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# EVALUATION OF TAMARIND SEED POLYSACCHARIDE (TSP) AS A MUCOADHESIVE AND CONTROLLED RELEASE COMPONENT OF CIPROFLOXACIN HCL MUCOADHESIVE MATRIX TABLET & COMPARISON WITH HPMC K-100 AND XANTHAN GUM

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**ABSTRACT**

The mucoadhesive matrix tablets of ciprofloxacin HCl were fabricated with objective of controlled release and prolonging duration of action. The mucoadhesive polymers used in formulations were tamarind seed polysaccharide (TSP), HPMC K-100 and Xanthan gum. These formulations were characterized for physiochemical parameters, in vitro adhesion retention time, in vitro mucoadhesive strength, swelling index and drug release. The modified in vitro assembly was used to measure the mucoadhesive strength of tablets with fresh goat stomach mucosa as a model tissue. Finally the results were compared between formulations made by TSP and HPMC K-100, Xanthan gum. The best mucoadhesive performance and in vitro drug release profile were exhibited by the tablets containing 30% TSP coded by T5, 35% HPMC K-100 coded by H6 and 35% Xanthan gum coded by X6. These formulations showed drug release at 12 hours 98.86 %, 97.57 % and 97.5% respectively as well as maintained excellent matrix integrity during the period of study. These formulations were more comfortable to the user due to less erosion, optimum swelling index.

**Key words:** Mucoadhesive matrix tablet, Tamarind seed polysaccharide, Bio adhesive Strength, *In vitro* adhesion retention time, Ciprofloxacin HCl.

## INTRODUCTION

Oral route is the most preferred route for administration of drugs. Tablets are the most popular oral formulation available in the market and preferred by the patients and physician alike. In long term therapy for the treatment of chronic disease conditions conventional formulations are required to be administered multiple doses and therefore have several disadvantages [1]. The primary benefit of a sustained release dosage form, compared to a conventional dosage form, is the uniform drug plasma concentration and therefore uniform therapeutic effect. Over the past two decades, sustained release dosage forms have made significant progress in terms of clinical efficacy and patient compliance. Matrix devices, due to their chemical inertness, drug embedding ability and drug release character, have gained steady popularity for sustaining the release of a drug [2]. Hydrophilic matrices are an interesting option when developing an oral sustained release formulation. The drug release from such matrices can be controlled through their physical properties. Polysaccharides are the choice of materials among the hydrophilic polymers used, because they are nontoxic and acceptable by the regulating authorities.

The various polysaccharides used in drug delivery application are cellulose ethers, xanthan gum, locust bean gum and guar gum. Another natural polysaccharide,

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Tamarind seed polysaccharide (TSP) obtained from the seed kernel of *Tamarindus indica*, possesses properties like high viscosity, broad pH tolerance, noncarcinogenicity, mucoadhesive nature, and biocompatibility. It is used as stabilizer, thickener, gelling agent, and binder in food and pharmaceutical industries. The TSP constitutes about 65% of the tamarind seed components.

Ciprofloxacin comes under the category of Fluorinated 4-quinolones. It has a broad antimicrobial activity and is effective after oral administration for the treatment of a wide variety of infectious diseases [2]. Ciprofloxacin is the most potent flouroquinolone active against a broad range of bacteria the most susceptible ones are the aerobic gram negative bacilli [3].

The goal behind the development of oral controlled release formulations at that time were the achievement of a constant release rate of the entrapped drug. The aim of the study was to formulate and evaluate ciprofloxacin HCl controlled release mucoadhesive matrix tablets.

## MATERIALS

Tamarind kernel powder, collected from plant source**,** Ciprofloxacin was obtained as a Gift sample from A to Z pharmaceuticals, Chennai, HPMC K100M and xanthan gum gum were purchased from Loba Chemicals, Mumbai. Micro crystalline cellulose (CMC) was purchased from Paxmy Chemicals Mumbai. Poly vinyl pyrolidine, magnesium stearate and ethanol were obtained from S.D. Fine Chemicals, Mumbai. All other reagents used were of analytical grade.

## METHODS

### Isolation of Tamarind seed polysaccharide:

The seeds of Tamarindus indica were washed thoroughly with water to remove the adhering materials. Then, the reddish testa of the seeds was removed by heating seeds in sand in the ratio of 1:4 (Seed: Sand). The testa was removed. The seeds were crushed lightly. The crushed seeds of Tamarindus indica were soaked in water separately for 24 hours and then boiled for 1 hour and kept aside for 2 h for the release of mucilage into water. The soaked seeds were taken and squeezed in a muslin bag to remove marc from the filtrate. Then, equal quantity of acetone was added to precipitate the mucilage. The mucilage was separated. The separated mucilage was dried at temperature 50°C, powdered and passed through sieve number 80. The dried mucilage was powdered and stored in airtight container at room temperature [4, 5, 6].

### Preparation of Mucoadhesive Matrix Tablets of Ciprofloxacin HCl

Tablet formulations were prepared by wet granulation method. A non-aqueous granulation process was adopted to prepare Ciprofloxacin HCl tablets. Granules were prepared as follows. Proportion of excipients with drug was as given in Table 1. All ingredients were sifted through sieve no. 60. And microcrystalline cellulose was mixed with Ciprofloxacin HCl manually and the obtained blend was mixed with tamarind seed polysaccharide (T1 to T6), HPMC K-100 (H1 to H6) and xanthan gum(X1 to X6) to form final blend. PVPK 30 was dissolved in ethanol (5% w/v) and used for wet granulation of the final blend. The wet mass was passed through sieve no. 12 and wet granules were dried at 50°C in an oven for 30 mints. Dried granules were sized by passing it through sieve no. 16 and lubricated with magnesium stearate and talc for 1 mint. Tablets were compressed using Rotary tablet machine with 12.08 mm standard concave punch. Tablet weight was (500 mg) kept constant as shown in table 1, 2, 3.

### Compatibility studies

Pure drug (Ciprofloxacin HCl) and their physical mixtures drug and polymers were examined by Fourier Transform Infrared (FT-IR) spectra. The spectra were recorded in a Thermo-IR 200 FTIR spectrophotometer. Potassium bromide pellet method was employed and background spectrum was collected under identical conditions. Each spectrum was derived from 16 single average scans collected in the range of 400-4000 $cm^{-1}$ at the spectral resolution of 20 $cm^{-1}$.

DSC curve of pure drug (Ciprofloxacin HCl) and their physical mixtures drug and polymers were obtained by a Differential Scanning Calorimeter at heating rate of 10°C/min from 30 to 300°C in nitrogen atmosphere (30mL/min).

### Evaluation of Granules

***Angle of repose***

Angle of repose (θ) was measured using fixed funnel method. The height of the funnel was adjusted in such a way that the tip of the funnel just touched the apex of the heap of the granules. The granules were allowed to flow through the funnel freely on to the surface. Angle of repose was calculated using the following equation [7].

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

Where h and r are the height and radius as of cone.

***Bulk density*** [8]

Bulk density is the ratio between a mass of granules and its bulk volume. It is expressed by g/cc.

$$\text{Bulk dencity} = \frac{\text{weight of powder}}{\text{bulk volume}}$$

***Tapped density*** [8]

Tapped density is the ratio between a mass of granules and volume of the granules after tapping.

It is expressed by g/cc.

Tapped density = (Weight of granules/Final volume after tapping)

***Bulkiness***

Bulkiness is the reciprocal of bulk density. It is expressed by cc/g.

Bulkiness = (1/Bulk density)

***Compressibility index and Hausner ratio*** [9]

The compressibility index and the closely related Hausner ratio have become the simple, fast and Popular methods of predicting granules flow characteristics. The compressibility index and Hausner ratio were determined by measuring both the Bulk density and tapped density of Granules.

Compressibility index = (Tapped density-Bulk density / Tapped density) × 100.

Hausner ratio = Tapped density / Bulk density

**Evaluation of Tablets**

***Hardness*** [11, 12]

The strength of tablet is expressed as tensile strength (kg/cm2). The tablet-crushing load, which is the force, required breaking tablet by compression. It was measured using a tablet hardness tester (Pfizer Hardness Tester).

***Weight variation*** [10]

Twenty tablets ware randomly selected and individually weighted (shimdzu). The average weight of tablets was calculated.

***Friability*** [12]

Ten tablets were placed in the Roche friabilator, which was then operated for 100 revolutions. After 100 revolutions the tablets were dedusted and reweighed. Percentage friability was calculated by the following formula.

Percentage friability = [(Initial weight - Final weight)/ Initial weight] × 100

***Estimation of drug content*** [13]

Ten tablets from each formulation were powdered. The powder equivalent to 100 mg of Ciprofloxacin HCl was weighed and dissolved in phosphate buffer pH 7.4 suitable dilutions was prepared and the solution was analyzed in UV-double beam spectrophotometer at 278nm using pH 7.4 as blank.

***Thickness***

Thickness of the tablet was tested using vernier callipers (Besto).

***Swelling studies*** [14, 15, 16]

The extent of swelling was measured by taking different formulation of tablets and their initial weight was noted. Tablet from each batch was placed in Petri plate in pH 6.8 phosphate buffer. At time interval of 2, 4, 6, 8, 10, 12 hours tablets were removed from buffer medium and excess water on their surface was carefully absorbed with filter paper. The swollen tablets were weighed and swelling index was calculated.

Swelling index = [(W1-W2)/W2] X 100.

***Mucoadhesive strength*** [17, 18, 19]

The mucoadhesive forces of the tablets were determined by means of mucoadhesive measuring device shown in Figure No. 1. The pieces of fundus tissues of sheep were stored frozen in saline solution and thawed to room temperature before use. At time of testing a section of tissue (c) was secured keeping the mucosal side out, on the upper glass vial (b) using a rubber band and aluminum cap. The diameter of each exposed mucosal membrane was 1 cm. The vial with the fundus tissue (c) was stored at $37^{O}C$ for 10 min. Then one vial with section of tissue (c) was connected to the balance (a) and another vial was fixed on height adjustable pan (E). To a lower vial a tablet of polymer (d) was placed with the help of cello tape. The height of the lower vial was adjusted so that a tablet could adhere to the mucosal tissue on the upper vial. A constant force was applied on the upper vial for 2 minutes after which it was removed and the upper vial was then connected to the balance. Then, the weight on right side pan was slowly added in an increment of 0.5 g till thetwo vials just separated from each other. The total weight (gm) required to detach two vials was taken as a measure of mucoadhesive strength. From this mucoadhesive strength, the force of adhesion was calculated using the following formula

Force of adhesion (N) = **[**Mucoadhesive strength X 9.81] 100

***Tablet adhesion retention period***

The adhesion retention period of the tablets was evaluated, in triplicate, by an in vitro method reported by Nakamura et al. [20] for measuring the nasal mucoadhesion of some water-soluble polymers. Briefly, an agar plate (1%, w/w) was prepared in 0.1 N HCl (pH 1.2). A side of the tablet was wetted with 50 µL of 0.1 N HCl and attached to the center of agar plate by applying a light force with a fingertip for 20 s [26]. Five minutes later, the agar plate was attached to a USP disintegration test apparatus (model TDL-082 electrolab) and moved up and down in 0.1 N HCl (pH 1.2) at 37 ± 0.5 $^{0}$C (Figure No.2). The adhering tablet on the plate was immersed into the solution at the lowest point and got out of the solution at the highest point. The retention period of the tablet on the plate was noted visually.

***In vitro Release Studies***

For all the formulated tablets were carried out using USP II paddle method at 50 rpm in 900 ml of 0.1N HCl solution as a dissolution medium, The dissolution medium was maintained at $37^{0}$ ± 0.5 $^{0}$C. 5 ml of dissolution medium was withdrawn every 60 minutes intervals for 12 hrs. 5 ml of 0.1 N HCl was replaced to maintain the

constant volume throughout the experiment. The percentage of ciprofloxacin released from each formulation was measured at 270 nm using UV-visible spectrophotometer (Elico-SL164).

**Table 1. Tablet composition of different formulations of ciprofloxacin HCl controlled release matrix tablets with TSP**

| **Ingredients** (mg/tablet) | **T1** | **T2** | **T3** | **T4** | **T5** | **T6** |
|---|---|---|---|---|---|---|
| Ciprofloxacin | 200 | 200 | 200 | 200 | 200 | 200 |
| Tamarindseed polysaccharide | 50 | 75 | 100 | 125 | 150 | 175 |
| Microcrystalline cellulose | 222 | 197 | 172 | 147 | 122 | 97 |
| PVP K 30 (5%) | 25 | 25 | 25 | 25 | 25 | 25 |
| Magnesium Stearate | 02 | 02 | 02 | 02 | 02 | 02 |
| Talc | 01 | 01 | 01 | 01 | 01 | 01 |

**Table 2. Tablet composition of different formulations of ciprofloxacin HCl controlled release matrix tablets with HPMC K-100**

| **Ingredients** (mg/tablet) | **H1** | **H2** | **H3** | **H4** | **H5** | **H6** |
|---|---|---|---|---|---|---|
| Ciprofloxacin | 200 | 200 | 200 | 200 | 200 | 200 |
| HPMC K-100 | 50 | 75 | 100 | 125 | 150 | 175 |
| Microcrystalline cellulose | 222 | 197 | 172 | 147 | 122 | 97 |
| PVP K 30 (5%) | 25 | 25 | 25 | 25 | 25 | 25 |
| Magnesium Stearate | 02 | 02 | 02 | 02 | 02 | 02 |
| Talc | 01 | 01 | 01 | 01 | 01 | 01 |

**Table 3. Tablet composition of different formulations of ciprofloxacin HCl controlled release matrix tablets with Xanthan gum**

| **Ingredients** (mg/tablet) | **X1** | **X2** | **X3** | **X4** | **X5** | **X6** |
|---|---|---|---|---|---|---|
| Ciprofloxacin | 200 | 200 | 200 | 200 | 200 | 200 |
| Xanthan gum | 50 | 75 | 100 | 125 | 150 | 175 |
| Microcrystalline cellulose | 222 | 197 | 172 | 147 | 122 | 97 |
| PVP K 30 (5%) | 25 | 25 | 25 | 25 | 25 | 25 |
| Magnesium Stearate | 02 | 02 | 02 | 02 | 02 | 02 |
| Talc | 01 | 01 | 01 | 01 | 01 | 01 |

**Figure 1. Modified physical balance for Measurement of mucoadhesive strength**

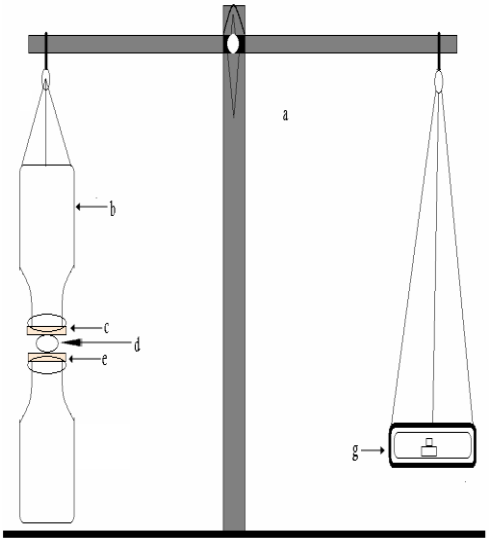
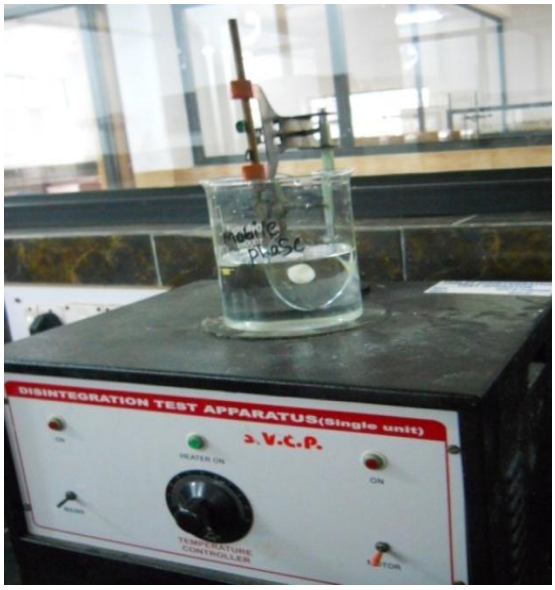



**Figure 2. Tablet adhesion retention period measurement apparatus**



**RESULTS AND DISCUSSION**

In the present study, ciprofloxacin HCL controlled release mucoadhesive matrix tablets were prepared by using, three polymers tamarind seed polysaccharides (TSP), HPMC K 100M and Xanthan gum, with six percentages (10%, 15%, 20%, 25%, 30% and 35%). A total number of six formulations were prepared by non-aqueous wet granulation method. Angle of repose for all formulations is between 30 to 35, bulk density is between 0.430-0.3498, tapped density is between 0.512- 0.568, bulkiness is between 2.49-3.00, compressibility index is between 11-18 is within the acceptable limits, and hausners ratio is between 1.11-1.18. The above values of pre compression parameters show the prepared granules having good flow property (Table No. 4). weight variation was within ±5% it was within the acceptable limit, hardness was within 4-10 was within the acceptable limits, friability was within 1% it was within the limit, drug content was within 90-110 it was within the acceptable limits, all formulations showed uniform thickness (Table No. 5).

Infra-red (IR) spectroscopy was used as means of studying drug – polymer compatibility and confirmed by comparing undisturbed structure of IR spectra of Ciprofloxacin. The major peaks O-H, C=O, Aromatic C-H, and C-F stretching at 3527.80$cm^{-1}$, 1704.48$cm^{-1}$, 1491.46$cm^{-1}$, 1341.40 $cm^{-1}$ (Figure No. 3)which were present in drug ciprofloxacin HCl are also present in physical mixture which indicated no drug- polymer interaction.

The DSC thermogram of ciprofloxacin HCl exhibited endothermic peak at 257.97°C, ciprofloxacin HCl physical mixtures of TSP at 247.60°C, ciprofloxacin HCl physical mixtures of HPMC K-100 at 241.62°C and ciprofloxacin HCl physical mixtures of xanthan gum at 247.62°C. The results depicted that there exists a slight variation in the endothermic peaks of ciprofloxacin HCl to that of physical mixtures. The DSC thermograms are shown in the Figure No. 4.

To know the effect of polymer blend on water uptake capacity of matrix tablets, the tablets were subjected for swelling studies. Figure No. 5, 6, 7 depict the swelling behaviour of different matrix tablets. Swelling of the matrix, which is indicated by the transition of the polymer from the glassy to the rubbery state, is an important parameter in the determination of the release characteristics of the matrix system. Matrix tablets of TSP were intact up to 8hrs during swelling study in 0.1 N HCl.

The in vitro retention time is one of the important physical parameter of mucoadhesive tablet which was recorded as per the procedure mentioned above. The results shows that H1, H2, H3, X1, X2, X3 tablets shows lower in vitro retention time of 4 hours, While the TSP groups tablets show the longer retention time of greater than 8 hours.. For In-vitro Retention time, the results shows that H1, H2, H3, X1, X2, X3 tablets shows lower in vitro retention time due to erosion and faster fragmentation within 4 hours (Table No. 6, 7, 8).

The mucoadhesive strength of tablet was dependent on the property of the bioadhesive polymers, which on hydration adhere to the mucosal surface and also on the concentration of polymer used. Mucoadhesive strength and mucoadhesive force values are given in table.

*In- vitro* release studies were carried out for all the formulations as per USP-II tablet dissolution tester employing rotating paddle at 50 rpm using 900 ml of 0.1 N HCl as dissolution medium. The results were evaluated for 12 hr. As per the results (Figure No. 8, 9, 10) of dissolution study formulations T1, T2, T3, T4, T5, T6,H1, H2, H3, H4, H5, H6, X1, X2, X3, X4, X5, X6 showed 97.22%, 97.78%, 98.22%, 97.66%, 98.86%, 94.22%, 97.85%, 97.48%, 97.17%, 98.53%, 96.67%, 97.88%, 97.83%, 97.45%, 97.37%, 98.5%, 96.68% and 97.5% respectively. This showed that the drug release from the tablet was sustained for 4 to 12 hr. T1 with 10% TSP, H1 with 10% HPMC K-100, X1 10% xanthan gum as retardant showed 97.22 %, 97.85 % and 97.83% release within 5 hr. where as in formulation F5 with 30% TSP, H5 with 30% HPMC K-100, X1 30% xanthan gum as a retardant showed 98.22 %, 97.17%, 97.37% release up to 12hr. This is mainly due to increasing polymer concentration or increasing path length diffusion. By using the different concentrations of TSP, HPMC K-100 and xanthan gum as a release retardant, drug release from TSP, HPMC K-100 and xanthan gum showed sustained for 4 to 12hr by varying the concentration of polymer matrix composition. Formulation F5 and F6 with TSP showed reasonable release 98.06, 94.12, %. And formulation F10, F11, F12 with Sodium CMC showed reasonable release 98.50, 96.68, 97.5 %, respectively. From the above results, it was found that the drug release is depleted as the concentration of TSP and Sodium CMC polymer was increased in polymeric matrix composition. Hence, formulations T5 with TSP, H6 with HPMC K-100, X6 with xanthan gum were found to be most promising formulations as they showed controlled release (98.86 %, 97.57 % and 97.5%) as well as maintained excellent matrix integrity during the period of study. Also all other parameters like hardness, thickness, friability, drug content and weight variation for these formulations were within the range. So, formulations T5, H6 and X6 were selected as the optimized formulations.

**Figure 3. Overlaid FT-IR graphs**

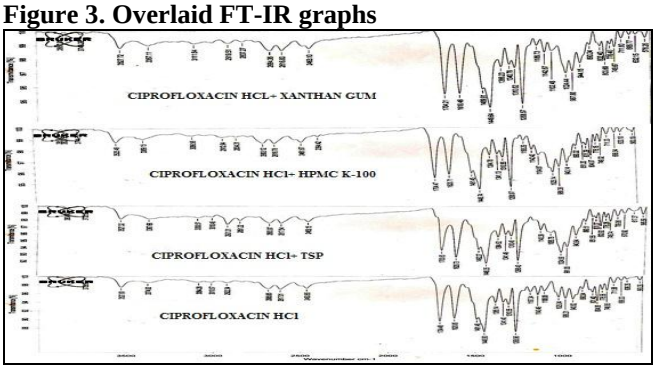


**Table 4. Granular properties of Ciprofloxacin HCl mucoadhesive controlled release tablets**

| Formulation code | Granular properties | | |
|---|---|---|---|
| | Angle of repose | Hausner ratio | Compressibility index (%) |
| **T1** | 28.23 ± 1.6 | 1.214± 0.016 | 13.39 ± 0.76 |
| **T2** | 28.16 ± 1.31 | 1.116± 0.011 | 12.20 ± 1.64 |
| **T3** | 27.22 ± 1.59 | 1.118± 0.013 | 10.74 ± 1.34 |
| **T4** | 29.89 ± 1.45 | 1.051± 0.015 | 13.60 ± 1.49 |
| **T5** | 28.92 ± 1.61 | 1.151± 0.011 | 16.31 ± 0.79 |
| **T6** | 26.90±1.23 | 1.094± 0.012 | 15.26±1.36 |
| **H1** | 25.30 ± 1.45 | 1.178± 0.014 | 14.11 ± 0.76 |
| **H2** | 24.55 ± 1.53 | 1.056± 0.013 | 15.13 ± 1.64 |
| **H3** | 28.98 ± 1.57 | 1.161± 0.019 | 13.65 ± 1.34 |
| **H4** | 29.85 ± 1.44 | 1.138± 0.014 | 17.21 ± 1.49 |
| **H5** | 28.97 ± 1.58 | 1.191± 0.018 | 16.22 ± 0.87 |
| **H6** | 27.13±1.23 | 1.178± 0.014 | 15.19 ± 1.36 |
| **X1** | 25.35 ± 1.62 | 1.178± 0.015 | 13.16 ± 0.54 |
| **X2** | 24.34 ± 1.45 | 1.060± 0.014 | 14.18 ± 1.42 |
| **X3** | 27.57 ± 1.52 | 1.171± 0.011 | 12.64 ± 1.12 |
| **X4** | 28.35 ± 1.64 | 1.137± 0.015 | 16.27 ± 1.27 |
| **X5** | 28.58 ± 1.37 | 1.216± 0.014 | 15.29 ± 0.65 |
| **X6** | 27.13±1.26 | 1.194± 0.017 | 14.15 ± 1.14 |

**Table 5. Tablet properties of Ciprofloxacin HCl mucoadhesive controlled release tablets**

| Formulation code | Parameters | | | |
|---|---|---|---|---|
| | Thickness(mm) | Hardness (kg/cm$^2$) | Friability (%) | % 0f drug content |
| **T1** | 3.86 ± 0.15 | 5.9 ± 0.15 | 0.154 ± 0.13 | 99.45 |
| **T2** | 3.89 ± 0.17 | 6.0 ± 0.23 | 0.25 ± 0.41 | 99.79 |
| **T3** | 3.87 ± 0.33 | 5.8 ± 0.17 | 0.370 ± 0.21 | 100.04 |
| **T4** | 3.90 ± 0.12 | 5.9 ± 0.14 | 0.252 ± 0.12 | 99.65 |
| **T5** | 3.91 ± 0.18 | 6.2 ± 0.49 | 0.342 ± 0.35 | 99.36 |
| **T6** | 3.92 ± 0.14 | 6.3 ± 0.12 | 0.349 ± 0.21 | 99.51 |
| **H1** | 3.93 ± 1.62 | 6.4 ± 0.25 | 0.321±0.013 | 99.55 |
| **H2** | 3.85 ± 1.32 | 6.5 ±0.34 | 0.529±0.011 | 99.89 |
| **H3** | 3.86 ± 1.57 | 6.2 ± 0.15 | 0.239±0.014 | 99.87 |
| **H4** | 3.89 ± 1.43 | 6.5 ±0.44 | 0.410±0.012 | 99.64 |
| **H5** | 3.96 ± 1.58 | 6.8 ± 013 | 0.348±0.016 | 99.48 |
| **H6** | 3.94±1.29 | 6.7 ± 0.34 | 0.430± 0.01 | 99.68 |
| **X1** | 3.89 ± 0.15 | 6.0 ± 0.15 | 0.254 ± 0.24 | 99.58 |
| **X2** | 3.92 ± 0.17 | 6.2 ± 0.23 | 0.325 ± 0.42 | 99.53 |
| **X3** | 3.87 ± 0.33 | 5.9 ± 0.17 | 0.470 ± 0.23 | 99.74 |
| **X4** | 3.92 ± 0.12 | 6.3 ± 0.14 | 0.352 ± 0.15 | 99.69 |
| **X5** | 3.94 ± 0.18 | 6.4 ± 0.49 | 0.442 ± 0.38 | 99.47 |
| **X6** | 3.96 ± 0.14 | 6.5 ± 0.12 | 0.449 ± 0.23 | 99.24 |

**Table 6. Mucoadhesive parameters of formulations from T1 to T2**

| Formulation code | Parameters | |
|---|---|---|
| | Mucoadhesive strength(g) | Adhesion retention period |
| **T1** | 18.46 | 4 hours 48 min. |
| **T2** | 18.72 | 5 hours 15 min. |
| **T3** | 19.29 | 6 hours 42 min. |
| **T4** | 19.56 | 7 hours 15 min. |
| **T5** | 19.46 | 8 hours 5 min. |
| **T6** | 19.78 | 8 hours 30 min. |

**Table 7. Mucoadhesive parameters of formulations from T1 to T2**

| Formulation code | Parameters | |
|---|---|---|
| | Mucoadhesive strength(g) | Adhesion retention period |
| **H1** | 16.71 | 2 hours 48 min. |
| **H2** | 17.07 | 3 hours 15 min. |
| **H3** | 17.42 | 4 hours 12 min. |
| **H4** | 18.29 | 5 hours 35 min. |
| **H5** | 18.72 | 6 hours 18 min. |
| **H6** | 18.81 | 6 hours 37 min. |

**Table 8. Mucoadhesive parameters of formulations from T1 to T2**

| Formulation code | Parameters | |
|---|---|---|
| | Mucoadhesive strength(g) | Adhesion retention period |
| **X1** | 16.71 | 2 hours 58 min. |
| **X2** | 17.07 | 3 hours 35 min. |
| **X3** | 17.42 | 4 hours 25 min. |
| **X4** | 18.29 | 5 hours 45 min. |
| **X5** | 18.72 | 6 hours 28 min. |
| **X6** | 18.81 | 6 hours 47 min. |

**Figure 4. Overlaid DSC thermograms**

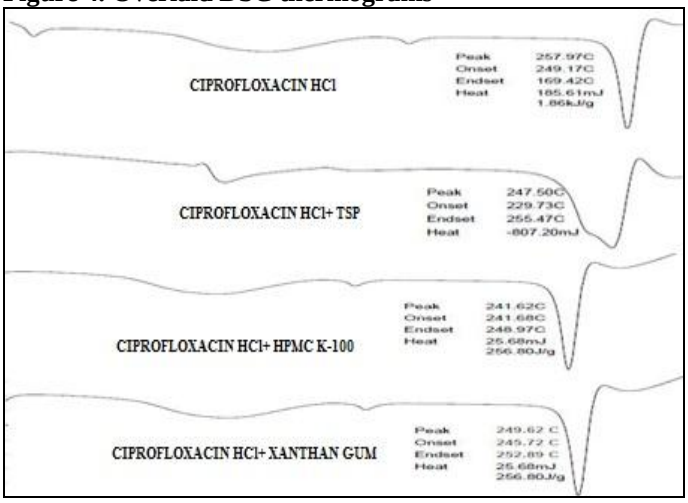



**Figure 5. Swelling index of Formulations T1 to T6**

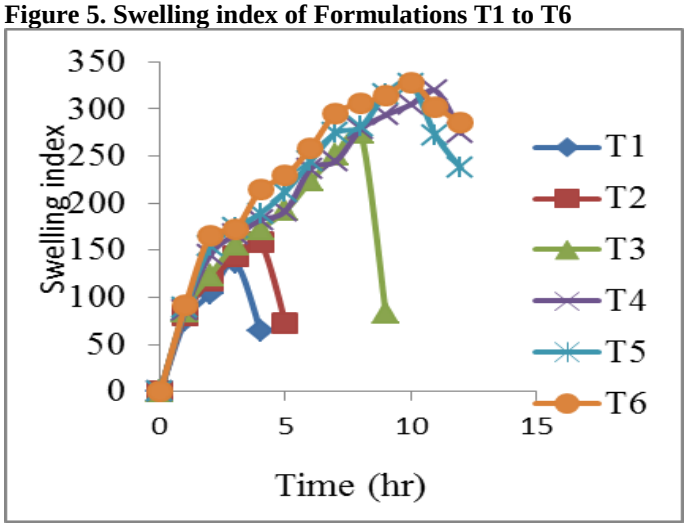



**Figure 6. Swelling index of Formulations H1 to H6**

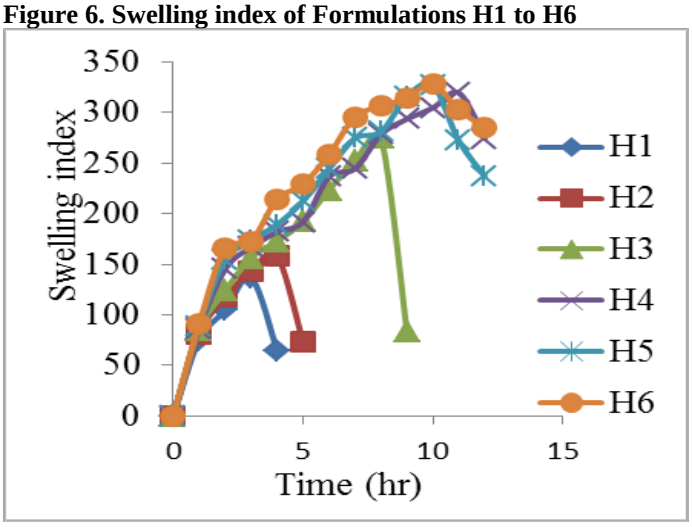



**Figure 7. Swelling index of Formulations X1 to X6**

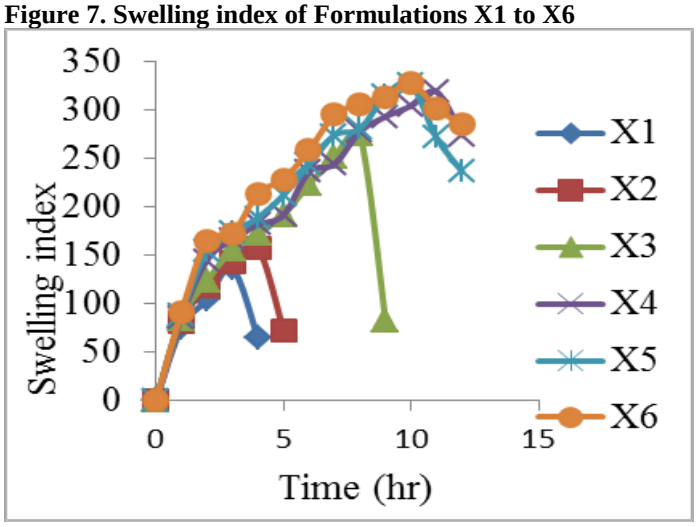


**Figure 8. *In-vitro* drug release profile of T1 to T2 formulations**

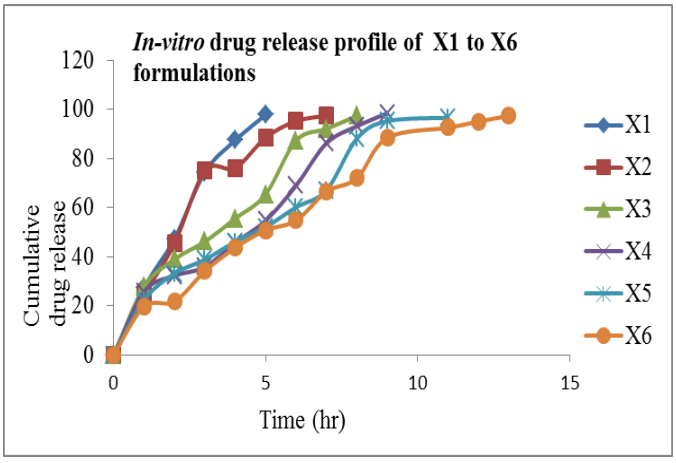



**Figure 9. *In-vitro* drug release profile of H1 to H2 formulations**

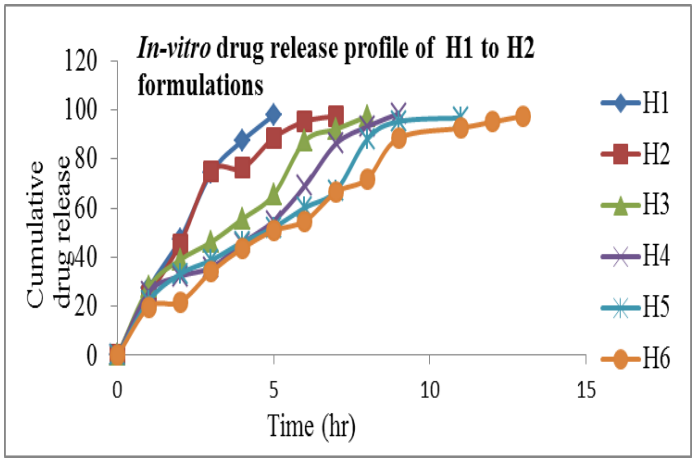
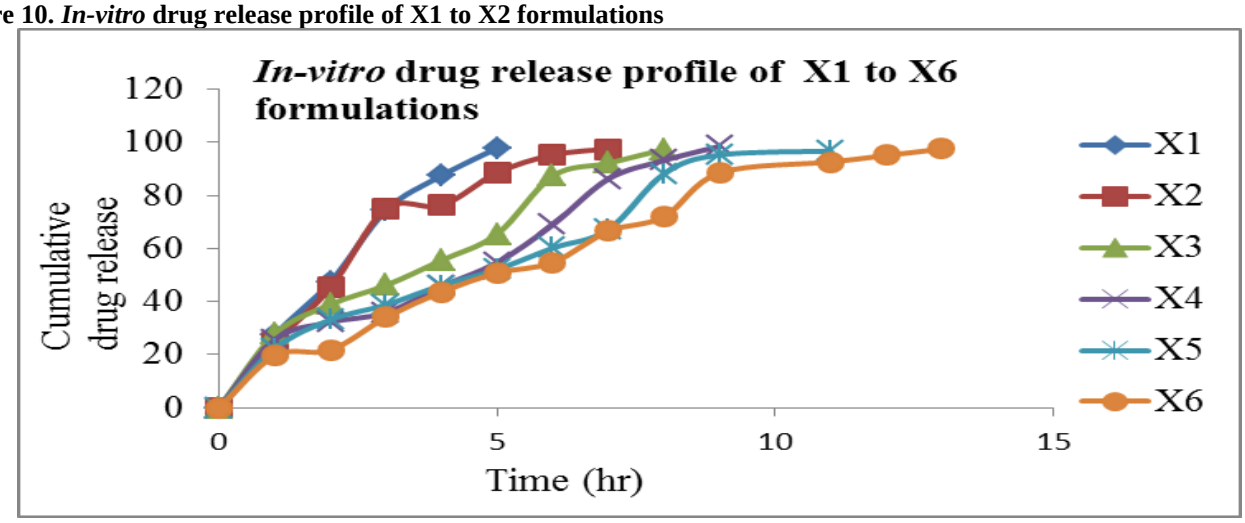



**Figure 10. *In-vitro* drug release profile of X1 to X2 formulations**




## CONCLUSION

In this present study controlled release mucoadhesive matrix tablet of ciprofloxacin HCl was prepared by non-aqueous wet granulation technique, using TSP, HPMC K-100 and Xanthan gum Polymers as mucoadhesive and release retardant components. It was found that increase in the concentration of TSP, HPMC K-100 and Xanthan gum in polymeric ratio decreases the drug release. TSP is non-carcinogenic, biocompatible and has high drug holding capacity. These led to its application as excipient in hydrophilic drug delivery system. HPMC K-100 and Xanthan gum swells in gastric fluid to produce a highly viscous layer around the tablet through which the drug must diffuse. This property makes them useful ingredients for sustained release matrix tablet. The formulation T5, H6 and X6 containing 30%, 35%, 35% of TSP, HPMC K-100 and Xanthan gum respectively showed good drug release with good matrix integrity. From the above result, it has been found that the optimized formula T5 containing 30% of TSP as drug retarding polymer shows better sustained effect for 12 hr when compared to H5 containing 30% of HPMC K-100 and X5 containing 30% of Xanthan gum having sustained effect for 11 hr. Different parameters like hardness, friability, weight variation, drug content uniformity, *in-vitro* drug release were evaluated for these formulations. Based on these results, formulations T5, H6 and X6 were found to be the most promising formulations.

## REFERENCES

1. Veiga T Saisa, ME Pina. *Drug Develop. Ind. Pharm*, 1997, 23, 1997, 547.
2. Tripathi KD. *Essentials of Medical Pharmacology*, Jaypee Brothers, 4th ed., Delhi; 1996,
3. 696.
4. Goodman and Gilman's. *The pharmacological Basis of Therapeutics*, 9th ed, McGraw-Hill,
5. Newyork, 2003, 1065.

6. Nandi RC. A Process for preparation of polyose from the seeds of Tamarindus indica, Ind. Pat, 1975, 142-192,.
7. Rao PS, Srivastav HC. Tamarind. In Industrial Gums, (Ed.) R.L. Whistler, Academic Press, 2nd Ed, New York, 1973, 369-411.
8. Rao PS. Extraction and purification of tamarind seed polysaccharide. J Sci Ind Research, 4, 1946, 705.
9. Carr RL. *Chem. Eng*, 72, 1965, 163–168.
10. Cooper J and C Gunn, SJ Carter. *Tutorial Pharmacy*, 1986, 211–233.
11. Shah D, Shah Y and Rampradhan M. *Drug Dev. Ind. Pharm*, 23, 1977, 567–574.
12. Leon Lachman, Herbert A. Liberman and L Joseph Kamig. *The Theory and Practice of Industrial Pharmacy*, 3rd edition, 1991, 296 – 302.
13. Rippie E. *Encyclopedia of Pharmaceutical Technology*. J Swarbrick ; (Eds) Marcel Dekker
14. Inc. NY. 1990, 149-166.
15. Pharmacopoeia of India. Ministry of Health and Family Welfare, 2, 2007, 938.
16. Bhardwaj TR, Kanwar M and Lal R. *et al*. Natural gums and modified natural gums as sustained-release carriers. *Drug Dev. Ind. Pharm*, 26, 2000, 1025-1038.
17. Munday DL, Cox PJ. Compressed xanthan and karaya gum matrices: hydration, erosion and drug release mechanisms. *Int. J. Pharm*, 203, 2000, 179-192.
18. Korsmeyer RW, Peppas NA. Macromolecular and modelling aspects of swelling controlled systems, 2009.
19. Chinkering DE and Mothiowitz E. Defination, Mechanism and theories of bioadhesion, Bioadhesive Drug Delivery system, fundamental, Novel approaches and development, Marcel and dekker Inc 1999, 11-24.
20. Khar RP, Ahuja A, and Ali J. Mucoadhesive drug delivery system, CBS publication, 353.
21. Peppas NA, Sahlin JJ: Hydrogels as mucoadhesive and bioadhesive materials: a review. Biomaterials, 17, 1996, 1553.
22. Nakamura F, Ohta R, Machida Y, Nagai T. In vitro and in vivo nasal mucoadhesion of some water-soluble polymers. *Int. J. Pharm*, 134, 1996, 173–181.
23. Gangwar Shivam, Gangwar Satyam1, Singh Shivani, Jain Shobhit, Verma Sanjeev, Kumar Arvind. Starch as a Material for Drug Delivery. *International Journal of Biological & Pharmaceutical Research,* 1(2), 2010, 56-60.
24. Agaiah Goud B, Rajub J, Rambhau D. Improved Oral Absorption Of Carbamazepine From Sorbitan Monolaurate Based Proniosome Systems Containing Charged Surface Ligands. *International Journal of Biological & Pharmaceutical Research,* 3(1), 2012, 37-42.
25. Chandramohan K and Rajkapoor B. Comparative Pharmacokinetic Profile Of Tinidazole Colon Targeted Formulation With An Immediate Release Formulation. *International Journal of Biological & Pharmaceutical Research,* 3(1), 2012, 43-47.
26. Pankaj Shukla, Panchaxari M Dandagi, Rini Thomas, Sharath Chandra P. Effect Of Various Superdisintegrants On The Drug Release Profile And Disintegration Time Of Metaproterenol Sulfate Orally Disintegrating Tablets. *International Journal of Biological & Pharmaceutical Research,* 3(1), 2012, 169-176.