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# Formulation and evaluation of colon specific microbial degradable matrix tablet using sterculia gum as carrier

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## ABSTRACT

Current study is to develop the colon targeted matrix tablet using the natural polysaccharide sterculia gum as carrier and model drug ciprofloxacin HCl. The matrix tablets were prepared by wet granulation technology using the various proportions of sterculia gum with carbopol 934 P, sterculia gum and ethyl cellulose polymer blends. Granules of all formulations were evaluated for rheological, post compressional properties and *in vitro* dissolution study in different pH buffers of pH 1.2 , pH 7.4 , pH 6.8 (saline phosphate buffer) without and with 4% rat cecal content in order to mimic GIT condition . Formulation SGC2 to SGC4 and SGE7 to SGE9 has released 13.6% to 38.9% in the initial 5h and released more amount of drug in stomach and small intestine than colon. Formulation SGC5 containing 45% of sterculia gum and 25% carbopol 934 p and Formulation SGE10 containing 45% of sterculia gum and 25% ethyl cellulose has released minimum 10.91 % to 13.04 % in the initial 5h and sustained the drug release up to 24 h and at the end of study released 75% to 79.99%. Formulations with 4% rat cecal content at the end of 24 h study drug released is 90.44% to 95.33% indicating higher amount of drug release is due to enzymatic break down of sterculia gum in the matrix tablet. Hence the above results conclude that the formulation SGC5 and SGE10 are potential in targeting the drug to colon to treat irritable bowel disease.

***Key Words***: Ciprofloxacin HCl, Carbopol 934 P, Ethyl Cellulose, Wet granulation, Rat cecal content, Irritable bowel disease.

## INTRODUCTION

Colon, as a site offers distinct advantages on account of near neutral pH, a much longer transit time, reduced digestive enzymatic activity and a much greater responsivenes to absorption enhancers. For local pathologies of the colon, colon specific drug delivery, not only increase the bioavailability of the drug at the target site, reduce the dose to be administered but also would reduce the side effects. Various approaches have been developed for colon targeting. These include pH-sensitive polymers, time dependent release systems or enzymatically biodegradable colon delivery system (Sinha and Kumria, 2003).

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Time dependent release formulations are designed to restrict the drug release in stomach and small intestine and delivery the drug to colon. But variation in gastric and small intestine emptying time results in limiting the use. However the pH of the GIT is acidic in the stomach and increases in the small and large intestine. This pH variation in different segments of GI has been exploited for colon specific delivery. But the pH of GIT is subject to both inter and intra individual variations, depending upon the diet, disease, age, sex and the fed and fasted state. Hence the use of microbial triggered colon specific drug delivery system is essential (Sinha and Kumria, 2001).

The upper part of GIT, i.e. the stomach and the duodenum has a microflora of less than $10^3$–$10^4$ CFU/ml. The microflora of colon on the other side is in the range of $10^{11}$–$10^{12}$ CFU/ml consisting mainly of anaerobic bacteria, e.g. *Bacteroides*, *Bifidobacteria*, *Eubacteria*, *Clostridia*, *Enterococci*, *Enterobacteria*, etc.

This vast microflora fulfils its energy needs by fermenting various types of substrates that have been left undigested in the small intestine, e.g, di and trisaccharides, polysaccharide etc. For this fermentation, the microflora produces a vast number of enzymes like glucuronidase, xylosidase, arabinosidase, galactosidase, nitroreductase, azoreductase, deaminase and urea dehydroxylase . Because of the presence of these biodegradable enzymes only in the colon, the use of bacterial degradable polymers for colon specific drug delivery seems to be a more site specific approach as compared to other approaches (Vinay *et al.*, 2011). Some studies were carried out on the basis of the activity of colonic bacteria on polysaccharide. Rubinstein *et al.* have demonstrated the usefulness of pectin, calcium pectinate and chondroitin sulphate as potential colon-specific drug delivery carriers. Studies were also carried out on pectin formulations by Ashford *et al.* using pectinolytic enzymes and in vivo gamma scintigraphic studies (Rama *et al.*, 1998).

This given the idea to evaluate the usefulness of sterculia gum as carrier using model drug ciprofloxacin HCl. Sterculia gum is a complex polysaccharide of high molecular weight. A molecular weight as high as 9,500.000 and Viscosity of 1% solution is CPS >1100 has been reported. On hydrolysis it yields galactose, rhamnose and galacturonic acid (www.willybenecke.com/karaya 2012). The present research work aimed to develop the sterculia gum colon specific matrix tablet in combination with carbopol 934 P and ethyl cellulose at various proportions by wet granulation technology. To study the physical integrity up to 24 h and the *in vitro* dissolution without and with 4% rat cecal content to explore the application of sterculia gum as drug carrier in colon matrix tablet.

## MATERIAL AND METHOD

Ciprofloxacin HCl as gift sample obtained from gland pharma, Hyderabad. Sterculia gum as a gift sample received from Nutriroma Company, Hyderabad. The carbopol 934 P, ethyl cellulose, starch, talc and magnesium sterate was purchased from S.D. Fine chemicals, Mumbai, all other solvents used were of analytical grade.

**Method of preparation of Ciprofloxacin HCl colon targeted matrix carrier tablet** (Krishnaiah *et al.*, 2001)

The ingredients required to prepare a batch of tablets as given in formula (table 1) were weighed accurately and passed through # 120 mesh sieve and uniformly blended in a mortar. Starch pastes were prepared. The powder blend was taken in a mortar and was thoroughly triturated with starch paste to produce wet mass. Then wet mass was passed through mesh # 14. Granules so obtained were dried at 40°C for 2 h. Dried granules again passed through mesh # 18. Later, talc and magnesium sterate were added as required and blended. Then the granules are evaluated for rheological characteristics. The dried granules were compressed into tablet using 13 mm plain punches and at 4-8 kg/cm$^2$ pressure using a 10 station Tablet pilot press (Chamunda pharma, India). The obtained tablets were evaluated for post compressional characteristics and *in vitro* dissolution studies.

**Evaluation of pre compressional characteristics of ciprofloxacin granular bed**

*Angle of repose ($^o\theta$)* (Sudheshnababu *et al.*, 2012)

Angle of repose was determined by measuring the height and radius of the heap of the granule bed. A cylindrical two side open tube of 6 cm length is placed on graph paper. Granules were placed in the tube and slowly removed the tube vertically. With the help of scale the height and radius of the heap were measured and noted. Average of triplicate reading were noted (n = 3).

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

h = height of heap of granular bed.

r = radius of heap of granular bed.

*Bulk density*

Bulk density was determined (Konark instruments, India) by placing the granules blend in a measuring cylinder and the total volume was noted. The weight of granule bed was determined in a Dhona 200 D electronic balance. Bulk density was calculated by using the formula. Average of triplicate reading were noted (n = 3).

$$\text{Bulk density} = \frac{\text{Total weight of granules}}{\text{Total volume of granules}}$$

*Tapped density*

Tapped density was determined (Tapped density apparatus, Konark instruments, India) by taking the

**Table 1: Formulation of ciprofloxacin HCl colon targeted matrix tablet.**

| Ingredients | Formulation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | SGC1 | SGC2 | SGC3 | SGC4 | SGC5 | SGE6 | SGE7 | SGE8 | SGE9 | SGE10 |
| Ciprofloxacin HCl | 250 | 250 | 250 | 150 | 150 | 250 | 250 | 250 | 150 | 150 |
| Sterculia gum | 200 | 280 | 360 | 360 | 360 | 200 | 280 | 360 | 360 | 360 |
| Carbopol 934 p | 40 | 80 | 120 | 160 | 200 | - | - | - | - | - |
| Ethyl cellulose | - | - | - | - | - | 40 | 80 | 120 | 160 | 200 |
| Starch paste 10% | q.s | q.s | q.s | q.s | q.s | q.s | q.s | q.s | q.s | q.s |
| HPMC K4M | 294 | 174 | 54 | - | - | 294 | 174 | 54 | - | - |
| Na CMC | - | - | - | 114 | 74 | - | - | - | 114 | 74 |
| Talc | 10.6 | 10.6 | 10.6 | 10.6 | 10.6 | 10.6 | 10.6 | 10.6 | 10.6 | 10.6 |
| Mg.sterate | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 |
| Total weight mg | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 |

**Table 2: Evaluation of pre compressional properties of granular bed of ciprofloxacin HCl colon targeted matrix tablet.**

| Formulation | Angle of repose (˚θ) | | Bulk density ( g/cm³ ) | Tapped density ( g/cm³ ) | Compressibility index % |
|---|---|---|---|---|---|
| | Before adding glidant | After adding glidant | | | |
| SGC1 | 25.51 ± 0.36 | 24.48 ± 0.40 | 0.67 ± 0.02 | 0.71 ± 0.09 | 5.3 ± 0.40 |
| SGC2 | 25.67 ± 0.33 | 24.4 ± 0.15 | 0.58 ± 0.08 | 0.63 ± 0.04 | 9.3 ± 0.94 |
| SGC3 | 25.66 ± 0.3 | 24.2 ± 0.16 | 0.58 ± 0.02 | 0.63 ± 0.04 | 8.1 ± 1.14 |
| SGC4 | 27.22 ± 0.20 | 25.13 ± 0.27 | 0.43± 0.01 | 0.49 ± 0.01 | 8.1 ± 0.96 |
| SGC5 | 26.28 ± 0.41 | 24.70 ± 0.2 | 0.51 ± 0.06 | 0.55 ± 0.01 | 5.9 ± 0.96 |
| SGE6 | 25.17 ± 0.13 | 23.73 ± 0.24 | 0.48 ± 0.04 | 0.53 ± 0.01 | 9.3 ±1.34 |
| SGE7 | 28.29 ± 0.26 | 26.27 ± 0.41 | 0.47 ± 0.01 | 0.52 ± 0.03 | 10.7 ± 1.59 |
| SGE8 | 26.04 ± 0.48 | 24.52 ± 0.38 | 0.49 ± 0.04 | 0.57 ± 0.02 | 13.3 ± 1.34 |
| SGE9 | 29.30 ± 0.38 | 27.05 ± 0.08 | 0.48 ± 0.03 | 0.56 ± 0.01 | 13.4 ± 1.31 |
| SGE10 | 26.05 ± 0.12 | 24.34 ± 0.26 | 0.49 ±0 .08 | 0.57 ± 0.00 | 14.1 ± 0.27 |

**Table 3: Evaluation of post compressional properties of ciprofloxacin HCl colon targeted matrix tablet.**

| Formu-lation | Weight variation (mg) | Thickness (mm) | Diameter (mm) | Hardness (kg/cm3) | Dissintegra-tion | Friability % | Drug content (mg) |
|---|---|---|---|---|---|---|---|
| SGC1 | 804 ± 2.18 | 5.5 ± 0.12 | 13.5 ± 0.17 | 7.6 ± 0.16 | ND | 0.34 ± 0 .03 | 249 ± 0.9 |
| SGC2 | 803 ± 4.20 | 5.4 ± 0.02 | 13.7 ± 0.17 | 7.0 ± 0.33 | ND | 0.36 ± 0.05 | 251 ± 0.8 |
| SGC3 | 805 ± 2.18 | 5.2 ± 0.12 | 13.6 ± 0.18 | 6.6± 0.16 | ND | 0.34 ±0.04 | 249 ± 0.9 |
| SGC4 | 802 ± 1.12 | 5.4 ± 0.04 | 13.6 ± 0.14 | 6.8 ± 0.42 | ND | 0.37 ± 0.03 | 150 ± 0.6 |
| SGC5 | 800 ± 1.18 | 5.9± 0.12 | 13.2 ± 0.26 | 7.0 ± 0.22 | ND | 0.32 ± 0.05 | 150 ± 0.5 |
| SGE6 | 806 ± 2.20 | 5.3 ± 0.50 | 13.3 ± 0.22 | 6.8 ±0.18 | ND | 0.33 ± 0.08 | 251 ± 1.2 |
| SGE7 | 803 ± 4.10 | 5.5 ± 0.15 | 13.1 ± 0.07 | 7.0 ±0.33 | ND | 0.38 ±0.06 | 250 ± 1.2 |
| SGE8 | 804 ± 1.80 | 5.6 ± 0.16 | 13.4 ± 0.31 | 6.4 ±0.09 | ND | 0.44 ± 0.04 | 250 ± 0.8 |
| SGE9 | 803 ± 2.22 | 5.4 ± 0.18 | 13.5 ± 0.13 | 5.6 ± 0.28 | ND | 0.40 ± .18 | 151 ± 0.3 |
| SGE10 | 804 ± 3.20 | 5.6 ± 0.20 | 13.5 ± 0.12 | 6.0 ± 0.56 | ND | 0.41 ± 0.06 | 151 ± 0.6 |

**Table 4: Swelling study of sterculia gum containing Ciprofloxacin HCl colon targeted matrix tablets.**

| Time (hour) | % swelling index | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | SGC2 | SGC3 | SGC4 | SGC5 | SGE7 | SGE8 | SGE9 | SGE10 |
| 0.00 | 0 | 0 | 0.00 | 0.00 | 0 | 0 | 0.00 | 0.00 |
| 0.25 | 14.54 | 17.23 | 22.12 | 27.34 | 12.32 | 15.31 | 18.42 | 20.52 |
| 0.50 | 18.26 | 20 | 35.62 | 42.26 | 15.96 | 19.32 | 26.42 | 31.23 |
| 1.00 | 25.12 | 26.24 | 48.32 | 58.16 | 23.21 | 26.87 | 32.86 | 41.25 |
| 2.00 | 35.78 | 38.28 | 65.56 | 76.84 | 31.27 | 34.59 | 46.24 | 54.96 |
| 4.00 | 40.98 | 42.56 | 98.14 | 108.4 | 38.52 | 40.23 | 72.62 | 90.28 |
| 6.00 | 58.36 | 60.44 | 124.4 | 136.3 | 49.86 | 52.32 | 96.54 | 120.4 |
| 8.00 | 61.58 | 63.98 | 145.2 | 166.4 | 54.64 | 57.92 | 125.4 | 148.3 |

dried granules in a measuring cylinder and measuring the volume of granules after 100 tappings and weight of the total granules. Average of triplicate reading were noted (n = 3).

$$\text{Tapped density} = \frac{\text{Weight of granules}}{\text{Volume of granules after 100 toppings}}$$

*Compressibility index* (Pornsak *et al.*, 2007)

Compressibility index was determined by placing the granules in a measuring cylinder and the volume (V0) was noted before tapping. After 100 tapings again volume (V¬) was noted. Average of triplicate compressibility indices of granule readings were taken and tabulated (n = 3).

$$\text{Compressibility index} = 1 - \frac{V}{Vo} X\ 100$$

$V_0$ = volume of powder/granules before tapping.
V = volume of powder/granules after 100 tapings.

**Evaluation of compressional characteristics of the ciprofloxacin tablets**

*Weight uniformity*

Twenty tablets were taken and weighed individually. Average weight was calculated standard deviation and percent coefficient of variance was computed.

*Thickness test*

The tablets were evaluated for their thickness using a micrometer (Mitutoyo, Japan). Average of three readings were taken and the results were tabulated (n = 3).

*Diameter test*

The tablets were evaluated for diameter using a micrometer (Mitutoyo, Japan). Average of three readings were taken and tabulated (n = 3).

*Hardness test*

The tablets were evaluated for their hardness using Pfizer hardness tester. Average of three reading were taken and tabulated (n = 3).

*Friability test*

The friability of the tablets was determined in Roche Friabilator. Five tablets were weighed accurately and placed in the tumbling chamber and rotated at 25 rpm for a period of 4 min. Tablets were taken and again weighed. The percentage weight loss was determined by using formula given below. The experiment was repeated for three times and average was noted.

$$\%\ \text{Friability} = \frac{\text{Initial wt of tablets} - \text{Final wt of tablets}}{\text{Initial wt of tablets}} \text{ X } 100$$

*Swelling study* (Pornsak *et al.*, 2007)

Accurately weighed tablet was placed in a Petridish containing 100 ml of distilled water. At regular intervals of time, the tablet was taken out and the excess moisture on the surface of tablet was removed with tissue paper and the tablets were weighed again. The percent of swelling index were calculated by using formula.

$$\%\ \text{Swelling} = \frac{\text{Final wt of tablet-Initial wt of tablet}}{\text{Initial wt of tablet}}$$

*Determination of drug content* (Thahera *et al.*, 2012)

Five Ciprofloxacin tablets were crushed into powder in a mortar and powdered equivalent to ciprofloxacin dose was taken in a volumetric flask containing distilled water and kept aside with constant shaking on a rotary shaker for 24 h to extract the total drug present in the tablet. Then the absorbance of the solutions was measured after suitable dilution at 271 nm against distilled water as blank. Averages of triplicate readings were taken. The content of drug was calculated using slope from calibration curve.

*In vitro dissolution study* (Krishnaiah *et al.*, 1998)

The *in vitro* dissolution study was performed in three different buffers of pH 1.2 for 2 h and pH 7.4 for 3 h and pH 6.8 for 19 h without and with 4% rat cecal content in order to mimic from mouth to colon.

The drug release study were carried out in pH 1.2 in USP dissolution test apparatus of 900 ml fluid (Apparatus 1, 100 rpm, 37°C) at regular interval sample is withdrawn and suitable dilutions are made and estimated for amount of drug release by measuring absorbance of sample in UV spectrophotometer at the $\lambda_{max}$ of 271 nm. At the end of study dissolution medium were replaced with Sorenson phosphate buffer of pH 7.4 and continued the drug release study for 3 h. The samples were withdrawn at regular intervals and diluted with respective dissolution medium and estimated the drug release by measuring the sample absorbance at $\lambda_{max}$ of the drug in UV spectrophotometer.

**Table 5:** ***In vitro*** **release of ciprofloxacin HCl from colon targeted sterculia gum as carrier in matrix tablet.**

| Time (hour) | Formulations | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SGC1 | SGC2 | | SGC3 | | SGC4 | | SGC5 | | SGE6 | SGE7 | | SGE8 | | SGE9 | | SGE10 | |
| | % Cu.A. Realese | % Cu.A.Realese | | % Cu.A.Realese | | % Cu.A.Realese | | % Cu.A.Realese | | % Cu.A. Realese | % Cu.A.Realese | | % Cu.A.Realese | | % Cu.A.Realese | | % Cu.A.Realese | |
| | | Control | With cecal | Control | With cecal | Control | With cecal | Control | With cecal | | Control | With cecal | Control | With cecal | Control | With cecal | Control | With cecal |
| 0.00 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0.5 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1 | 3.90 | 7.50 | 2.00 | 1.60 | 1.40 | 2.96 | 3.53 | 3.44 | 4.14 | 8.40 | 0.60 | 0.60 | 3.50 | 0.60 | 2.42 | 2.86 | 2.25 | 2.68 |
| 2 | 13.50 | 13.2 | 5.80 | 3.20 | 3.40 | 6.74 | 8.04 | 7.68 | 9.26 | 21.7 | 3.80 | 4.20 | 8.80 | 2.80 | 5.46 | 6.46 | 5.01 | 5.97 |
| 3 | 36.60 | 21.3 | 15.2 | 8.80 | 9.20 | 9.30 | 11.1 | 8.89 | 10.7 | 57.7 | 11.2 | 14.4 | 12.0 | 7.80 | 8.65 | 10.2 | 7.82 | 9.32 |
| 5 | 73.60 | 31.7 | 30.4 | 15.8 | 15.5 | 11.3 | 13.5 | 10.9 | 13.2 | 100.8 | 38.9 | 34.7 | 20.3 | 17.9 | 12.0 | 14.2 | 10.9 | 13.0 |
| 6 | 99.80 | 40.1 | 61.9 | 17.8 | 30.6 | 16.4 | 19.6 | 13.7 | 16.6 | - | 49.7 | 75.1 | 27.1 | 20.4 | 16.8 | 19.9 | 15.3 | 18.3 |
| 9 | - | 91.0 | 100.3 | 24.0 | 53.9 | 23. 4 | 27.8 | 18.9 | 22.9 | - | 99.4 | 100.3 | 55.1 | 66.2 | 21.9 | 26.0 | 21.5 | 25.1 |
| 12 | - | 99.9 | - | 52.5 | 74.7 | 28.9 | 34.5 | 25.5 | 30.2 | - | | | 69.8 | 82.9 | 28.2 | 33.4 | 27.2 | 32.5 |
| 15 | - | - | - | 78.5 | 98.9 | 39.9 | 47.6 | 35.9 | 43.4 | - | | | 79.4 | 99.9 | 42.1 | 49.8 | 39.7 | 47.6 |
| 20 | - | - | - | 99.3 | - | 62.2 | 74.1 | 59.0 | 71.2 | - | | | 99.7 | | 65.9 | 77.9 | 62.9 | 75.1 |
| 24 | - | - | - | | - | 78.0 | 93.0 | 75.0 | 90.4 | - | | | | | 83.0 | 98.2 | 79.9 | 95.3 |

*Rat cecal content collection*

The susceptibility of matrix tablet to colonic enzymatic degradation was assessed by conducting drug release studies by modify USP dissolution apparatus. A 150 ml beaker containing 100 ml of 4 % w/v rat cecal content was placed and the basket was manipulated to the centre of the beaker. The rat cecal content was collected from male albino rats. The rats of 150-200g were selected and kept for fasting for one day with intermittent administering water before experiment. The rats were taken from cage and anesthetized by spinal cord traction before 30 min prior to the experiment. Abdomen of rat was opened and the caecum was ligated at both ends and then suspended in saline phosphate buffer of pH 6.8 with the continuous supply of $CO_2$, in order to maintain the anaerobic condition. The caecum were opened and the cecal contents were weighed, transferred into 100 ml of Sorenson phosphate buffer of pH 6.8 to make 4% w/v of rat cecal content solution, the cecal enzymes are active in anaerobic condition, to mimic the anaerobic condition, the solution was continuously bubbled with $CO_2$.

The drug release study of matrix tablet was conducted in modified dissolution apparatus, by placing the tablet in basket and immersed in 100 ml of 4% rat caecal content in Sorenson phosphate buffer of pH 6.8 in 150 ml beaker. The beaker was maintained at 37°C with continuous supply of $CO_2$, studied the drug release up to 19 - 20 h as the colonic transit time 24 h. The sample was withdrawn at regular intervals by maintaining sink condition. Absorbance of the sample was measured in UV spectrophotometer at 271nm of the drug and concentration was calculated by regression equation.

## RESULTS AND DISCUSSION

In the present research work colon targeted matrix tablets were developed by using sterculia gum as matrix carrier. The developed formulations SGC1 to SGC5 are containing the sterculia gum with carbopol 934 P and formulation SGE6 to SGE10 containing the sterculia gum with ethyl cellulose. In the above formulations sterculia gum 45% is kept constant and studied the effect of concentration variation of carbopol 934 P and ethyl cellulose. The angle of repose of all formulation before adding glidant were found between 25.5±0.36° and after adding glidant ratio of 2:1 reduced the angle of repose and found between 29.30±0.38°. Bulk densities of all formulations were found in the range of 0.43±0.01 to 0.67±0.02 g/cc and the tapped densities were found between 0.49±0.01 and 0.71±0.09 g/cc. The compressibility index of all formulations was found between 5.3±0.40 and 14.1±0.27%. The above results indicated that the granules are freely flowing and easily compressible.

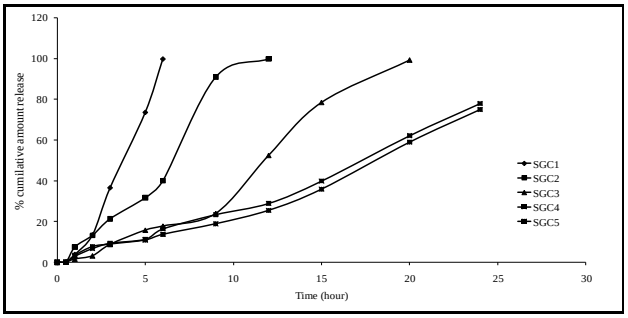


**Figure 1: Comparative *In vitro* release of ciprofloxacin HCl from the formulation SGC1,SGC2,SGC3,SGC4 and SGC5 using carrier sterculia gum in combination with carbopol 934 p without rat cecal content.**

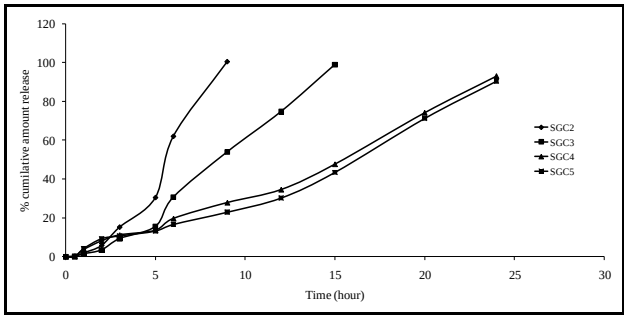


**Figure 2: Comparative *In vitro* release of ciprofloxacin HCl from the formulation,SGC2,SGC3,SGC4 and SGC5 using carrier sterculia gum in combination with carbopol 934 p with rat cecal content.**

Colon targeted matrix tablets were prepared on 10 station tablet punching machine and evaluated for post compressional charactestics and *in vitro* study with and without 4% rat. Tablets weight variation were found between 800 ±1.78 to 804 ± 3.20 mg and thickness was found in the range of 5.2 ±0.12 to 5.60 ± 0.20 mm. The diameter of tablets was found in the range of 13.1 ± 0.07 to 13.7 ± 0.17 mm. The above results confirm that tablets within the IP specification limit and are reproducible from batch to batch. Tablets hardness was found in between 5.6 ± 0.28 and 7.6 ± 0.16 kg/cm$^3$ and the friability is less than 1% indicating the tablets are having the sufficient strength and hardness, which will remain intact during drug release studies. The drug content was in the range of 99% to 100% showed content uniformity.

The formulations were subjected to swelling study upto 8 h in Petridish containing distilled water. The percentage of swelling index of SGC2 to SGC5 formulations were found between 61.5% - 166.4%, and for formulation SGE7 to SGE10 swelling index was found between 54.64% - 148.3% indicating increasing in swelling index on increasing the polymer matrix concentration. The above results confirm that the formulation containing carbopol 934 P is having higher swelling index than the formulation containing the ethyl cellulose, since the carbopol 934 P highly swellable polymer which will give synergistic swelling with matrix carrier in the formulation.

To assess the physical integrity and intactness in the physiological environment of stomach and small intestine a drug release study was conducted in pH 1.2 buffer for 2 h and pH 7.4 buffer for 3 h. The susceptibility to enzymatic degradation in the colon *in vitro* study is performed without and with 4% rat cecal content upto 24 h.

The matrix tablet SGC1 containing 45% sterculia gum and 5% carbopol 934 P has released 99.8% of drug within 6 h and it could not sustain the drug delivery to colon which might be due to lower amount of carbopol in the tablet. On increasing the

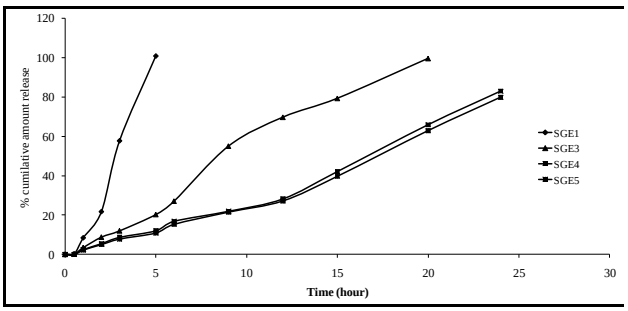


**Figure 3: Comparative *In vitro* release of ciprofloxacin HCl from the formulation SGE6, SGE7, SGE8, SGE9 and SGE10 using carrier sterculia gum in combination with ethyl cellulose without cecal content.**

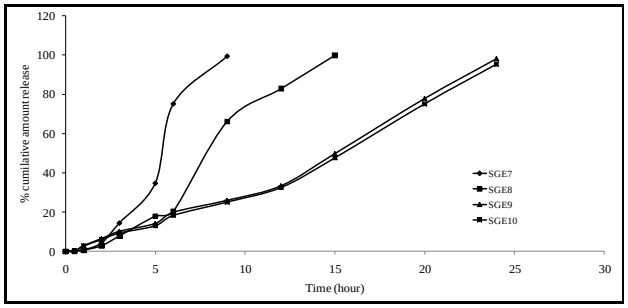


**Figure 4: Comparative *In vitro* release of ciprofloxacin HCl from the formulation SGE6, SGE7, SGE8, SGE9 and SGE10 using carrier sterculia gum in combination with ethyl cellulose with cecal content.**

5% more amount of carbopol in the formulation SGC2 has released 31.7% at 5 h and complete drug released at the end of 12 h is 99.9% indicating the increased amount of carbopol slightly sustained the drug release. Further in SGC3 containing 45% sterculia gum and 15% carbopol has released only 15.8% at 5h and released 99.3% drug at the end of 20 h is indicating increased amount of carbopol caused the higher swelling of tablet and sustained the drug release upto 20 h. The formulation in presence of 4% rat cecal at the end of 15 h drug released is 98.9% indicating the higher the drug release rate is due to enzymatic break of sterculia gum. Formulation SGC4 containing 45% sterculia gum and 20% carbopol has released only 11.34% at 5h and released 78% drug at the end of 24 h. The formulation in presence of 4% rat cecal at the end of 24 h drug released is 93% indicating the higher the drug release rate is due to enzymatic break down of sterculia gum. Formulation SGC5 containing 45% sterculia gum and 25% carbopol has released 10.00 % at 5 h and released 75% drug at the end of 24 h. The formulation in presence of 4% rat cecal at the end of 24 h drug released is 90.44% indicating the higher the drug release rate is due to enzymatic break down of sterculia gum.

Further formulations SGE6 to SGE10 are developed in combination of sterculia gum with ethylcellulose. Formulation SGE6 containing 45% sterculia gum and 5% ethyl cellulose has released 100.0% of drug within 5 h and it could not sustain the drug delivery to colon which might be due to lower amount of ethylcellulose in the tablet. On increasing ethyl cellulose to 5% in the formulation SGE7 has released 38.9% at 5 h and complete drug released at the end of 9 h is 100.3% however more amount of drug is released in stomach and small intestine, hence further study with 4% rat cecal content is not continued. Formulation SGE8 containing 45% sterculia gum and 15% ethyl cellulose has released 20.30 % of drug within 5 h and released 99.70% drug at the end of 21h indicating the increased amount of ethylcellulose reduced the drug release in first 5 h and sustained the release up to 21 h. The formulation in presence of 4% rat cecal drug released at 15 h is 99.9% indicating higher drug release rate due break down of sterculia gum by cecal content.

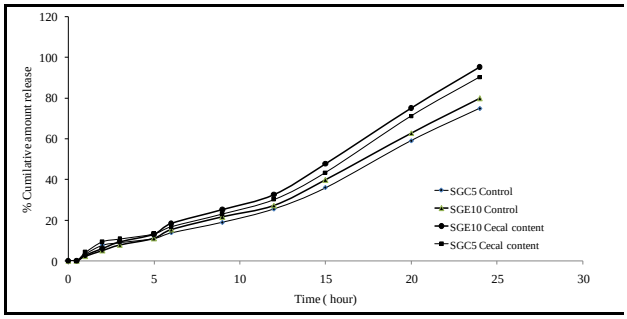


**Figure 5: Comparative *In vitro* release of ciprofloxacin HCl from the formulation SGC5 and SGE10 with out and with cecal content.**

Further SGE9 formulation containing 45% sterculia gum and 20% ethyl cellulose released 12% drug within 5 h and released 83% drug at the end of 24h indicating the increased amount of ethylcellulose reduced drug release in first 5 h and sustained the release up to 24 h. The formulation with 4% rat cecal content released 98.19% drug at the end of 24 h indicating higher drug release rate due break down of sterculia gum by microbial degradation. Formulation SGE10 containing 45% sterculia gum and 25% ethyl cellulose has released 11% of drug within 5 h and released 79.99% drug at the end of 24h indicating increased amount of ethylcellulose reduced the drug release in first 5 h and sustained the release up to 24 h. The formulation with 4% rat cecal content at the end of 24 h drug released 95.33% indicating higher drug release rate due break down of sterculia gum by cecal content.

From the above results conclude that the formulation SGC5 and SGE10 prevent higher drug release in stomach and small intestine and could sustained the drug release up to 24 h and delivered the maximum amount of drug to colon. The sterculia gum in the formulation carried the drug to colon and released the drug by enzymatic break down of sterculia gum due to rat cecal content.

## CONCLUSION

Colon targeted matrix tablet are developed by using carrier sterculia gum and the model drug ciprofloxacin HCl. Granules are evaluated for rheological properties and the results confirm they are freely flowable and compressible within the acceptable limit. Matrix tablet is evaluated for post compressional study and results revealed that batches of

tablet are within IP specification and are reproducible from batch to batch. Among the developed formulation the SGC5 and SGE10 released minimum amount of drug in the physiological environment of stomach, small intestine and sustained the drug upto 24 h to carry maximum amount of drug to colon and released the drug there by enzymatic break down of sterculia gum. Hence the above results conclude that the matrix tablet SGC5 and SGE10 with sterculia gum are the potential colon targeted matrix tablet.

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