



ISSN:2456-9739

Available Online at <http://www.bjbr.org>

BRITISH JOURNAL OF BIO-MEDICAL RESEARCH

Cross Ref DOI: <https://doi.org/10.24942/bjbr.2019.525>

Volume 03, Issue 04, July -August 2019

Research Article

Formulation And In Vitro Evaluation Of Gastroretentive Raft Drug Delivery Of Propranolol

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ARTICLE INFO

Article History:

Received on 17th July 2019
Peer Reviewed on 28th July 2019
Revised on 14th August 2019
Published on 29th August 2019

Keywords:

Gastro Retentive, Raft, Floating, Propranolol, Gelation

ABSTRACT

Propranolol hydrochloride, a non-selective β - adrenergic receptor blocking agent, has been widely used for treatment of hypertension. Its oral bioavailability is very low because of its short half-life. Thus, the gastro-retentive drug delivery system is selected to improve oral bioavailability of propranolol. The aim of present study was an attempt to formulate and evaluate Raft forming floating drug delivery system of propranolol hydrochloride. Raft formulation offers sustained drug release as well as prolonged gastric retention of propranolol. Propranolol raft formulation prepared by simple gelation method by using polymers sodium alginate, pectin, and gellan gum as a gel forming polymer and their combination to produce six formulations (F1-F6). The FTIR study has shown that there is a good compatibility between the drug and polymer. All the formulations were subjected for evaluation like physical appearance, pH, viscosity, *in vitro* gelling capacity and measurement of water uptake by the gel, *in-vitro* drug release, drug content, *in-vitro* floating study. The formulation F5 containing combination of sodium alginate and gellan gum was found to be best formulation since it exhibited a good appearance, *in vitro* gelling capacity, viscosity, *in vitro* floating ability and the amount of drug release was found to be 96.42%. The kinetic study showed that it follows zero order model by non-fickian release mechanism.

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INTRODUCTION

Propranolol hydrochloride, a non-selective β - adrenergic receptor blocking agent, has been widely used for treatment of hypertension, angina pectoris, arrhythmia, and migraine prevention. It shows good stability and well dissolves in acidic environment of stomach. Even though propranolol is completely absorbed in gastrointestinal tract, the oral bioavailability is very low (26%) because of its short half-life(3hr) and high first pass metabolism. Thus, the gastro-retentive dosage form is selected to improve oral bioavailability of propranolol [1].

Gastro retentive drug delivery system (GRDDS) can be defined as a system which retains in the stomach for a prolonged period of time and releasing active moiety in a controlled and sustained manner in the body. There are several, numbers of Gastro retentive drug delivery systems have been designed to prolong gastric residence time. The main aim of preparing gastro retentive drug delivery system is to minimize the problem associated with existing oral sustained release dosage form and to develop patient benefited drug delivery [2, 3]. Oral drug delivery is a one of the simplest routes of drug delivery for their systemic as well as local effect. Liquid oral dosage forms are easy to administer as compared to unit solid dosage forms but sustained effect are not achieved due to their less residential time in gastrointestinal tract so, due to this problem *In-situ* raft forming system used to overcome the problems[4]. The *in situ* raft dosage form, anew advanced gastro retentive drug delivery system liquid before administration and after it converts into gel as it contact with gastric fluids by various mechanisms in gastric environment such as physiological stimuli (e. g., temperature and pH), physical changes in biomaterials (e. g., diffusion of solvent and swelling), and chemical reactions (e. g., enzymatic, ionic crosslinking and photo-initiated polymerization).By this way achieves sustained release effect. This approach is useful for systemic as well as local effect of drugs administered [5, 6].

Raft forming system is one of the floating drug delivery systems via different route such as oral, nasal, ophthalmic, etc can be formulated. Various natural and synthetic polymers such as gellan gum, alginic acid, xyloglucan,

pectin, chitosan, poly (DL-lactic acid), poly (DL-lactide-co-glycolide) and polycaprolactone are used for formulation development of raft-forming drug delivery systems. Gastro retentive raft forming system helps to increase the bioavailability of drug compared to the conventional liquid dosage form. The raft formed from raft forming system, being lighter than gastric fluids, floats over the stomach contents or adhere to gastric mucosa due to the presence of bioadhesive nature of the polymer and produce gastric retention of dosage form and increase gastric residence time resulting in prolonged drug delivery in the gastrointestinal tract[7,8].

The current research work made an attempt to prepare formulation and evaluation of propranolol hydrochloride raft forming drug delivery system to sustain the release of drug. The polymers sodium alginate, pectin, gellan gum were used as gel forming polymer and calcium carbonate as a cross linking agent. The raft was evaluated for parameters like gelling capacity, floating lag time, floating duration, pH, *in vitro* drug release, viscosity, drug content, and *in vitro* gelling capacity etc[9].

MATERIALS AND METHODS

MATERIALS:

Propranolol hydrochloride, sodium alginate, gellan gum, pectin and Hydroxyl propyl methyl cellulose (HPMC K4M) (Yarrow Chem, India), sodium citrate, calcium carbonate (Globe scientific, India) were procured are used in the formulation. All other reagents were of analytical grade. Deionized water is used for the preparation of the formulation.

METHODS:

Preparation of raft

Propranolol containing *in situ* raft was prepared by dissolving raft forming polymer in 40ml purified water containing sodium citrate at temperature 40-50°C. It was then allowed to cool and to this add the additional polymer HPMCK4M that dissolved separately in a beaker containing 40ml purified water and to this add gas generating substance calcium carbonate and drug and mixed well until completely disperse all the content. Then make up the solution with purified water. The solution was then stored in amber coloured bottles[10,11].

Table no 1: Composition of *in situ* raft of propranolol hydrochloride

Ingredients(gm)	F1	F2	F3	F4	F5	F6
Propranolol	0.4	0.4	0.4	0.4	0.4	0.4
Sodium citrate	0.5	0.5	0.5	0.5	0.5	0.5
Calcium carbonate	0.75	0.75	0.75	0.75	0.75	0.75
HPMC K4M	1	1	1	1	1	1
Sodium alginate	2	-	-	1	1	-
Pectin	-	2	-	1	-	1
Gellan gum	-	-	0.75	-	0.25	0.25

EVALUATION

EVALUATION OF PURE DRUG PROPRANOLOL HYDROCHLORIDE

Organoleptic evaluation

Organoleptic properties of drug like colour, appearance and odour were observed and recorded [12].

Melting point determination

Melting point of drug sample was determined by melting point apparatus. The small quantity of drug was taken in a capillary tube sealed at one end and was placed in digital melting point apparatus and temperature range at which the drug melts is noted [12].

Solubility determination

The solubility of propranolol was checked in distilled water, alcohol and chloroform [13].

Determination of UV Absorbance Maxima of propranolol hydrochloride

The standard stock solution of propranolol hydrochloride in water was used to determination the λ max of (0.1 N HCl, pH 1.2) was used as blank for the study. The spectrum was taken between the UV range of 200-400nm. The highest peak obtained from the spectrum analysis was taken as λ max for propranolol Hydrochloride [14].

Preparation of Standard Calibration Curve of propranolol hydrochloride in 0.1 N HCl

Propranolol hydrochloride (100 mg) was dissolved in 10ml of (0.1 N HCl, pH 1.2) and volume was made up to ml in 100 ml volumetric flask. From the above solution 10ml was taken and made up to 100ml using 0.1N HCl. From the above solution 2ml,4ml, 6ml,8ml and 10ml were taken and up to 100ml using 0.1N HCl. The absorbance of resulting solutions is measured at 289nm using UV spectrophotometer. Calibration curve was plotted [14].

Identification of Drug by FTIR

Fourier-transform infrared (FT-IR) spectra were obtained using an FT-IR spectrometer. The pure drug was mixed thoroughly with potassium bromide, an infrared transparent

matrix, at appropriate Sample: KBr ratio, respectively. The KBr discs were prepared by compressing the powders at appropriate pressure for 5 min in a hydraulic press. Forty scans were obtained at a resolution of 4 cm^{-1} , from 4000 to 400 cm^{-1} [15].

EVALUATION OF PROPRANOLOL *IN SITU* RAFT

Physical Appearance

The physical appearance of *in situ* raft solution is one of the most important characteristic features of preparation. The clarity, appearance and color of solutions was determined by visual inspection [16].

pH

pH is the one of the most important factors involved in the formulation. The pH of formulation should be such that the formulation will be stable at the pH and at the same time there would be no irritation to the patient upon administration of the formulation. The pH was measured in each *in situ* raft solutions of propranolol hydrochloride using a calibrated digital pH meter [16,17].

Drug Content

10ml of the *in situ* raft solution was added to 100ml of simulated gastric fluid and stirred for 1hour on magnetic stirrer. The solution was filtered, suitably diluted with simulated gastric fluid and the drug concentration was determined by using a UV-visible spectrophotometer at 289nm against a suitable blank solution [18,19].

Sol to gel time

In vitro gelation time of propranolol raft was determined by using USP (Type II) dissolution apparatus containing 500 mL of 0.1N HCl (pH 1.2) at 37 ± 0.5 °C. As the formulation was coming in contact with 0.1N HCl, (pH 1.2) it converted from sol to gel and time was measured. It was observed that within fraction of seconds the solution converted into gel later it floated in buffer solution [20].

Scanning electron microscopy (SEM)

Surface morphology of the formulation was visualized by scanning electron microscopy. The samples were coated

with gold under argon atmosphere using gold sputter module VG microtech in high vacuum evaporator and observed under various magnifications (100-1000×).

Viscosity determination

The viscosities of the propranolol raft solutions were determined by Brook field viscometer (Model RVDV-II+P). The samples were sheared at a rate of 50 rpm using S63 spindle at room temperature. Viscosity measurement for each sample was done in triplicate, with each measurement taking approximately 30s [21].

In vitro gelation capacity

The *in-vitro* gelling capacity of prepared propranolol raft formulations was measured by placing five ml of the gelation solution (0.1N HCl, pH 1.2) in a 15 ml borosilicate glass test tube and maintained at 37±1°C temperature. One ml of formulation solution was added with the help of pipette. The formulation was transferred in such a way that places the pipette at surface of fluid in test tube and formulation was slowly released from the pipette. As the solution comes in contact with gelation solution, it was immediately converted into stiff gel like structure. The gelling capacity of solution was evaluated on the basis of stiffness of formed gel and time period for which the formed gel remains as such. The *in-vitro* gelling capacity was graded in three categories on the basis of gelation time and time period for which the formed gel remains [22].

(+) Gels after few minutes and dispersed rapidly.

(++) Gelation immediate and remains for few hours.

(+++ Gelation immediate and remains for an extended period

In-vitro floating study

The *in-vitro* floating study of propranolol raft was carried out using 900 ml of 0.1N HCl (pH 1.2). The medium temperature was kept at 37°C. Ten milliliter formulation was introduced into the dissolution vessel containing medium without much disturbance. The time the formulation took to emerge on the medium surface (floating lag time) and the time the formulation constantly floated on surface of the dissolution medium (duration of floating) were noted [22,23].

Water uptake study

In this study raft formed in 40 ml of 0.1 N HCl (pH 1.2) was used. From each formulation, the raft portion from the 0.1 N HCl was separated, and the excess HCl solution was blotted out with a tissue paper. The initial weight of the raft taken was weighed and to this raft 10 ml of distilled water was added, and after every 30 min of the interval water was

decanted and the weight of the Raft was recorded, and the difference in the weight was calculated and reported [23]

$$\% \text{ water uptake} = \frac{w_2 - w_1}{w_1} \times 100$$

Where,

W1 = initial weight of gel (10 mg),

W2 = weight of swollen matrix after 16 h

In vitro Drug release

The release rate of propranolol HCl from in situ raft was determined using USP dissolution testing apparatus with a paddle stirrer at 50 rpm. This speed was slow enough to avoid the breaking of gelled formulation and was maintaining with the mild agitation conditions believed to exist in vivo. The dissolution medium used was 900 ml of 0.1 N HCl, and temperature was maintained at 37°C. 5 ml of the solution was withdrawn from the dissolution apparatus at different time intervals. The samples were filtered through Whatman filter paper. Absorbance of propranolol HCl was determined spectrophotometrically at 289 nm using UV Spectrophotometer [24,25].

Drug Release Kinetic Studies

The drug release kinetic studies were done by various mathematical models like zero order, first order, Higuchi's square root, Hixson-Crowell cube root law and Peppas equation. The model that best fits the release data is selected based on the correlation coefficient (r^2) value in various models. The model that gives high ' r^2 ' value is considered as the best fit of the release data. The release constant was calculated from the slope of the appropriate plots, and the regression coefficient (r^2) was determined [25].

Stability Studies

In the present study, stability studies were carried out at 40°C ± 2°C, 75 ± 5% RH and 25°C ± 2°C, 75% ± 5% RH for a specific time period up to 3 months for the optimized formulation. The optimized formulation was analyzed for the drug contents study, pH, lag time (sec), floating time (hours), viscosity before gel (cp), viscosity after gel (cp), cumulative drug release (%). Experiments were performed in triplicate and average values are noted [25].

RESULT AND DISCUSSION

Organoleptic evaluation

The physical properties of pure drug propranolol hydrochloride were observed visually that are noted in table no 2.

Table 2: Physical properties of propranolol

colour	White powder
odour	odourless
Taste	Tasteless
Appearance	Fine powder

Melting point determination

Melting point of Propranolol was found to be 164° C which indicates the purity of the sample

Solubility determination

The soluble ability of pure drug propranolol hydrochloride was determined in different solvent and result showed in table no 3.

Table 3: Solubility of propranolol

SOLVENT	SOLUBILITY
Water	Soluble
0.1 N HCl	Slightly soluble
methanol	Soluble
chloroform	Slightly soluble
ethanol	Soluble
dichloromethane	Sparingly soluble

Determination of UV Absorbance Maxima of Propranolol hydrochloride.

The highest peak obtained from the spectrum analysis was taken as λ max for propranolol Hydrochloride that used was found to be 289 nm.

Standard calibration curve of Propranolol Hydrochloride

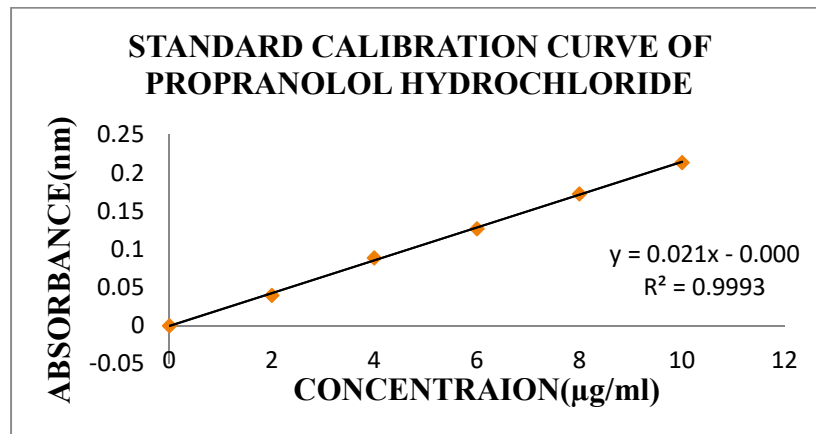
The absorbance of Propranolol Hydrochloride standard solutions containing 2-10 μ g/ml of drug in 0.1 N Hcl was shown in table 3. Figure 1 shows a representative standard calibration curve with slope and regression coefficient of 0.021 and 0.999 respectively. The curve was found to be linear in the range of 2-10 μ g/ml at 289 nm. The calculation of the drug content and in vitro drug release are based on this calibration curve

Table no 4: Data of calibration curve of propranolol hydrochloride

Concentration(μ g/ml)	Absorbance (at 289nm)
0	0
2	0.040 \pm 0.001
4	0.089 \pm 0.001
6	0.127 \pm 0.001
8	0.173 \pm 0.002
10	0.214 \pm 0.001

Each reading is an average of 3 determinations \pm standard deviations (SD)

Fig 1: Standard calibration curve of propranolol



Identification of Drug by FTIR

Drug and Excipient interactions are analyzed by Fourier transform infrared (FTIR) spectroscopy. The characteristic IR absorption peaks of pure propranolol HCl at 3321.42(N-H stretch), 2964.59(C-H stretch), 1242.16(C-O-C stretch), 1052.93(O-H stretch). It was shown in figure 2. The characteristic IR absorption peaks of Optimized

formulation at 3421.72 (N-H stretch), 2962.66(C-H stretch), 1242.16(C-O-C stretch), 1021.59(O-H stretch). It was shown in figure 3. All the characteristic peaks of Propranolol HCl were present in spectra at respective wave lengths thus indicating compatibility between drug and excipients. It shows that there was no significant change in the polymer and drug interaction

Fig 2: FTIR Spectrum of Propranolol

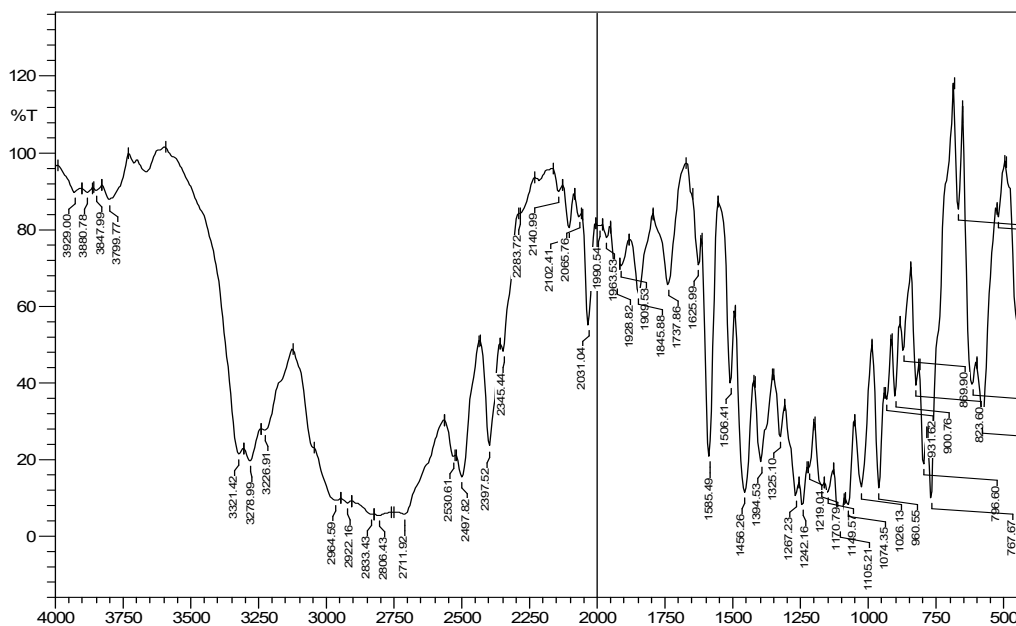


Fig 3: FTIR Spectrum of physical mixture of propranolol hydrochloride and excipients

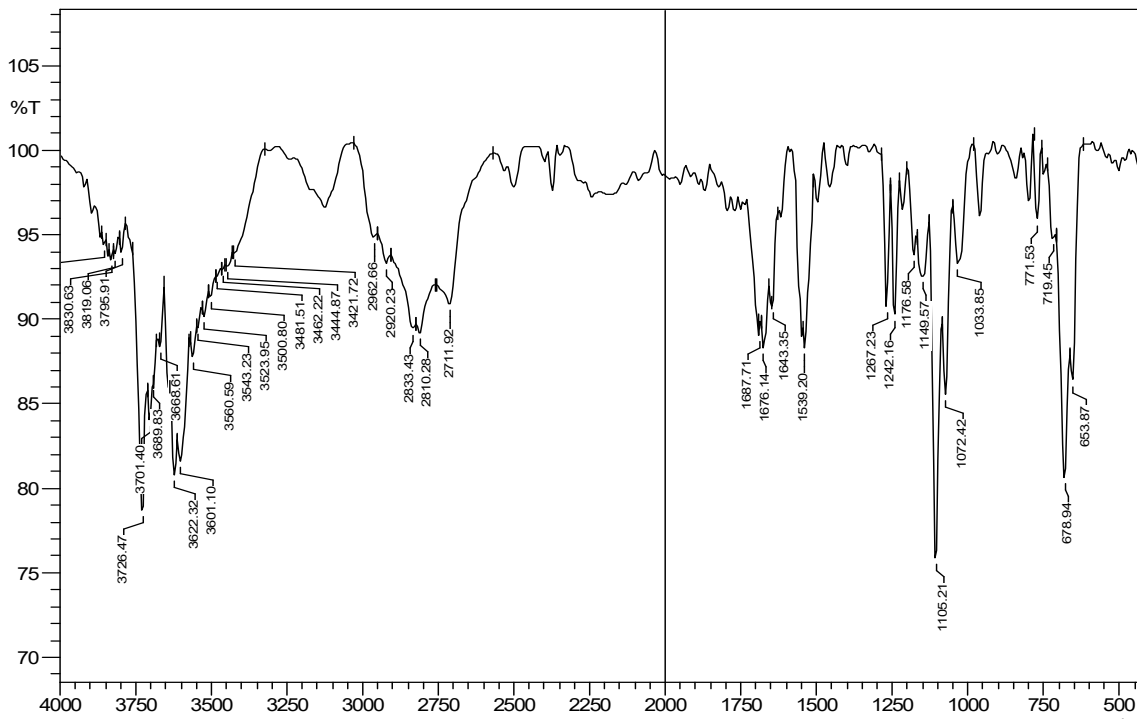


Fig 4: Propranolol floating raft



FORMULATION OF PROPRANOLOL FLOATING RAFT

Physical appearance

Prepared formulations were found to be clear white milky to pale yellow opaque solutions. It was shown in table no 5

pH

The pH of all formulations was in between 6.98 to 7.20. It was shown in Table no 5 and the graph plotted in figure 5. It was found to be satisfactory thus there would be no irritation to patients upon administration of the formulation.

Drug Content

Table no 5 shows the drug content was found to be in acceptable range for all formulations. Percentage of drug content in all formulations were in the range of 94.12% to 98.66% and the graph was plotted in figure 6.

Sol-gel transition time

Table no 5 shows the sol-gel transition time was found to be in range of 4-8 sec for all formulations and graph plotted in figure 7.

Table 5: Evaluation Parameters of raft forming system

formulation code	Physical Appearance	pH ± SD	Drug Content ±SD	SOL-GEL TIME(Sec)±SD
F1	White milky solution	7.05 ± 0.040	98.15 ±0.225	3±0.836
F2	Opaque solution	6.98 ± 0.035	94.12 ±0.256	8 ±0.707
F3	White milky solution	7.14 ± 0.058	98.01 ±0.234	5±0.707
F4	White milky solution	7.11 ± 0.053	96.98 ±0.271	4±0.547
F5	White milky solution	7.12 ± 0.019	98.66 ±0.360	3±0.836
F6	White milky solution	7.20 ± 0.011	97.20 ±0.332	6±0.547

Each reading is an average of 3 determinations± standard deviations(SD)

Fig 5: pH of propranolol raft solution

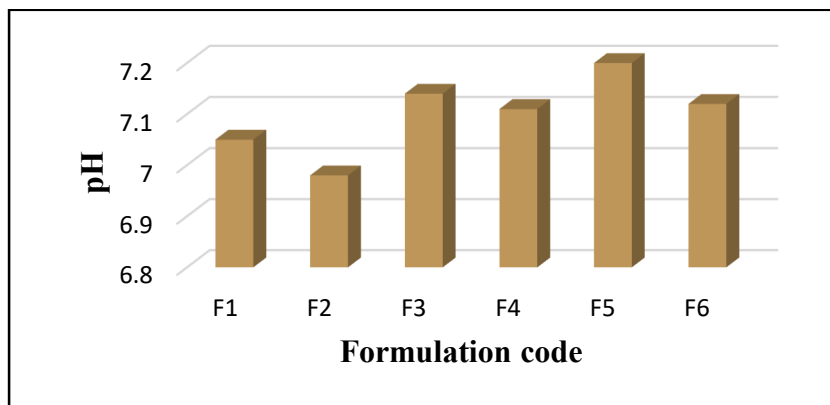


Fig 6: Percentage drug content of propranolol raft

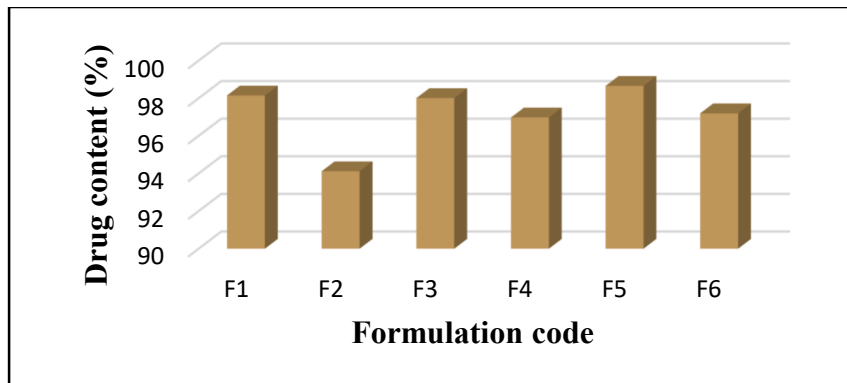


Fig 7: Sol-gel transition time

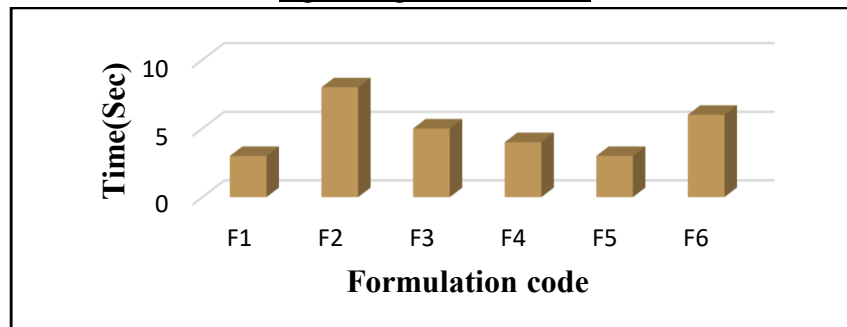
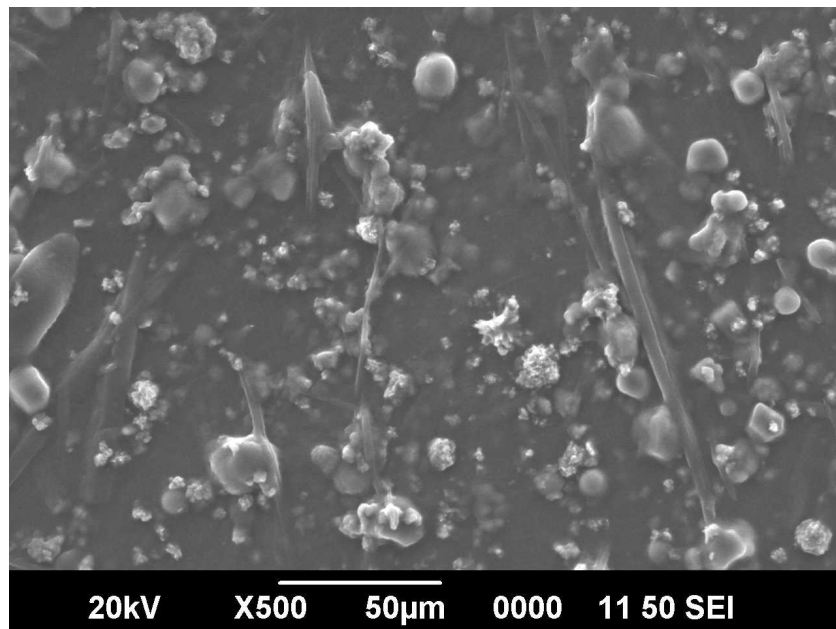


Fig 8: SEM image of propranolol raft solution



Scanning electron microscopy (SEM)

Viscosity determination

The formulation should have an optimum viscosity that will allow easy swallowing as a liquid, which then undergoes a rapid sol-gel transition. Result of viscosity measurement of sol form shown in Table no 6. Viscosity measurement of all formulations was varies from 193 to 420.5 cps. All the formulations were found easily pourable.

Result of viscosity measurement of raft form shown in the Table no 6. Viscosity of *In-situ* formed raft of the all formulations was varies from 30.2 to 569.1 cps according gelling polymer added. There was directly proportional effect on viscosity, so viscosity of *In-situ* formed raft of the formulation was taken as one of the dependent parameters for optimization of formulation. The graph plotted in figure 9

In vitro gelation capacity

Gelling studies were carried out using 0.1N HCl (pH 1.2), and the obtained data were represented in table no 6. Gelation occurs when the insoluble calcium carbonate solubilizes when it comes in contact with acidic medium releasing carbon dioxide and calcium ions. The calcium ions interact with the anionic polymer in the formulation

causing instantaneous gelation and provide a gel barrier that restricts drug release.

In-vitro floating study

The floating ability of the prepared formulations were evaluated in Simulated Gastric Fluid (0.1N HCl, pH1.2). The results floating lag time and duration of floating is shown table no 6. In contact with the gastric environment, calcium carbonate effervesced, releasing carbon dioxide and calcium ions. Then, gelation and complexation by Ca^{+2} ions took place to provide a gel barrier at the surface of the formulation. The released carbon dioxide was entrapped in the gel network producing a buoyant preparation, which resulted in extended floating. The floating properties of the formulation, mainly depend on calcium carbonate. All formulations exhibited total floating time of less than or greater than 8 h. floating lag time of all formulations were in between 30-45s and it plotted as graph in figure 10.

Water uptake study

Table no 6 shows the water uptake was found to be in acceptable range for all formulations. Percentage of water uptake in all formulations were in the range of 24.13% to 49.20% and graph plotted in figure 11.

Table 6: Evaluation Parameters of raft forming system

Formulation code	Viscosity (CP)		In vitro gelling capacity	In vitro floating study		Water uptake (%)
	Solution	Raft		Floating lag time(sec)	Duration of floating(hr)	
F1	205.3±0.251	368±0.273	+++	35±0.01	>8	33.33±0.265
F2	193±0.503	304.2±0.606	++	45±0.05	<8	24.13±0.340
F3	213.6±0.214	326.5±0.210	+++	40±0.02	>8	25±0.334
F4	340.1±0.213	415.8±0.447	+++	30±0.06	>8	43.75±0.309
F5	420.5±0.147	569.1±0.105	+++	25±0.01	>8	49.20±0.216
F6	308.2±0.365	396.3±0.434	+++	35±0.02	>8	44.26±0.247

Each reading is an average of 3 determinations± standard deviations (SD)

Fig 9: Viscosity of propranolol raft

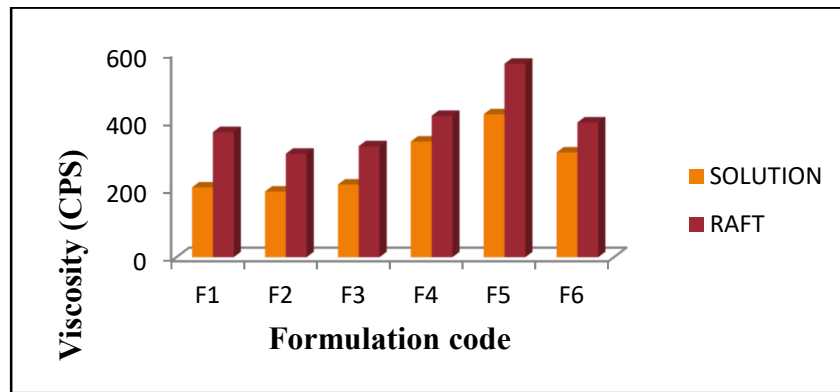


Fig 10: In vitro lag time of propranolol raft

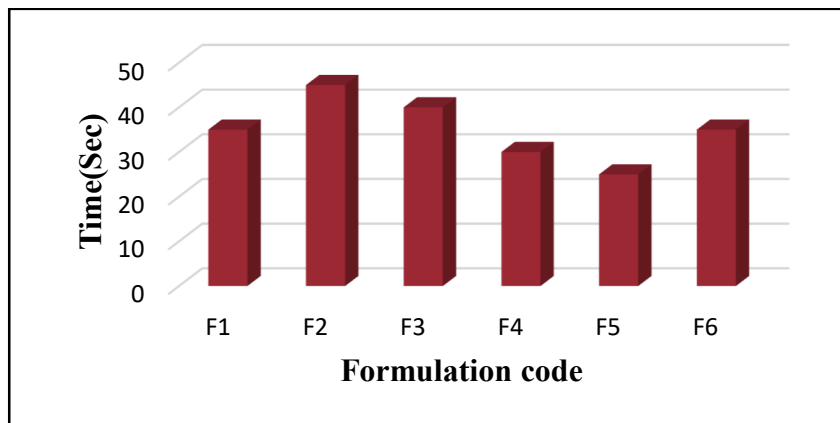
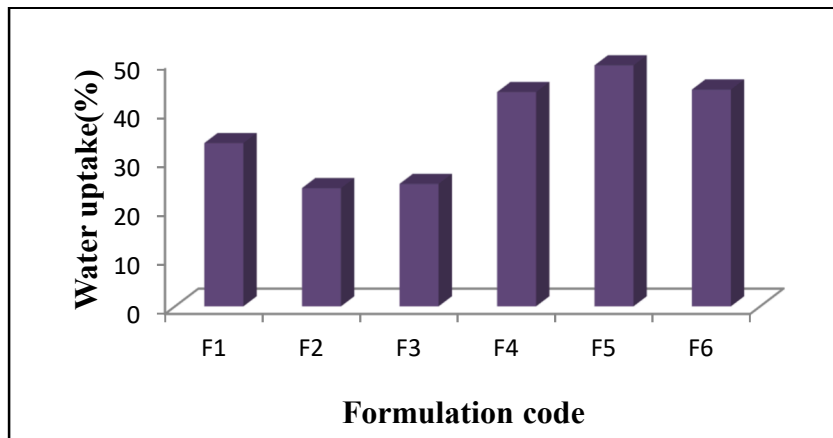


Fig 11: Water uptake of propranolol raft

**In-Vitro Drug Release**

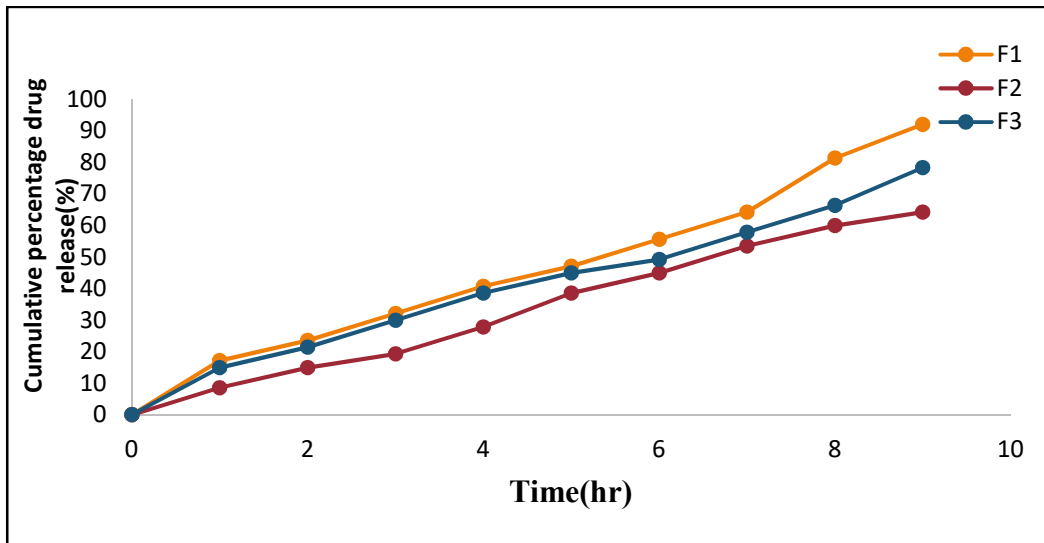
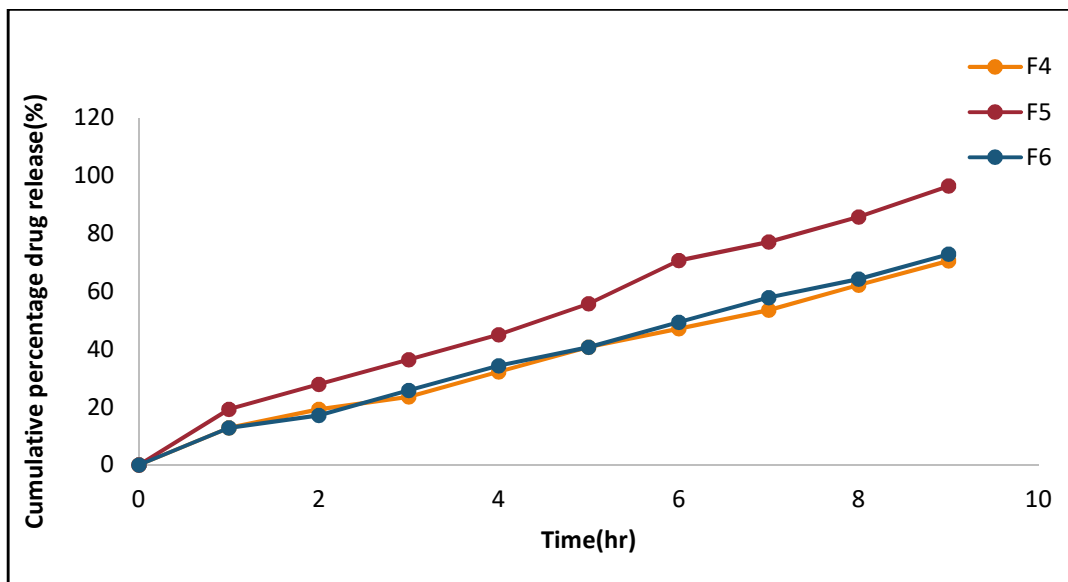
The *in-vitro* drug release of the raft forming system were carried in 0.1N HCl from 0 to 9 hrs by USP type-II apparatus and the values are shown in table no 7. The plot of %Cumulative drug release v/s time (hrs) was plotted and depicted as shown in figure no 12 and 13. The raft forming polymer and HPMC with a primary role in the sol-gel

phenomenon and buoyant also affected the release rate to some extent. *In vitro* drug release study was conducted on the formulations for a period of 9 hours during which the highest drug release of 96.42% was observed with formulation F5 and the least drug release of 64.28% with F2 during the 9 hour dissolution study.

Table 7: In vitro drug release of propranolol raft

Time(hr)	Cumulative percentage of drug release (%)					
	F1	F2	F3	F4	F5	F6
0	0	0	0	0	0	0
1	17.17±0.01	8.57±0.05	15±0.08	12.85±0.12	19.28±0.05	12.85±0.07
2	23.57±0.25	15±0.18	21.42±0.43	19.28±0.36	27.85±0.04	17.14±0.41
3	32.14±0.18	19.28±0.25	30±0.31	23.57±0.28	36.42±0.24	25.71±0.29
4	40.71±0.38	27.85±0.38	38.57±0.09	32.14±0.15	45±0.21	34.28±0.41
5	47.71±0.10	38.57±0.24	45±0.51	40.71±0.35	55.71±0.04	40.71±0.26
6	55.71±0.28	45±0.21	49.28±0.18	47.14±0.26	70.71±0.23	49.28±0.19
7	64.28±0.08	53.57±0.06	57.85±0.30	53.57±0.42	77.14±0.12	57.85±0.33
8	81.42±0.15	60±0.28	66.42±0.07	62.14±0.18	85.71±0.01	64.28±0.07
9	92.14±0.03	64.28±0.03	78.41±0.21	70.57±0.05	96.42±0.02	72.85±0.11

Each reading is an average of 3 determinations ± standard deviations (SD)

Fig 12: *In vitro* drug release profile of propranolol raft (F1-F3)Fig 13: *In vitro* drug release profile of propranolol raft (F4-F6)

Drug Release Kinetic Studies

The drug release data of propranolol hydrochloride were fitted to models representing Higuchi's, zero order, first order, Hixson crowell and Korsmeyer-peppas equation kinetics model to know the drug release mechanisms (fig 14-18). The data were processed for regression analysis using Ms Excel statistical function. The goodness of fit was evaluated using the correlation

coefficient (r^2) values. The correlation coefficient (r^2) for all the formulations using different kinetics equation is listed in Table no 8. It was found that the *in vitro* drug release of optimized batch F5 was best explained by zero order as the plots showed the highest linearity ($R^2 = 0.992$). The formulation code F5 followed the zero order with the drug release mechanism was found to be non fickian diffusion.

Table no 8: kinetic modeling of optimized formulation

Kinetic model fitting						
Formulation code	Zero order	First order	Higuchi matrix	Hixson crowell	Korsmeyer peppas	N
F5	0.992	0.840	0.942	0.939	0.686	0.772

Fig 14: Zero order

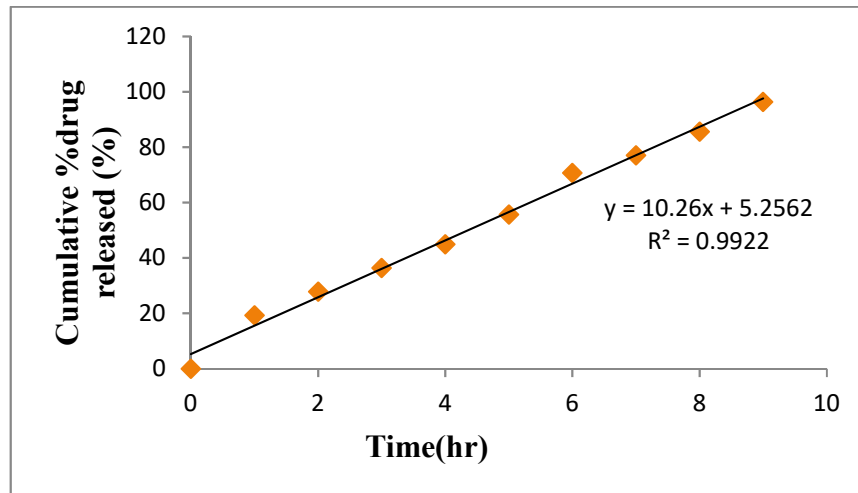


Fig 15: Hixson crowell

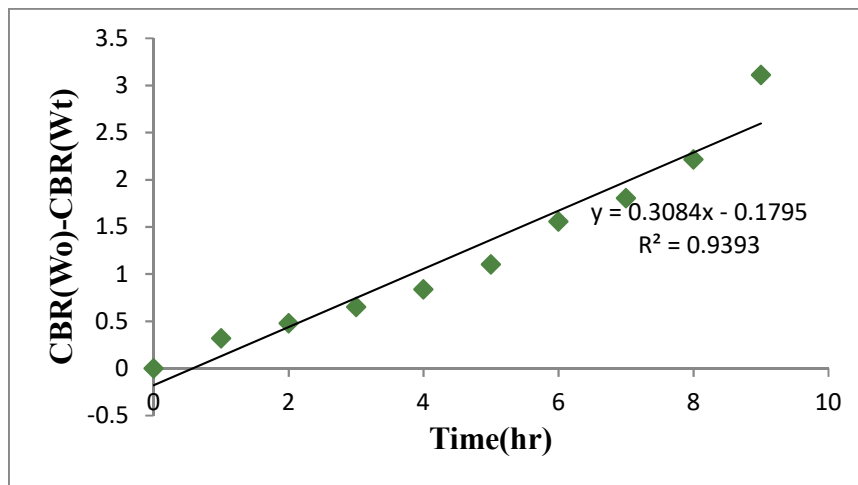


Fig 16: First order

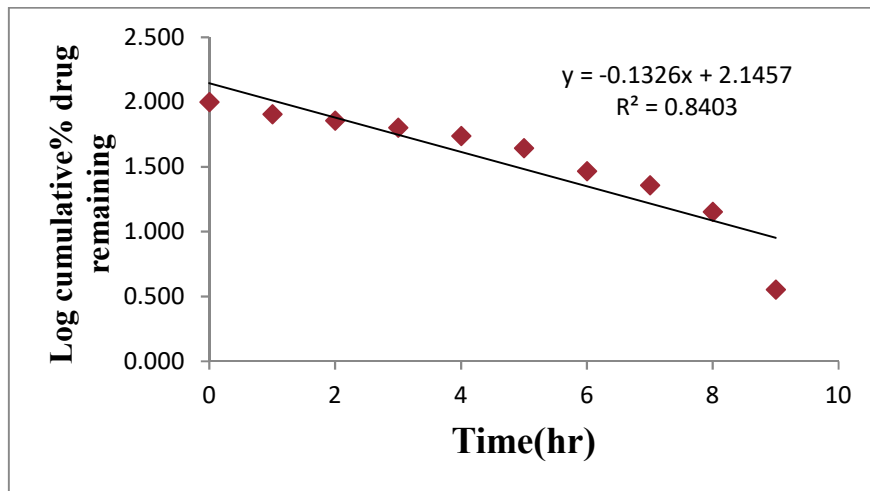


Fig 17: Korsmeyer peppas

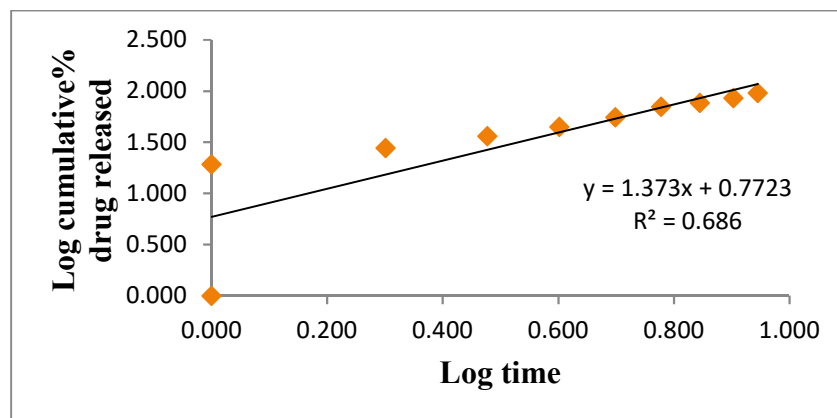
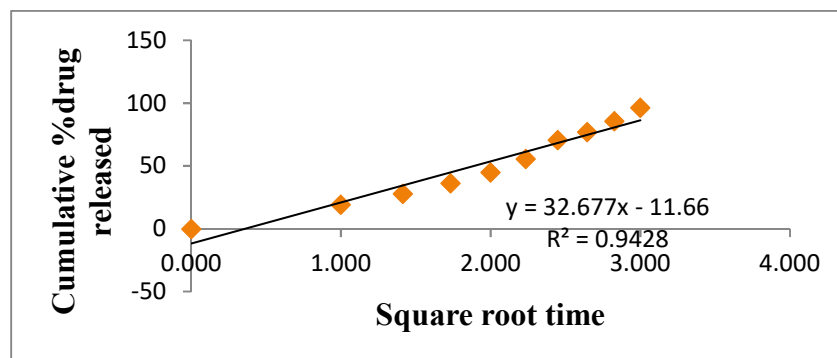


Fig 18: Higuchi matrix Stability Studies



Stability study of the optimized formulation (F5) carried out for 0 to 90 days in two physical condition. On physical observation of the stored samples there was found that no change in physical appearance of the in situ raft. The drug content, viscosity, and *in vitro* drug release did not change

significantly on storage. This studies suggests the physical and chemical stability of propranolol raft solution. The results are shown in the table no 9.

Table no 9: Stability study of Propranolol raft

Time (days)	Physical appearance	Viscosity		Percentage drug content (%)	Cumulative percentage drug release (%)
		Solution	Raft		
0	-	420.5±0.847	569.1±0.305	98.66 ±0.360	96.42±0.02
30	No changes	419.8±0.105	568.6±0.08	98±0.0112	96±0.05
60	No changes	419.2±0.125	568.1±0.09	97.6±0.08	95.5±0.105
90	No changes	418.7±0.165	567.9±0.01	97±0.114	95±0.103

Each reading is an average of 3 determinations ± Standard deviation (SD)

CONCLUSION

The present work was carried out to develop a novel gastroretentive based *raft* drug delivery system of Propranolol hydrochloride. From all the above results, it clearly demonstrated the successful development of propranolol raft dosage form which provides sustained release and prolonged gastric retention. The *insitu* raft were prepared by simple gelation method using different raft forming polymers (sodium alginate, pectin, gellan gum) and their combination with calcium carbonate as a crosslinking and gas generating agent. From the study conducted, the following conclusions were drawn, as per the pre-established objectives the physico-chemical characterization and *in vitro* evaluation of raft were performed and obtained satisfactory results with its ability to enhance bioavailability through its longer gastric residence time and ability to sustain drug release.

ACKNOWLEDGEMENT

We would like to thank Mr. Shaiju S Dharan, Principal of Ezhuthachan college of pharmaceutical sciences for his assistance and guidance with this research work.

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How to cite this article:

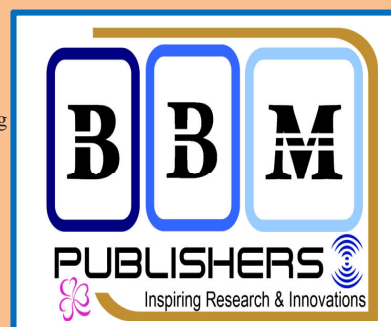
Bineesha K B, Shaiju S Dharan, Jicky T Panicker, Julie E James, Sojan Abraham Jousha. *Formulation And In Vitro Evaluation Of Gastroretentive Raft Drug Delivery Of Propranolol*. Br J Bio Med Res , Vol.03, Issue 04, Pg.929-946, July - August 2019. ISSN:2456-9739 Cross Ref DOI : <https://doi.org/10.24942/bjbmr.2019.525>

Source of Support: Nil

Conflict of Interest: None declared.

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