Original Article

Use of Black Gram Polysaccharide Mucilage as Release Retardant in the Development of Sustained Release Matrix Pellets of Ciprofloxacin Hydrochloride

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ABSTRACT

Ciprofloxacin HCl is a BCS class III drug with high solubility and low permeability. It is a second generation fluoroquinolone antibiotic used in the treatment of mild to moderate urinary and respiratory tract infections. It has half-life of 4-5 h and bioavailability about 70%. The main objective of this research work was to develop sustained release matrix pellets of ciprofloxacin HCl to obtained better delivery of ciprofloxacin HCl to the stomach and the proximal parts of the small intestine by increasing the mean residence time (MRT) in the stomach using novel natural excipient that is black gram polysaccharide as release retarding polymer. The pellets were prepared by an extruder spheronizer. The characterization of pellets was done using X-ray powder diffraction (XRPD), Scanning electron microscopy (SEM), flow properties, percent friability, drug content, percent production yield, swelling ability of pellets, mucoadhesive strength, and *in-vitro* drug release and stability studies. The optimized pellets were found to be free flowing and had yield 30.4% and drug content 97.79 ± 0.60%. The optimized formulation NF1 showed sustained drug release of 96.08% up to 12 h. The optimized formulation (NF1) showed good flow properties which were within the official limits. The optimized formulation showed percent mucoadhesion of 72% in 0.1N HCL (pH 1.2). It can be concluded that black gram polysaccharide mucilage can be effectively used as release retarding excipient in sustained release formulations.

Key words: Sustained release drug delivery system, Ethyl cellulose, Black gram polysaccharide, Pelletization, *in vitro* drug release study.

INTRODUCTION

Oral sustained drug delivery system is useful if a drug is well-absorbed throughout the entire gastrointestinal tract. However, some drugs tend to be absorbed only in the stomach or upper part of the small intestines, mainly because of a narrow absorption window. The delivery site has to be controlled in order to control absorption.[1] Physiological factors such as gastrointestinal transit time, regional pH, surface area, enzymatic activity and colonic microflora influence drug absorption; some of these factors may be used to achieve control over drug absorption.[2] Gastro retentive drug delivery system is controlled drug delivery system with prolonged residence time in the stomach is of particular interest for drugs that are locally active in the stomach, have an absorption window in the stomach or in the upper small intestine and unstable in the intestinal or colonic environment. As the total gastro intestinal transit time of the dosage form is increased by prolonging the gastric residence time, these systems can also be used as extended release devices with a reduced frequency of administration and, thus, improved patient compliance.[3,4] This type of drug delivery system will have relatively less side effect and removes the need of repeated dosages.[5]

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Matrix pellets are one of the most popular multi-particulate dosage forms. Pelletization is an agglomeration process that converts fine powders or granules of bulk drugs and excipients into small, free-flowing, spherical or semi spherical units, referred to as pellet.[6,7] Pellets as drug delivery system offer not only therapeutic advantages, such as less irritation of the gastro-intestinal tract and lowered risk of side effects due to dose dumping, but also technological advantages, for example, better flow properties, less friable dosage form, narrow particle size distribution, ease of coating and uniform packing. Pellets are commonly filled into hard gelatine capsules but can also be compressed to tablets.[8]

Ciprofloxacin HCl is broad-spectrum fluoroquinolone antibacterial agent and absorbed from the stomach and the proximal part of the small intestine with oral bioavailability of about 70 % and 4-5 h half-life. It is used in treatment of complicated and uncomplicated urinary tract infections (UTIs). It is the most active quinolone against *Pseudomonas Aeruginosa*. The mechanism involved is the inhibition of DNA gyrase enzyme which is an essential component of bacterial DNA replication.[9-13]

Black gram polysaccharide is naturally occurring polysaccharide contains proteins, D-galactose, L-rhamnose, galacturonic acid, L-arabinose which is isolated from black gram seeds.[14] There are various sustained release polymers available which includes hydroxyl propyl methyl cellulose (HPMC), ethyl cellulose, polyethylene oxide and chitosan.

The basic rationale behind sustained/controlled drug delivery is to alter the pharmacokinetics and pharmacodynamics of pharmacologically active substances by using novel drug delivery systems or by modifying the molecular structure and/or physiological parameters inherent in a selected route of administration.[15-23]

The main objective of the present work was to prepare sustained release matrix pellets using a novel excipient (black gram polysaccharide) by extrusion-spheronization so as to extend the residence time of the drug in the stomach. The prepared pellets were characterised by flow properties, mucoadhesive strength, SEM, *in vitro* drug release. Novelty of this work is that, the matrix pellets of Ciprofloxacin HCl using black gram polysaccharide as release retarding material has not been reported.

MATERIALS AND METHODS

Black gram seeds were purchased from the local market, Shirpur, Ciprofloxacin HCl was obtained as gift sample from Cipla Ltd, Mumbai. Ethyl cellulose, MCC, PVPK30 was obtained as a gift sample from Colorcon Asia Pvt. Ltd. Goa, India. Isopropyl alcohol was obtained from S.D Fine Chemicals. All the reagents used were of analytical grade.

Isolation of Black Gram Polysaccharide Mucilage

250 g of Black gram seeds were taken and ground into a powder in a grinder. 20 g of this powder was taken in 1000 mL beaker containing 800 mL of water and the slurry was prepared. This slurry was boiled at a temperature below 60°C for 2 h under stirring condition. The viscous solution was kept overnight for the release of polysaccharides into water and squeezed in a muslin cloth to obtained the filtrate. To this filtrate equal amount of acetone was added to precipitate the polysaccharides. The polysaccharides were separated by filtration method, dried, powdered and stored at room temperature in air tight container.[30]

Characterization of Black Gram Polysaccharide Mucilage

To confirm the presence of polysaccharide Ruthenium red test, Molisch's test and Iodine test were performed.

Molisch's test- To the mucilage powder alcoholic 1 mL solution of α-Naphthol and few drops of conc. H_2SO_4 was added. At the junction of liquids, formation of violet ring indicates presence of carbohydrates.

Ruthenium red test- Accurately, 0.5 mL Ruthenium red reagent was added to the mucilage solution. Pink colour indicates presence of mucilage.

Iodine test- 1 mL of Iodine solution was added to the mucilage solution, appearance of reddish brown colour indicates presence of carbohydrates.

Equipment and Process of Pelletization

The extruder spheronizer equipped with a Screw type extruder and a cross hatch pattern spheronizer was used for the preparation of pellets containing Ciprofloxacin HCl (Extruder Spheronizer, UICELAB, Umang Pharmatech Pvt Ltd). Six different batches of formulation were prepared with different concentrations of polymer (Table 2). The contents of the formulation batches were mixed thoroughly and then damp mass was prepared with 15% PVP K30 in isopropyl alcohol and water. The damp mass was then passed through extruder with 1.5 mm mesh aperture at 70 rpm for 15 min. The extrudates were then placed in spheronizer and it was then run at a speed of 700 rpm. The obtained pellets were then dried in hot air oven for 30 min.

Characterization of matrix pellets

FTIR Study

IR spectra were recorded for the pure drug, physical mixture of drug and excipient and optimized formulation.

The sample mixed with IR grade KBr in the ratio of 1:100 and compressed using motorized pellet press at 10-12 tons pressure. The prepared pellets were then scanned over the range of 4000 – 400 cm^{-1} to get the IR spectra by using a FTIR spectrophotometer. The FTIR spectrum of physical mixtures was compared with reported spectra of pure drug and carrier, to confirm any changes occur or not in the principal peaks of spectra of plain drug and carrier.

XRPD Study

The crystallinity of pure ciprofloxacin HCl and optimized formulation was evaluated by XRPD. The patterns were recorded for pure drug and optimized formulation using an X- ray diffractometer ((Brucker Axs, 08 Advance). Samples were irradiated with S radiation and analysed between 2ºC and 60ºC. The voltage and current used were 30KV and 30mA respectively.

Determination of Flow Properties

Flow properties of different pellets formulation batches were determined which includes angle of repose, flow rate, Car's index and Hausner's Ratio.

Determination of Friability

The percent friability of pellets was determined using Roche Friabilator. Accurately, weighed 500 mg of pellets (W_1) were placed in the chamber of a Roche Friabilator (Electrolab Friability tester, EF 2, Mumbai, India) and it was subjected to testing at 100 rpm. The pellets were weighed again after 100 revolutions. The percent friability was calculated by following equation,

$$\text{Percent friability} = \frac{W1 - W2}{W1} * 100 \quad (1)$$

Where W_1=Initial weight of pellets, W_2=weight after 100 revolutions

Determination of Roundness and Circularity

The roundness and circularity of pellets was measured using a Motic DMWB2-223 digital microscope fitted with a 1/3 CCD Camera imaging accessory. Motic Images 2000 (1.3 Version) image analysis software was used for the measurements. The average diameter and different shape parameters such as roundness and circularity were determined from these images.[24,25] The roundness and circularity values of the prepared pellets were determined by following equations,

$$\text{Roundness} = \frac{0.9399P}{4\pi A} \quad (2)$$

$$\text{Circularity} = \frac{4\pi A}{p^2} \quad (3)$$

Where, P is the perimeter of the pellet image and A isthe area determined by the total number of pixels within the feature. The factor 0.9399 corrects the perimeter for the effect of the corners produced by digitization of the image. A roundness value of 1 corresponds to the image of a perfect sphere.

Surface Topography

The surface morphology of pellets was analysed using a scanning electron microscopy (SEM) (S-4800, Type-II, Hitachi High Technologies Corp. Tokyo, Japan). The samples were mounted on aluminium stubs and then coated with palladium by using vacuum coater and images were captured. The examination was performed at an appropriated magnification (X-30, X-50, X-100,and X-1000) using scanning electron microscopy.

Determination of Production Yield

The production yield of manufactured pellets was determined using the weight of the final product after screening divided by the initial total weight of the formulation mixture (drug and other polymers) used for preparation of pellets. The percent production yields were calculated by the following equation,

$$\text{Percent production yield} = \frac{Pw}{Tw} * 100 \quad (4)$$

Where P_W = practical yield of pellets, $T_{W=}$Theoretical yield of pellets

Determination of Drug Content

100 mg pellets were taken and triturated in mortar and pestle which was then dissolve in distilled water; volume was made up to 100 mL and sonicated for 10 min, filtered through 0.45 µm filter paper. 1.0 mL of filtrate was diluted up to 10 mL and the drug content was determined spectrophotometrically by measuring the absorbance at 270 mm (UV-1700, Shimadzu).

Determination of Swelling Abilities of Pellets

The swelling ability of each pellet to swell in media was determined by this test according to previously reported method.[26,27,28] The accurately weighed (W_1) pellets were placed in plastic container containing 0.1 N HCL (pH 1.2) and allowed them to swell. The container was placed in Orbital shaking incubator (Remi Instruments Lmd-CSI-24). After relative time intervals the pellets were withdrawn from container, blotted with filter paper and weighed (W_2) again. The percentage of swelling was calculated using following equation.

$$\text{Percent swelling} = \frac{W2 - W1}{W1} * 100 \quad (5)$$

Where W_1 = Weight of pellets before immersion into media

W_2= Weight of pellets after immersion into media

Mucoadhesive Strength of Pellets

The mucoadhesive strength of pellets was determined with *in vitro* wash-off test.[29] In this test a piece of intestinal mucosa of goat was (2×2cm) taken, mounted on glass slide. The slide was tied to the appropriate support. 50 (N_0) pellets were spread on the piece of mucosa and it was hung to the arm of disintegration test apparatus. The apparatus was operated so that the glass slide with mucosal tissue could move in up and down movement in the test medium that is 0.1 N HCL (pH 1.2) maintained at 37±5°C.The pellets were continuously observed for their adherence. After completion of 1 h pellets were washed with 0.1 N HCL for 20 min and the pellets still adhering to the mucosa were counted (N). The mucoadhesive strength of pellets in 0.1 N HCL was determined using following equation,

$$Na = \frac{N}{N0} * 100 \quad (6)$$

Where N_a = Mucoadhesion number, N=Pellets still adhering to the mucosa after 30 min, N_0=number of pellets spread on the mucosa before immersion in test media

In vitro Drug Release Study

1000 mg of pellets were taken to determine the drug release using USP paddle (Type II) apparatus 4 (TDT-08L plus, Electrolab, Mumabai, India). The paddle was then immersed in 0.1N HCL (pH1.2) because the main absorption window of the drug in stomach and maintained at 37±0.5°C at 100 rpm. 5 mL of sample was withdrawn after every 1 h up to 12 h and its drug release was measured spectrophotometrically at 270 nm. Each *in vitro* release study was performed in triplicate. Experimental results are expressed as mean ± S.D. The *in vitro* drug release data was fitted into zero order, first order, Higuchi, Korsmeyer–Peppas models.

Stability Studies

The optimized formulation was placed in environmental stability chamber for 90 days according to ICH guidelines Q1A (R2) to determine its stability at 40±2°C at 75±5% RH. The optimized formulation (NF1) was filled in glass vials, sealed and placed in stability chamber. The stability was characterised by percent friability, drug content and *in vitro* dissolution for the period of three months.

The experimental results are expressed as mean ± S.D. Statistical evaluation of the data was done using ANOVA. The evaluation of data was used to assess the significance of differences. Statistically significant difference between the means of formulation batches was defined as $p< 0.05$.

RESULTS AND DISCUSSION

Gastro retentive drug delivery system is an approach to prolong gastric residence time, there by targeting site-specific drug release in upper gastrointestinal tract (GIT). This system will have relatively less side effect and removes the need of repeated dosages and increase patient compliance. In the hypothesis, we have done the screening of various varieties of black gram seed which were available nearby region. From this screening we selected the species *Vigna mungo* for the study. For the extraction of polysaccharide simple maceration method of extraction was used. After extraction, the resulting polysaccharide material was screened for some pharmacognostic tests including Molisch's test, Ruthenium red test and Iodine test.

In the Molisch's test the violet ring at the junction of two liquids confirmed the presence of carbohydrates. In the Ruthenium red test the pinkish red colour to the particles of extracted material confirmed that mucilage was present in the extracted and isolated material. The presence of brown colour in Iodine test showed that, there was presence of carbohydrates in the extracted material. Based on test results, it is revealed that the extracted material was polysaccharide.

It was hypothesized to select the pellet over the tablet formulation because it has several advantages. Some of the advantages with respect to formulation are that there is no dose dumping; it can be divided in to desired dosage strength without process or formulation changes, when pellets containing the active ingredient are in the form of suspension, capsules, or disintegrating tablets, and they offer significant therapeutic advantages of pellets over tablets.

The drug excipient compatibility study was carried out to check whether there is any incompatibility between drug and the excipient. The release retarding excipient was taken in three concentrations such as low, medium, and high concentration. The optimization of formulation batches was done based on flow properties, friability, drug content, swelling ability and *in vitro* drug release study.

FTIR Study

The drug polymer interaction study was carried out by Fourier Transform Infrared Spectroscopy using KBr

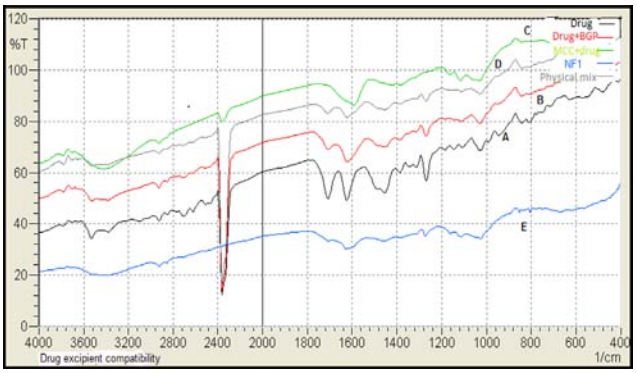

Figure 1: FTIR spectrum of pure drug, drug + black gram polysaccharide, MCC+drug, formulation (NF1) and physical mixture.

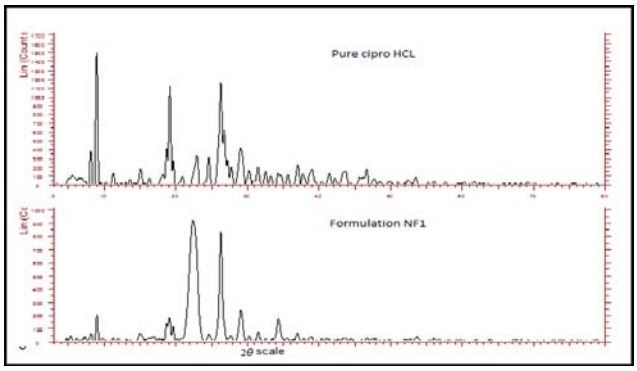

Figure 2: XRPD diffraction of pure drug and formulation blend (NF1) containing Ciprofloxacin HCL.

pellet method for pure drug, optimized formulation (NF1) and drug polymer combinations. The characteristic peaks of the drug (1400-1000, 3400-2400, 1725-1200, 1400-1200, 3000-2850, 3100-3500 cm^{-1}) were also appeared in the spectra of all the drug- polymer combination. Optimized formulation (NF1) has showed no interaction between any of the polymer with drug or between both the polymers. Hence there were no signs of incompatibility between drug and the polymers (Figure 1; Table 1).

XRPD Study

The pure drug and optimized formulation (NF1) were studied to determine their physical state that is crystalline or amorphous. The pure drug showed typical crystalline peaks at 2θ=8.8ºC, 19.1ºC, 29.02ºC, and 26.23ºC (Figure 2). The intensity of the peaks was observed to be decreased in the formulation blend. Due to change in peak intensity it is revealed that drug is converted from crystalline to amorphous form.

Flow Properties of Matrix Pellets

The flow properties of pellets formulations were determined which includes angle of repose, Hausnur's ratio, Carr's index and flow rate. (Table 3). The angle of repose of optimized batch was 25.07±2.20 it indicated the good flow behaviour. The angle of repose of other batches was in the range of 21.50±0.37 to 36.50±3.45 which indicates that the angle of repose within the official limits. The Carr's index of NF1, NF2, NF3, SF1, SF2 formulation batches was less than 20 which indicates good flow ability. The measured flow rate was 0.87±0.03 to 1.41±0.098 g/sec. The Hausnur's ratio of optimized batch was 1.13±0.10 which indicates good flow ability. The Hausnur's ratio for the remaining formulations was in the range of 1.10±0.050 to 1.24±0.022 which was within the official limits.

Friability of matrix pellets

The friability of matrix pellets was determined using Roche Friabilator. The percent friable amount gives the mechanical strength of pellets (Table 4). The percent friability of optimized formulation (NF1) was 0.60±0.03 which indicates good mechanical strength and the percent friable amount of formulations NF3, SF1, SF2 was in the range of 0.40±0.067 to 1.00±0.18 which is within official limits. Batch NF2 and SF3 showed friability more than 1 which is not within the official limits. Lower the percent friable amount greater is its mechanical strength.

Surface Topography

SEM evaluation was important to know the surface topography, pellet size and shape. It was found that multiple unit matrix pellets has showed oral or spherical shape or nearly spherical with rigid surface (Figure 4).

Determination of Production Yield and Drug Content

The production yield and drug content for all the batches were determined. The production yield of optimized batch was 30.4% and for all the remaining batches it was found between 30-50%. The drug content of optimized formulation (NF1) was found

Table 1: Drug excipient compatibility through FTIR spectroscopy.

Ciprofloxacin HCL	Drug+ Black Gram Polysaccharide	Drug+ (MCC) Microcrystalline Cellulose	Physical mixture
2924	1114.89	1425.44	1269
1707	947.08	3419.90	1028.09
1267.27	840.99	1116.82	839.06
1028		840.99	3520.21
3527.92			1708.99
1622.19			1624.12

to be 97.79±0.60%. The drug content of other formulation batches was in the range of 91.04±0.48 to 96.15±0.50% (Table 4).

Determination of Roundness and Circularity

The roundness and circularity of pellets was determined using Motic DMWB2-223 digital microscope fitted with a 1/3 CCD Camera imaging accessory. The optimized formulation (NF1) found nearly spherical and free flowing having circularity value of 0.9992±0.02 and roundness value of 1.26±0.04. Formulation batches NF2, NF3, SF1 and SF3 showed circularity and roundness values 0.9991±0.014 to 0.9997±0.035 and 1.18±0.032 to 1.41±0.061 respectively (Table 4). Based on sphericity results it is revealed the nearly spherical shape of pellets (Figure 3). Formulation SF2 formed some rod shaped particles having circularity value of 0.875±0.061 and roundness value of 1.97±0.019 which might be due to lower concentration of binder solution.

Swelling Ability of Matrix Pellets Containing Ciprofloxacin HCl

The swelling behaviour of the pellets indicated that the rate at which the pellets absorbed water from test media and swelled. The change in weight is a result of water uptake into the pellets and swelling were calculated for 60 min. The swollen pellets absorbed water present in 0.1 N HCl (pH 1.2). The mechanism of swelling is that the polymers absorbs water and get swelled as water further penetrates into the formulation. The optimized formulation NF1 showed % swelling of 72.65% in 0.1 N HCL (pH 1.2). Formulation SF3 showed highest swelling up to 91.12% because of more absorption of water into the polymer. The other remaining formulations showed % swelling in the range of 76.14 to 89.6.4%.

Table 2: Composition of Ciprofloxacin HCl matrix pellets in different batches.

Composition (mg)	NF1	NF2	NF3	SF1	SF2	SF3
Ciprofloxacin HCl	250	250	250	250	250	250
Ethyl cellulose	-	-	-	200	300	400
Black gram Polysaccharide	200	300	400	-	-	-
MCC	400	300	200	400	300	200
PVP K30	150	150	150	150	150	150
Total Weight / Hard Gelatin Capsule	1000	1000	1000	1000	1000	1000

Table 3: Flow properties of Ciprofloxacin HCl matrix pellets.

Batch No.	Flow rate (g/sec)	Angle of repose (°)	Carr's index (%)	Hausnur's ratio
NF1	1.01±0.010	25.07±2.20	16.83±1.53	1.13±0.10
NF2	1.1±0.079	21.50±0.37	11.84±1.53	1.10±0.050
NF3	1.41±0.098	28.79±2.05	9.23±0.71	1.13±0.050
SF1	1.068±0.10	29.47±0.27	15.75±0.89	1.15±0.025
SF2	0.87±0.03	36.50±3.45	19.40±0.57	1.22±0.015
SF3	1.17±0.010	32.01±1.19	21.79±0.22	1.24±0.022

Table 4: Physicochemical properties of matrix pellets.

Batch No.	Friability (%)w/w	Roundness ± S.D	Circularity ± S.D	Muco adhesion (%)	Drug content (%)	Production yield (%)	Description of pellets
NF1	0.60±0.03	1.26±0.04	0.9992±0.02	72	97.79±0.60	30.4%	Spheroids
NF2	1.40±0.17	1.34±0.078	0.9994±0.07	80	92.36±1.002	42.29%	Spheroids
NF3	1.0±0.18	1.18±0.032	0.9991±0.014	86	95.58±1.88	30.4%	Spheroids
SF1	0.88±0.067	1.41±0.061	0.9997±0.035	58	95.15±0.88	40.1%	Spheroids
SF2	0.40±0.063	1.97±0.019	0.875±0.061	90	91.04±0.48	42.6%	Rod shaped
SF3	1.60±0.23	1.39±0.053	0.9995±0.027	94	96.15±0.50	35.6%	Spheroids

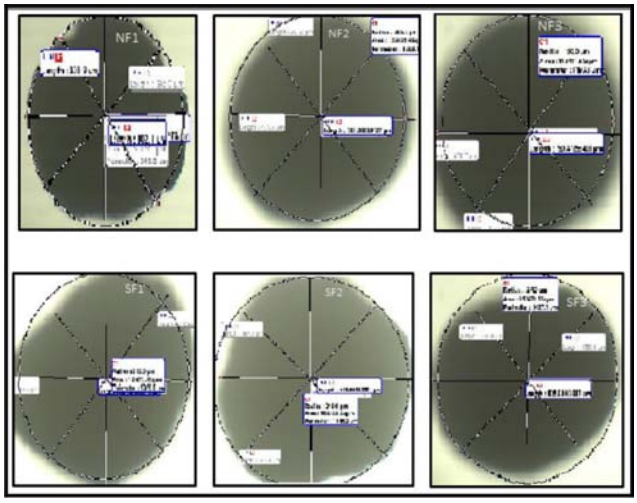

Figure 3: Photographic images of prepared different formulations.

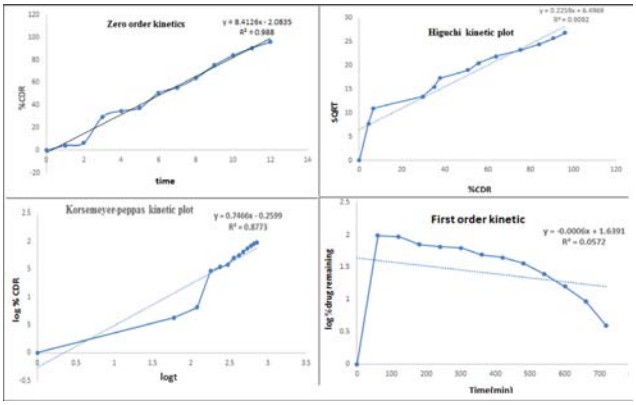

Figure 6: Drug release kinetics for optimized formulation (NF1).

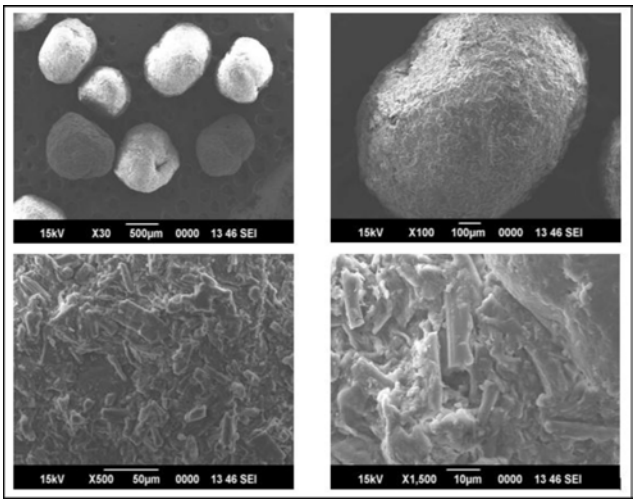

Figure 4: Photomicrographic images of optimized formulation NF1 at different magnifications.

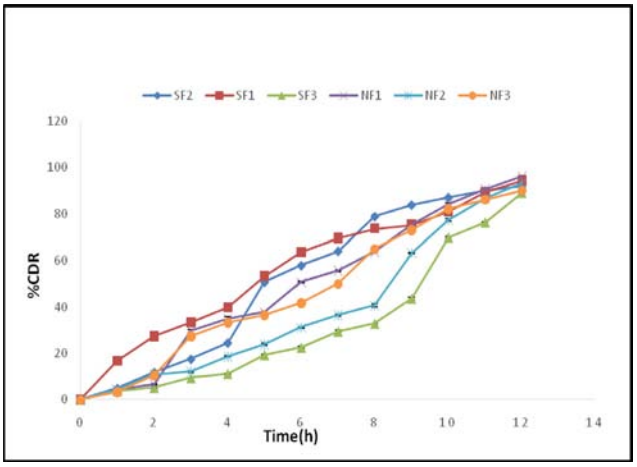

Figure 5: *In-vitro* drug release of matrix pellets formulations NF1, NF2, NF3, SF1, SF2, SF3 in 0.1N HCL (pH 1.2) medium.

Mucoadhesive Strength of Matrix Pellets

The matrix pellets exhibits good mucoadhesive strength in the wash-off test carried out on goat mucosal tissue. The optimized formulation NF1 showed good mucoadhesion of 72% while the formulation SF3 showed strong mucoadhesion of 94% in 0.1 N HCL which might be due to high concentration of polymer in the pellet formulation. Formulations NF2, NF3, SF1 and SF2 showed mucoadhesion in the range of 58-86% (Table 4).

In vitro Drug Release Studies

In-vitro dissolution studies of the pellet formulation was performed in 0.1 N HCL for 12 h. Optimized formulation (NF1) showed highest percent cumulative drug release of 96.08% up to 12 h (Figure 3) and showed sustained drug release which might be due to swelling of polymer. Formulations NF2, NF3, SF1, SF2 and SF3 showed sustained drug release up to 12 h as shown in Figure 5. The diffusional exponent (n) was calculated from the slope of the plots and regression coefficient (R^2) calculated. The optimized formulation (NF1) showed n values between 0.45 to 0.85 for spheres it indicated that the drug release by non-Fickian transport (Figure 6). The drug release from optimized formulation (NF1) followed zero order (R^2 =0.988), Higuchi (R^2=0.9092), first order (R^2 = 0.0572) and Korsmeyer-Peppas model (R2=0.8773, n=0.7466).

Stability studies

The optimized formulation (NF1) was subjected to stability studies according to ICH guidelines Q1A (R2) to determine its stability at 40±2ºC at 75±5% RH for the period of three months and percent friability, drug content, *in vitro* drug release were determined (Table 5).

Table 5: Stability study of optimized formulation.

Stability period	Parameter	Result
First month	Friability (%)	0.92
	Drug content (%)	96.57
	In vitro drug release (%)	96.73
Second month	Friability (%)	0.69
	Drug content (%)	96.08
	In vitro drug release (%)	96.19
Third month	Friability (%)	0.42
	Drug content (%)	96.25
	In vitro drug release (%)	96.05

CONCLUSION

Black gram polysaccharide is naturally occurring excipient which can be used as drug release retardant in sustained release formulations. The multiple unit sustained release system was prepared by extrusion-spheronization technique using black gram polysaccharide and ethyl cellulose as release retarding polymer. The prepared pellets were characterised by flow properties, surface topography, X-ray powder diffraction, percent production yield, drug content, mucoadhesive strength, percent swelling ability and *in vitro* drug release. The % production yield of optimized batch NF1 was 30.4% and the drug content was 97.79±0.60%. The optimized formulation showed the sustained drug release up to 12 h i.e. 96.08%. In conclusion, black gram polysaccharide can be effectively used as release retarding excipient in pellet formulations and the required drug release profile can be achieved.

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CONFLCIT OF INTEREST

The authors declare no conflict of interest.

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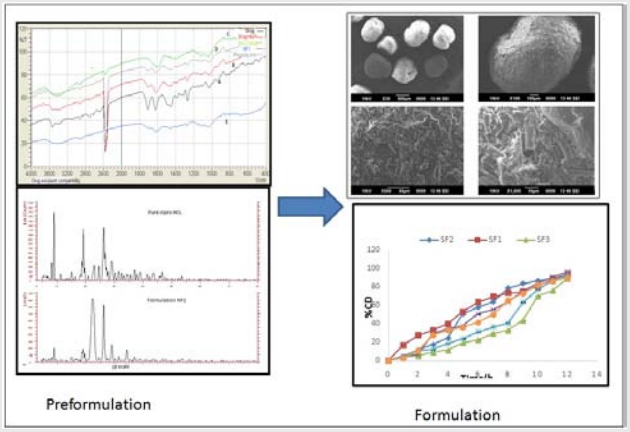
PICTORIAL ABSTRACT



SUMMARY

- We prepared the matrix pellets by extrusion-spheronization technique.
- We performed mucoadhesion studies
- We successfully developed the sustained release matrix pellets of the highly soluble ciprofloxacin HCL using natural release retardant.

About Author

Dr. Ige Pradum Pundlikrao: Is an Associate Professor, at Department of Pharmaceutics, R C Patel Institute of Pharmaceutical Education and Research, Shirpur, Maharashtra. He has ten years of teaching, industry and research experience. He had been published thirty five research papers in various national/international journals of high impact factors. He is currently working on the topics of research such as expertise *in vitro* and *ex vivo* methods to assess single unit and multiple unit dosage form and designing and developing solubility enhancement methods for biopharmaceutical classification system-II drugs-nanoparticles. He is reviewer of various national/international journals. His major attainment is outstanding Reviewer Award by Elsevier Publications in 2016.

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