\% \, Swelling \, index = Wt - Wi \, X \, 100 Wi$$

'Wi = Initial Weight and Wt= Final weight

In-vitro drug release studies

In-vitro dissolution study was performed for all the formulation using USP dissolution apparatus II (Electrolab TD-08L). Each tablet containing 250 mg of drug was placed into 900 ml of 0.1 N HCl (pH 1.2) maintained at a temperature of 37oC+0.5oC and paddle was stirred at 50 rpm. The 5 ml of sample solution was withdrawn at specified intervals of time and replaced with the same amount of dissolution medium maintained at same condition. The absorbance of the withdrawn samples was measured at λ max 280 nm using a UV- visible spectrophotometer (Shimadzu UV-1800) against 0.1 N HCl (pH 1.2) taken as blank. The tablet formulation batches were optimized on basis of results of all above post-compression evaluation parameters and subjected for further studies.

Mucoadhesive strength of tablet

Several methods are reported to measure the mucoadhesive strength of tablet.

Among those methods Modified physical balance and wash off methods was performed

***In-vitro* mucoadhesive study by modified physical balance method**

Measurement of adhesion force was determined by modified physical balance method21 as shown in Figure No. 1, using goat intestinal mucosa which was washed thoroughly with 0.1 N HCl (pH 1.2) then the membrane was tied to the glass slide using rubber band.The glass slide was kept in a beaker filled with 0.1 N HCl (pH 1.2) solution at 37±2 0C in such way that solution just reaches the surface membrane and kept it moist. The tablet to be tested was stuck on the mucus membrane and allow for 5min for swelling and then by using clip to attach the tablet. Then the weight on the left-hand side was slowly added in an increment of 0.5g till the tablet separated from the membrane. The weight and force necessary for detachment of the tablet from the mucosal surface was noted in triplicate as a measure of mucoadhesive strength. The force of adhesion was calculated.

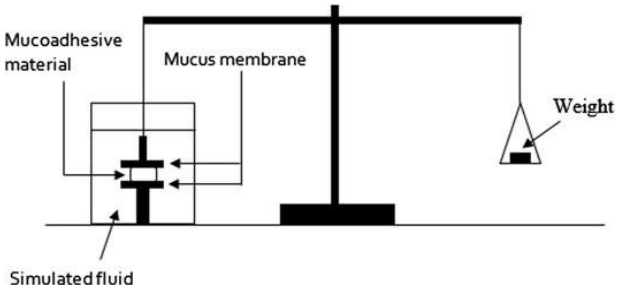


Fig. No. 1: Modified physical balance for mucoadhesive strength

In-Vitro residence time

The residence time of the tablet was determined by In-vitro wash-off test. It was performedby mounting pieces of goat intestinal mucosa on the glass slides provided with suitable support. After fixing of 2 tablets to glass slide, it was tied to the arm of USP disintegrating test apparatus and permitting a slow, regular up and down movement(~30min-1) in a test fluid kept at 37±2 0C as shown in Figure No.2. Time of detachment of tablets was noted, which can be used as a measure of mucoadhesion.

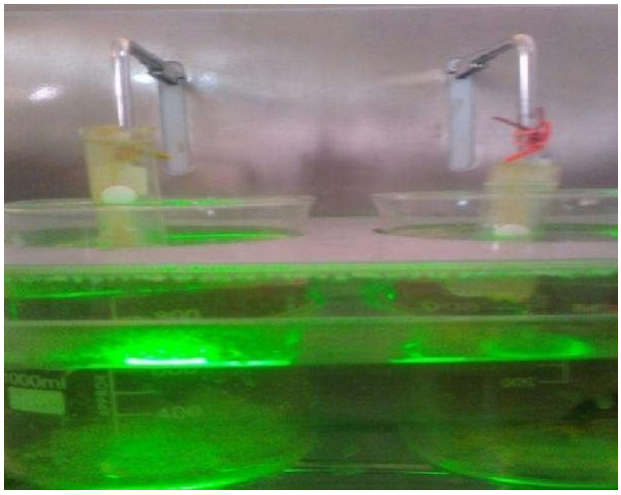


Fig. No. 2: In-vitro wash-off test of mucoadhesive tablets

In-vivo Gastric-retention study by X-Ray imaging

To determine gastric residence time (GRT) and transit behavior by locating the mucoadhesive formulation in gastrointestinal tract In-vivo gastric retention study by X- Ray radiography was performed. Healthy rabbits of 3-month age and about 2.5 kg weight were selected for X-Ray imaging by taking approval of Institutional Animal Ethics Committee (IAEC) at S.N. Institute of Pharmacy, Pusad Dist. Yavatmal, Maharashtra. The approved proposal number was CPCSEA/IAEC/CP_PL/05-2012.

The Radio-opaque mucoadhesive tablets were prepared using radio-opaque barium sulfate instead of drug as per formula of optimized batch. Animals are over night fasted and next morning half the tablet was administered orally through gastric tube fallowed by giving 25ml of water, x-ray radiographs were recorded under supervision of local radiologist immediately after administration of tablet and also at time interval of 2,4,6,8 and 10 hours.

Accelerated Stability studies

The stability Study of selected optimized formulation batch was carried out to determine the effect of additives on the stability of the drug and also to determine the stability of the formulation under the accelerated storage condition as per ICH guidelines. The tables subjected to elevated temperature and condition of 40±2 0C and 75±5% RH for 90 days in a stability chamber. The optimized batch was also

evaluated for physical appearance, hardness, drug contentand in-vitro drug release study after 45 and 90 days.

RESULTS AND DISCUSSION

Spectroscopic characterization of Cefuroxime axetil

Determination of λ max of Cefuroxime axetil

The UV-spectra of Cefuroxime axetil was obtained as shown in Figure No: 3. The resulting UV-spectrum of Cefuroxime axetil quantitatively compared to the spectrumobtained from a drug reference standard.

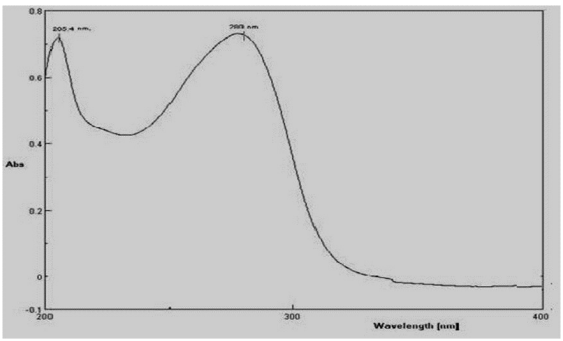


Fig. No.3: UV spectra of Cefuroxime axetil in 0.1 N HCl

The UV-spectra was characterized by maxima at 280 nm.

Calibration curve of Cefuroxime Axetil

Table No. 2: Data for calibration curve of Cefuroxime axetil

Sr. No.	Concentration (µg/ml)	Absorbance at 266.6 nm
1	10	0.257
2	20	0.475
3	30	0.655
4	40	0.876
5	50	1.084

The calibration curve found to be linear in the concentration range of 0- 50µg/mlwith straight line equation y = 0.021x + 0.038 and Regression coefficient R^2=0.996 asshown in Figure No. 3.

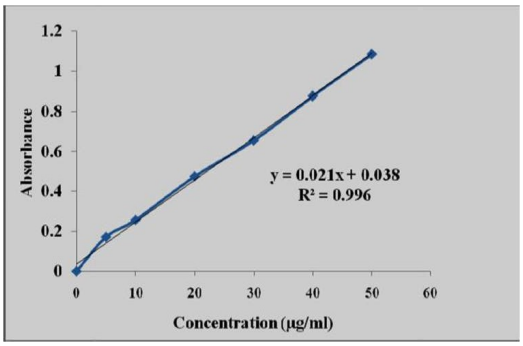


Fig. No.4: Calibration curve of Cefuroxime axetil in 0.1N HCl

Drug excipients compatibility studies by DSC and FTIR Spectrophotometer

Compatibility of Cefuroxime axitil with Excipients/ referred mucoadhesive agent Carbopol-934P or Mallow-Leaved Crossberry mucilage is determined by FTIR Spectroscopy. The Compatibility of Drug Cefuroxime axitil with Mallow-Leaved Crossberry Mucilage interpreted as follows;

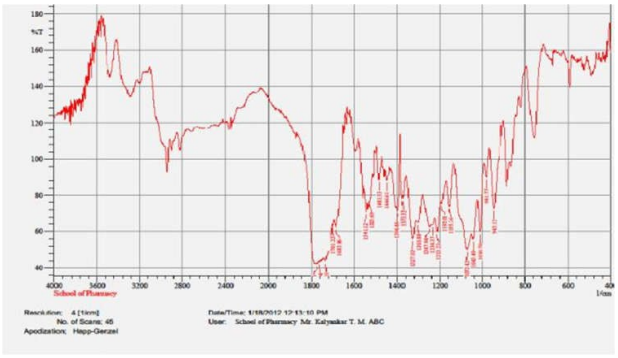


Fig. No. 5: FTIR Spectra of Cefuroxime axetil

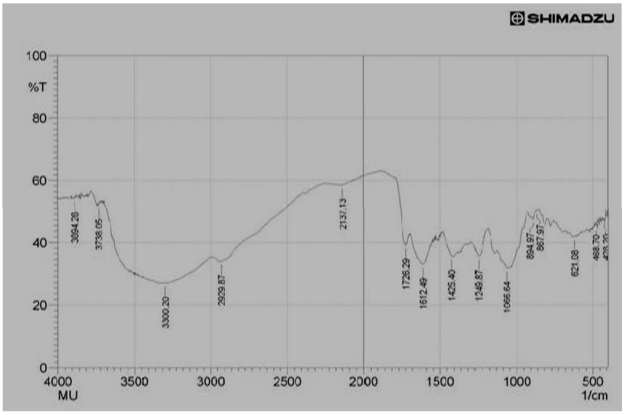


Fig. No. 6: FTIR Spectra of *Mallow-Leaved Crossberry* mucilage

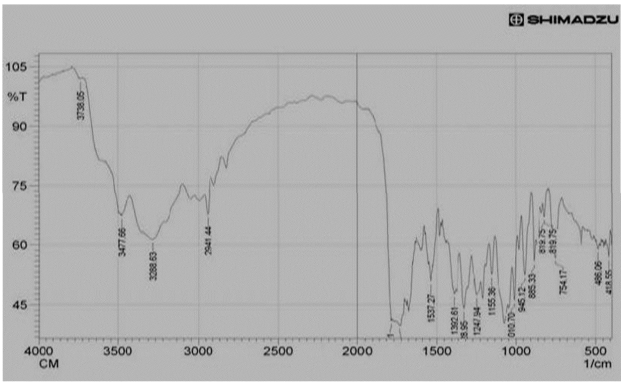


Fig. No.7: FTIR Spectra of Cefuroxime axitil + *Mallow-Leaved Crossberry* Mucilage

Interpretation of FT-IR

Table No.3: Interpretation of FT-IR spectra of compatibility study

Functional groups	Cefuroxime axetil pure drug	*Mallow-Leaved Crossberry* mucilage	Cefuroximeaxitil + *Grewia abutifolia* mucilage
	Observed peaks (wave number cm^{-1})		
N-H bending	1537.20	1619.24	1537.24
-CH_3 and -CH_2 Bending	1456.26	1425.40	1395.24
C-O bending	1211	1041.01	1247.90
C-N Amine	1325	1254.17	1328
S=O sulfoxide	1048	---	1010
C-H Alkenes	947.05	1066.64	945.12
C-H aromatic	885.33	818.04	885.33
N-H stretching	---	3320.20	3288.63
O-H stretching	---	3738.06	3738.06

The FTIR spectral analysis shows characteristic peaks of pure drug in FTIR spectraof Cefuroxime axitil and *Mallow-Leaved Crossberry* mucilage and also in the physical mixture of Cefuroxime axitil excipients; which confirms the absence of chemical interaction between drug and excipients hence drug is compatible with the excipients.

Evaluation of Mucoadhesive Tablet of Cefuroxime axetil using *Mallow- Leaved Crossberry* Mucilage Powder

Evaluation of pre-compression powder blend

The pre-compression powder blends for compression of tablets were evaluated for their micromeritics properties and the results were shown in the Table No 4.

Table No.4: Micromeritic properties of pre-compression powder blend

Batch Code	k Density (g/ml) n=3	Tapped Density (g/ml)n=3	Compressibility Index (%)	Hausner's Ratio	Angle of Repose θ n=3
T_1	0.6525±0.21	0.7548±0.33	5.20	1.062	32.25°±0.21
T_2	0.7548±0.35	0.7859±0.58	6.23	1.058	25.14°±0.18
T_3	0.7985±0.24	0.7895±0.15	7.25	1.088	27.85°±0.63
T_4	0.6859±0.15	0.7895±0.49	7.56	1.059	28.65°±0.32
T_5	0.7895±0.62	0.7565±0.47	5.69	1.099	28.69°±0.81
T_6	0.7548±0.81	0.7859±0.35	5.69	1.058	25.60°±0.46
T_7	0.7653±0.74	0.7895±0.44	6.56	1.059	27.89°±0.51
T_8	0.7895±0.63	0.7589±0.15	6.56	1.089	28.21°±0.48
T_9	0.7895±0.58	0.7895±0.55	5.65	1.058	27.58°±0.84
T_{10}	0.7548±0.49	0.7585±0.24	5.69	1.089	24.56°±0.69
T_{11}	0.7895±0.52	0.7564±0.15	5.88	1.059	25.50°±0.52
T_{12}	0.7548±0.47	0.7458±0.66	5.98	1.025	25°±0.33
T_{13}	0.7042±0.38	0.7462±0.35	5.62	1.059	27.12°±0.84
T_{14}	0.7142±0.52	0.7471±0.49	4.28	1.044	26.21°±0.47

Mean ± S.D.

The powder characteristic indicates good flowability with an angle of repose value ranging from 23.41 to 28.33 i.e. (<30). The bulk density of all the formulation showed in acceptable range. The bulk density of these powders was found to be in the range of 0.6850 to 0.7246 g/cm3 whereas, tapped density was in the range of 0.7246 to 0.7692 g/cm3 for all formulations. Carr's index of powder was found the range of 4.01 % to 6.25 % for all formulations. These values indicate that the prepared powder for all batches exhibited good flow properties.

Evaluation of post-compression powder blend/ tablet

The weights of the tablets of all formulations were low standard deviation values, representing uniformity of weight. The weight variation deviation of different formulations was found to be 3.384 to 4.584. The difference in weight was within the range of 5% complying with Pharmacopoeial specification (Indian Pharmacopoeia).

Table No.5: Post-Compression evaluation parameters

Batch code	Average weight (mg) n=20	Diameter (mm) n=5	Thickness (mm) n=5	Friability (%) n=12	Hardness (kg/cm^3) n=5	Drug content (%) n=3
T_1	499 ±3.10	11..22±0.051	5.45±0.05	0.31±0.02	7.58±0.381	95.54±1.66
T_2	497 ±1.89	11.26±0.057	5.47±0.129	0.60±0.10	7.25±0.433	95.87±2.57
T_3	500 ±2.38	11.30±0.081	5.30±0.141	0.64±0.12	7.5±0.511	98.88±1.33
T_4	499 ±4.69	11.25±0.10	5.32±0.095	0.39±0.15	7.91±0.144	99.91±2.13
T_5	492±4.91	10.40±0.070	5.38±0.023	0.40±0.02	7.16±0.288	98.87±3.11
T_6	502±2.91	11.24±0.054	5.28±0.083	0.59±0.06	7.75±0.435	97.84±2.94
T_7	492±3.78	11.28±0.044	5.34±0.054	0.57±0.05	7.33±0.144	98.26±3.03
T_8	493±2.82	11.30±0.141	5.25±0.070	0.50±0.09	7.13±0.251	97.61±2.79
T_9	491±5.36	11.30±0.00	5.35±0.070	0.64±0.07	7.75±0.433	101.12±2.41
T_{10}	494±12.01	11.25±0.070	6.20±0.071	0.76±0.04	7.50±0.245	99.4±1.33
T_{11}	510±5.65	11.35±0.070	6.25±0.00	0.31±0.09	7.52±0.141	97.97±2.85
T_{12}	498±4.18	11.15±0.070	6.10±0.072	0.28±0.13	7.33±0.144	97.81±1.42
T_{13}	500±1.84	11.20±0.141	6.15±0.00	0.65±0.12	7.91±0.144	98.32±2.36
T_{14}	495±2.87	11.20±0.000	6.30±0.072	0.51±0.06	7.75±0.435	99±2.39

Mean ± SD

The hardness for different formulations was found to be between 7.16 kg/cm^3 to 7.91kg/cm^3. It was indicating satisfactory mechanical strength. The thickness of all the formulations was found in the range of 5.30 mm to 6.35 mm. The friability of all the formulations was found in range of 0.18% to 0.66%. The tablets compressed were stable and having good physical characteristics. The drug content was between 95.54±2.79 to 101.12±2.41 %. Thus, all above quality

control parameters of tablet were within the official limit.

Swelling index of tablet

The results of swelling index for all the batches are tabulated in Table No. 7.6 and presented in figure No. 6. The tablet formulation batches T1 and T2 shows higher valuesof swelling index and get disintegrate in the early hours, which may lead to insufficient time for action of mucoadhesion and increase in swelling index was indicative of less mucoadhesion potential in T1 and T2 batches. Formulation batches T8 and T9 Shows increase in swelling at higher rates and losses integrity of tablet which is also indicative of weak mucoadhesion potential as compared to other batches prepared by using carbopol 934P. Thus, lower concentration of mucoadhesive polymer (≤30 %w/w) do not showssatisfactory results.

Table No.6: Swelling index data

Formulation batch	% Swelling index after					
	1 Hour	2 Hour	3 Hour	4 Hour	5 Hour	6 Hour
T1	185.62	166.63	70.11	24.65	--	---
T2	183.05	185.23	96.15	26.42	--	--
T3	166.14	175.2	183.05	136.11	121.32	92.2
T4	116.75	172.13	185.41	182.62	136.11	121.32
T5	106.31	166.14	175.2	183.05	176.11	151.32
T6	106.96	152.31	166.14	175.2	178.9	174.4
T7	95.96	161.45	172.76	181.58	185.41	182.62
T8	166.14	120.31	100.2	57.65	23.87	--
T9	160.84	159.63	125.34	78.32	29.92	-
T10	168.71	160.84	166.14	135.34	87.73	51.19
T11	146.75	172.13	165.41	156.27	142.75	129.82
T12	125.11	131.43	154.1	159.91	162.24	165.41
T13	95.96	151.58	158.45	160.83	162.53	168.71
T14	113.12	142.63	146.70	154.72	165.49	170.76

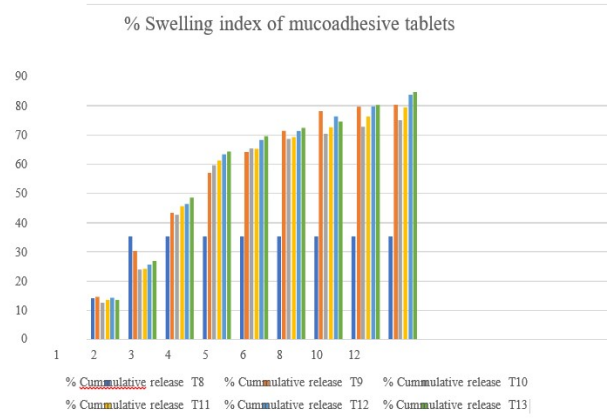


Fig. No. 8: % Swelling index of mucoadhesive tablets

There was gradual increase in selling index of tablet formulation batches prepared by *Mallow-Leaved Crossberry* mucilage (T3 to T7) and batches prepared by Carbapol 934P (T8 to T14) indicative of mucoadhesion potential. Tablets prepared by *Mallow-Leaved Crossberry* mucilage gives significant results as compared to tablets prepared by Carbapol 934P.

Mucoadhesive strength of tablet

The In-vitro mucoadhesive strength was determined by modified physical balance to measure the force (N) required for detaching the tablet and the results were given in the table7.7. Tablets come in contact with 0.1 N HCl (pH 1.2) forms mucilage and sufficiently swells to form simple bonding with mucus membrane and mucoadhesive strength increases with increase in concentration of mucoahesive polymer in tablets.

The mucoadhesion strength and mucoadhesion force batches T3 to T7 prepared by more than 34% w/w of *Mallow-Leaved Crossberry* mucilage powder was 20.13-23.56 g and 1.97- 2.31 N respectively, and for batches T10 to T14 prepared by more than 34% w/w of Carbopol 934 P was 20.96-23.86 g and 2.05-2.34 N respectively. Based on the results of mucoadhesion study it can be predicted that gastric retention of cefuroxime axetil by this approach can be achieved.

Table No. 7: Mucoadhesive strength of tablet

Batch Code	Mucoadhesive Strength (g) n=3, Mean ±SD	Mucoadhesion Force (N)	Mucoadhesion Retention time(hrs)*
T1	18.43±0.48	1.965896	Less than 1 hrs
T2	18.43±1.2	2.611783	Less than 1 hrs
T3	24.63±0.82	3.023803	More than 3 hrs
T4	24.13±1.02	2.974753	Up to 2 hrs
T5	24.96±0.51	3.056176	More than 3 hrs
T6	24.68±0.79	3.224908	More than 3 hrs
T7	25.56±0.53	3.311236	More than 3 hrs
T8	19.99±0.69	2.568619	Less than 1 hrs
T9	23±1.25	2.8639	Less than 1 hrs
T10	24.96±0.63	3.056176	More than 3 hrs
T11	24.68±0.96	3.224908	More than 3 hrs
T12	27.56±0.65	3.311236	More than 3 hrs
T13	27.86±0.6	3.340666	More than 3 hrs
T14	25.75±1.1	3.231775	Up to 2 hrs

All the batches also evaluated for *In-vitro* Mucoadhesion retention time by wash off test, the batches T3, T5, T6 and T7 with the *Mallow-Leaved Crossberry* mucilage and batches T10, T11, T12 and T13 with the polymer Carbopol 934P shows more than

3 hours retention. Hence, overall swelling and mucoadhesion behavior observed for tablet batches prepared with *Mallow-Leaved Crossberry* mucilage are good agreement with the results of its physicochemical characterization

In-vitro dissolution studies

The *In-vitro* drug release studies were carried out for all formulated batches of Cefuroxime axetil muco-adhesive tablets in 0.1 M HCl (pH 1.2). The percentage cumulative drug release of all the formulation was determined for 12 hrs and shown in Table No.7.8 and 7.9 and presented in Figure No. 2 and 3. All formulations showed prolong sustained release of Cefuroxime axetil over 12 hrs. The cumulative drug release from these muco-adhesive tablets containing Cefuroxime axetil was within the range of 62.56±1.61 to 73.92±0.64. As the increased ratio of mucoadhesive polymer leads to retardthe drug release. A significantly higher rate extended release of drug was found to be near required theoretical profile value from batch T1 and T3 compared with other batches. The prepared mucoadhesive tablets containing sodium alginate (T1 to T3) showed a higher rate extended released up to 12 hrs as compared to the formulation with Carbopol which was up to 12 hrs.

Formulations batch T_3 has good results of post-compression evaluation parameters such as *In-vitro* swelling ability, mucoadhesion strength, mucoadhesive retention time and dissolution profile. Hence, it was optimized and subjected to further studies.

Table No. 8: *In-vitro* drug release Study (T_1- T_7)

Timein hrs.	% Cummulative release of Cefuroxime axetil from mucoadhesive Tabletincorporated with *Mallow-Leaved Crossberry* mucilage						
	T_1	T_2	T_3	T_4	T_5	T_6	T_7
1	42.45±2.3	40.26±2.8	38.96±1.6	36.89±1.9	35.45±1.3	34.65±1.9	30.26±1.9
2	65.65±1.9	62.64±1.6	56.95±2.4	55.69±2.1	54.63±2.9	53.36±1.4	50.24±2.1
3	86.43±3.1	84.56±2.6	75.23±2.6	74.23±2.3	73.25±2.1	72.53±1.5	70.23±2.6
4	91.33±2.9	89.54±2.9	88.48±2.8	86.58±2.4	84.65±1.7	83.24±2.2	80.26±2.8
5	98.79±2.7	90.54±3.6	95.25±1.9	88.96±2.9	86.52±1.9	86.24±1.5	85.23±2.3
6	95.53±1.8	91.56±2.7	96.65±3.2	94.26±3.1	88.65±2.1	89.52±1.9	88.96±1.8
8	96.36±2.1	95.54±2.8	95.35±3.6	99.65±2.7	92.65±2.3	92.51±2.3	90.26±1.6
10	98.58±2.4	99.63±2.6	96.83±1.9	94.62±2.4	98.56±2.6	97.56±2.8	94.65±2.7
12	99.63±2.6	99.58±2.9	99.68±2.8	96.52±1.8	94.26±2.8	92.53±2.7	96.23±2.4

n=6 Mean ± SD

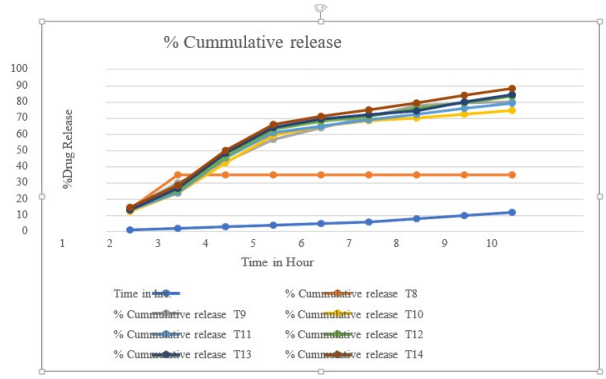


Fig. No.9: *In-vitro* drug release study (T_1 to T_7)

Table No. 9: *In-vitro* drug release Study (T8- T_{14})

Time in hrs.	Release of Cefuroxime axetil from mucoadhesive formulation incorporated with Carbopol 934P						
	T_8	T_9	T_{10}	T_{11}	T_{12}	T_{13}	T_{14}
1	14.25±2.4	14.65±1.6	12.64±1.5	13.65±1.6	14.36±2.6	13.65±2.1	15.23±1.8
2	35.21±2.1	30.25±1.2	23.98±0.8	24.23±2.3	25.65±1.7	26.94±1.6	28.64±1.7
3	55.23±1.4	43.25±1.9	42.63±1.2	45.62±1.8	46.36±1.6	48.56±1.4	50.24±1.9
4	64.21±1.9	56.95±2.1	59.53±1.9	61.23±2.4	63.25±1.9	64.35±0.8	66.23±1.7
5	72.42±2.5	64.21±0.9	65.23±2.8	65.23±0.8	68.2±1.4	69.57±1.1	71.25±1.3
6	78.65±1.7	71.24±1.9	68.54±1.4	69.23±1.6	71.23±2.1	72.36±2.6	75.23±2.4
8	81.65±1.8	77.96±2.8	70.26±2.4	72.54±2.3	76.25±2.3	74.56±1.7	79.56±2.1
10	84.62±2.3	79.56±1.9	72.63±1.7	76.23±1.7	79.65±2.4	80.23±1.5	84.23±1.9
12	85.88±2.9	80.25±1.4	74.88±1.6	79.36±1.6	83.62±1.9	84.63±1.2	88.47±1.1

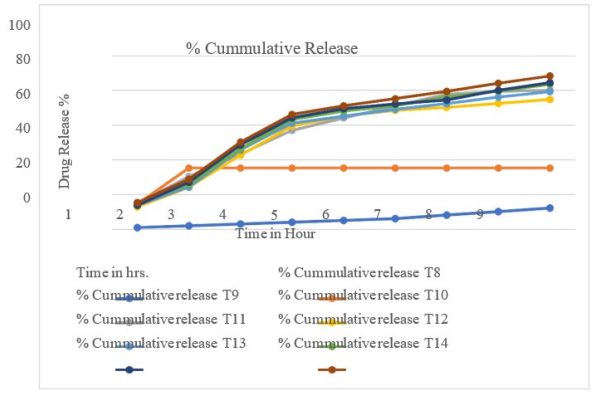
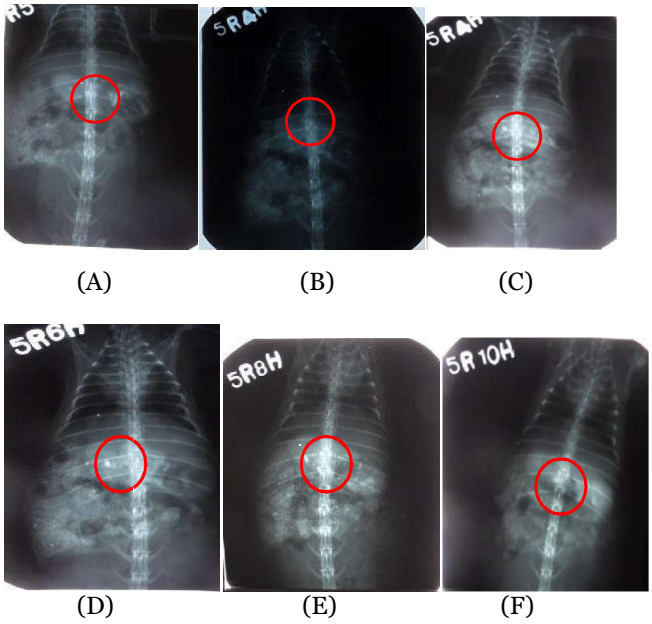


Fig. No.10: *In-vitro* drug release study (T8 to T14)

In-vivo Gastric-retention study by X-Ray imaging

The Radio-opaque mucoadhesive tablets were prepared using radio-opaque barium sulfate instead of drug as per formula of optimized batch T_3 while other excipients in same quantities. Animals are overnight fasted and next morning half the tablet was administered orally by considering the comparatively

narrow alimentary track of rabbits through gastric tube fallowed by giving 25 ml of water, X-Ray radiographs were recorded under supervision of local radiologist immediately after administration of tablet and also at time interval of 2, 4, 6, 8 and 10 hours and presented in Figure No. 7.10.



(A) (B) (C)

(D) (E) (F)

Fig. No.11: X-Ray images-(A) Barium sulfate administered Rabbit; (B) wastaken after 2 hrs. (C) After 4h; (D) was after 6h; (E) after 8 h and (F) after 10 h after of tablet administration.

In-vivo X-ray imaging study clearly indicates the presence of tablet in the intestine and it remains in the stomach up to 10 hrs hence it confirms the achievement ofGastro-retention due to its ability to adhere the GI mucosal.

Accelerated stability studies

Accelerated stability study showed that there were no considerable changes in physical appearance, thickness, hardness, drug content and *in-vitro* drug release from formulations T1 to T3 after subjecting the formulation at 40°C ± 2°C & 75% ±5% RH for90 days. No significant difference in thickness and hardness was observed. However, a minute change in drug content was detected after 90 days. Table No. 10 describes that there was hardly any difference between dissolution profile of among all the formulation before and after stability study.

Table No.10: Accelerated stability study of optimized formulation (T3)

Parameters	Days		
	0	45	90
Physical appearance	White texture, smoothappearance	No changes observed	No changes observed
Thickness (mm)	4.02	4.02	4.02
Hardness (Kg/cm²)	5-6	5-6	5-6
Drug content (%)	98.72	97.51	95.24
% Cumulative drug release			
1 hour	38.96±1.6	37.21 ± 1.20	35.81 ± 1.02
4 hour	88.48±2.8	86.36 ± 2.42	85.12 ± 1.14
12 hour	99.68±2.8	99.25 ± 0.57	99.98 ± 1.10

Hence, matrix tablet prepared were found to be stable, it can be concluded that theformulated mucoadhesive tablet using *Mallow-Leaved Crossberry* mucilage powder are stable under appropriate storage conditions

CONCLUSION

The study successfully demonstrated that Mallow-Leaved Crossberry mucilage possesses excellent mucoadhesive and matrix-forming properties, making it a promising natural polymer for developing gastro-retentive tablets of Cefuroxime axetil. The optimized formulation exhibited extended drug release, effective gastric retention, and stability under storage conditions. Furthermore, the mucilage was non-toxic, safe for pharmaceutical use, and comparable to Carbopol 934P. These findings pave the way for future exploration of Mallow-Leaved Crossberry mucilage in various drug delivery systems.

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