Journal of Pharma Creations (JPC)

JPC |Vol.11 | Issue 3 | Jul - Sept -2024

www.pharmacreations.com

DOI : https://doi.org/10.61096/jpc.v11.iss3.2024.221-229

ISSN: 2348-6295

Research

Formulation, In Vitro And In Vivo Evaluation Of Repaglinide Pulsatile Release Delivery System For The Treatment Of Daibetus Melitus

S. Vasanth Kumar[1], K. Senthilkumaran*[2]

[1]Assistant Professor, Department of Pharmaceutics, K.K. College of Pharmacy, Chennai, Tamilnadu, India.
[2]Professor and Head, Department of Pharmaceutics, K.K. College of Pharmacy, Chennai, Tamilnadu, India.

*Author for Correspondence: K. Senthilkumaran
Email: drkskumaran67@gmail.com

Published on: 4 Jul 2024

Published by:
DrSriram Publications

Abstract

In present study aimed to optimise the pulsatile release tablet of repaglinide, the Box-Behnken design paradigm was used. 16.14 mg of CCS, 28.91 mg of lactose, and 4.37 mg of eudragit were found to be the appropriate formulation variables, and the tablet's response was 94.45%. medication released, followed by a 5.99-hour lag time (T) and a desirability of around 1. FT-IR analysis revealed significant peaks of REP was found in tablets, indicates no interaction between drug and polymers. Assay of REP formulation showed 98.89±0.5 % REP was present in the chronomodualted tablet and bioavailability of REP was found to be 103.77 %. A chronomodualted drug delivery of REP for the treatment of diabetes mellitus (The dawn phenomenon leads to high levels of blood sugar, a condition called hyperglycemia. It usually happens between 4 a.m. and 8 a.m) was successfully developed. The system was found satisfactory in term of drug release after lag time of 6 hrs. The dosage form can be taken at bad time and release the drug at early morning when high level of blood glucose reached in blood. The chronomodulated delivery system could release the drug repaglinide at early morning and control the blood sugar level and its leads to patience compliance.

Keywords: Repaglinide, Chrinomodulated delivery, Diabetus mellitus, Box-Behnken design.

INTRODUCTION

Pulsatile Drug Delivery System (PDDS) are gaining importance as these systems deliver the drug at specific time as per the pathophysiological need of the disease, resulting in improved patient therapeutic efficacy

and compliance. PDDS are promising for various disorders. Such a novel drug delivery has been attempted for Chronopharmacotherapy of diseases which shows circadian rhythms in their pathophysiology.
Response surfaces methodology (RSM) a extensively trained advance into the growth as well as optimizations of drugs delivery campaign. Base taking place the principle of designs of trials, the method encompass the employ of a range of type of new designs, generations of polynomials equation as well as map of the response in excess of the new area to decide the best preparations. The method requires least testing in addition to moment in time, therefore prove to be faraway additional effectual plus cost efficient than the conventional technique of formulate the dosage form.

For present research work, various computation in favor of the current optimizations studies was perform by means of Design Expert® softwares (Design Expert trial versions 9; State-Ease Inc., Minneapolise, MN, USA) where a Three factors two levels complete factorial designs were used for systematic learning of effect of extent Crosscarmellose Sodium and Lactose and extend of Eudragit S100 weight gain were selected as the independent variables i.e. factor. The level of this factor was chosen taking place the base of beginning trial batch results and observations. The entire the additional formulations aspect in addition to process variable was reserved constant all the way through the studies. Polynomial model counting interactions in addition to linear term was generating in favor of the complete responses variable by means of multiples linear regressions analysis (MLRA) approaches.

Methods

Preparation of Repaglinide pulsatile release tablets

The granules were prepared by wet granulation method. The drug Repaglinide, Croscarmellose Sodium and lactose were passed through sieve 40# separately and blended thoroughly. After proper mixing then slowly added the binding solution containing PVP K-30 in IPA till fine uniform granules were obtained. The damp mass were conceded throughout sieve 16# as well as desiccated on 50°C for 30 min to get Moisture content less than one. Then lubricate the dried granules with magnesium stearate which were already passed through sieve 40#. Then lubricated granule was packed together taking place cadmach tablets punches machine for all formulations.

Coating of Eudragit S100 over the tablets

Eudragit S100 coating dispersion requires addition of polyethylene glycol as plasticizer and stirred the solution for few minutes with a magnetic stirrer. This solution was sprayed over the above processed tablets up to different weight gains.

Evaluation of repaglinide tablets

To design tablets and later to monitor tablets production, qualitative, quantitative evaluation and assessments must be made. Various standards have been set in the various pharmacopoeias regarding the quality of pharmaceutical tablets. These include thickness, size, diameter, shape, weight, hardness, disintegration and dissolution characters. The diameter and shape depends on the die and punches selected for the compression of tablets. The remaining specifications assure that tablets do not vary from one production lot to another. The following standards or quality control tests were carried out on Repaglinide Pulsatile release tablets.

Tablet evaluation tests

General appearance

The general appearance of tablets, its visual identity and overall "Elegance" is essential for consumer acceptance, control of lot-to-lot uniformity and general tablet-to-tablet uniformity and for monitoring the production process. The control of general appearance involves measurement of attributes such as a tablets size, shape, colour, presence or absence of odour, taste, surface textures, physical flows and consistency. The formulated tablets were evaluated for organoleptic characters such as shape, colour, odour etc.

Hardness test or crushing strength

Hardness, which is now more appropriately called crushing strength determinations are made during tablet production. The hardness of tablets (kg/cm^2) was carried out by using Monsanto type hardness tester. If the tablet is too hard, it may not disintegrate in the required period of time. If the tablet is too soft, it may not be able to withstand the handling during subsequent processing such as coating or packing and shipping operations. The crushing strength of 4kg is usually considered to be the minimum requirement for a tablet. Oral tablets have a hardness 4-10 kg/cm^2, however, hypodermic and chewable tablets are usually much softer (2-5 kg/cm^2) and some sustained release tablets are much harder (10-20 kg). The degree of hardness varies with the different manufactures and with the different types of tablets. The hardness of a table is an indication of its strength. Hardness (diametric crushing strength) is a force required to break a tablet across the diameter.

The tablet was placed horizontally in contact with the lower plunger of the Monsanto hardness tester and zero reading was adjusted. Then the tablet was compressed by forcing the upper plunger until the tablets breaks and this force was noted.

Friability test

Friability is the loss of weight of tablet in the container/package due to removal of fine particles from the surface. This test is applicable to compressed tablets and is intended to determine the physical strength of tablets. It is usually measured by the use of Roche friabilator. The drum is attached to the horizontal axis of a device that rotates at 25 ± 1 rpm. It should be ensured that with every turn of the drum the tablets roll or slide and fall on to the drum wall or onto each other. Ten tablets are weighed (w_1) and placed in the apparatus where they are exposed to rolling and repeated shocks as they fall 6 inches in each turn within the apparatus. After 4 minutes of this treatment or 100 revolutions, the tablets are weighed (w_2) and this weight was compared with the initial weight of tablet. The loss of weight may be due to abrasion is a measure of the tablet friability. The value is expressed in percentage. A maximum loss of weight not greater than 1% is acceptable for most tablets. If the tablets are cracked, chipped or broken after tumbling, the sample fails the test. The friability was determined using the following formula:

$$\text{friability} = \frac{(w_1 - w_2)}{w_1} \times 100$$

Where,

w_1 = weight of ten tablets before test

w_2 = weight of ten tablets after test.

Uniformity of weight or weight variation test

This test is not applicable to coated tablets other than film coated tablets. This is an important in process quality control test to be checked frequently (every half an hour). Any variation in the weight of tablets (for any reason) leads to either under medication or overdose. Therefore, every tablet in each batch should have uniform weight. Twenty tablets of each formulation were selected at random and weighed individually. The weight of individual tablet was noted. Average weight was calculated from the total weight of all tablets. The individual weights were compared with the average weight. Not more than two tablets must differ from the average weight and / or not more than the percentage values stated in the table below. The percentage deviation was calculated by using the following formula:

$$\text{percentage deviation} = \frac{\text{individual weight - average weight}}{\text{Average weight}} \times 100$$

Uniformity of weight

Estimation of drug content

To ensure the Consistency of dosage Units and should be determine the content of active ingredient present in the label claim. Dosage units are defined as dosage forms containing a single dose or a part of a dose of an active substance in each dosage unit. The term “Uniformity of dosage unit” is defined as the degree of uniformity for substance among dosage units. The test for content uniformity is based on the assay of the active medicament. The content uniformity is necessary because the quantity of the active medicament is within the limit (±5%) in the formulation. Ten tablets from each formulation were powdered. The powder equivalent to 100 mg of repaglinide was weighed and dissolved in sufficient quantity of methanol and made up to 100 ml with methanol. From this 10 ml was pipette out into a 100 ml standard flask and make upto the mark with phosphate buffer pH 7.4. From this 10 ml was pipetted out to 100 ml standard flask and make upto the mark with phosphate buffer pH 7.4. The absorbance of the solution was determined in UV – visible spectrophoto- meter at suitable nm. Generally, the drug content in any formulation should be with in the limit of 95-105%.

Thickness of Tablets

The tablets should have uniform thickness. The thicknesses of all the tablets are determined by using vernier callipers.

***In vitro* drug release study of Repaglinide Pulsatile release formulations**

The test was carried out in a rotating basket method specified in the USP XXIII dissolution tester (Electrolab, TDT-08L, India) by the side of a rotation speeds of 100 rpm during 900 ml dissolution mediums on 37 ± 0.5 °C during medium among 0.1 N HCl pH 1.2, pH 7.4 (phosphate buffer) for 2 h, 3 h, and till the end of

the test, respectively. 5 ml aliquots of the dissolution fluids be impassive on particular instance interval along with replaced with new dissolution media with assay in favor of the quantity of rapaglinide through spectrophotometers (JASCO V630, Japan) through wavelengths 245 nm. The dissolution data's were analyze to estimate % drug releasing at different time intervals.

***In vivo* x-ray radio imaging study**

Animals

Standard laboratory condition of temperature 24 ± 2 °C, relative moisture 55 ± 5 % and 12:12 hrs daylight dim cycles be maintained throughout all the experiments. Rabbits had free access of water filtered through Aquaguard® and fed with a standard diet *ad libitum*. The rabbits were allowed to acclimatize for 1 week before experiment. Rabbits fasted for 24h before administration of formulation.

***In vivo* pharmacokinetics study**

The *in vivo* study of optimize rapaglinide tablet formulation Six male albino rabbit weigh just about 1.5 kg in addition to among the times of 12 month was chosen in favor of the optimized study respectively. The rabbits were divided into two groups of three in optimized formulations . Every groups were subjected to a single dosage randomized parallel designs studies. The animal was house independently beneath ecological condition (23 ± 2 °C, 55 ± 5 % relative humidity, 12 hour brightness / dim cycles). The rabbit was fasted during the night in addition to allow free admission to tap water simply. The tests sample of optimized along with the marketed formulation were administer to the rabbit through gastric intubation technique, 0.5 ml of blood sample were reserved as of the marginal veins of rabbits on different moment interval. The plasma sample were alienated through centrifugations, drugs was extract along with subsequently assayed in favor of repaglinide by HPLC.

Data Analysis

Information was generating by high and mighty the first orders amalgamation along with one compartments models among first orders eliminations. The highest peak concentrations (C_{max}) along with time of its incidence (T_{max}) were straight compute commencing the plasma concentrations against time plots. The elimination rate constants (Kel) are resolute as of the terminal stage of the log plasma concentrations against time profiles through least square regressions study. As of this Kel is designed as Kel=slope×2.303. The eliminations half life's was calculated as $t_{1/2}$ =0.693/Kel. The area below the plasma concentrations time curves starting 0→t ($AUC_{0\rightarrow t}$), along with area below first moment curves starting 0→t ($AUMC_{0\rightarrow t}$) furthermore mean residence times (MRT) were considered by means of trapezoidal rules.

Sample preparation and analytical procedure for detection of plasma rapaglinide concentration

A entire of 0.5 mL of plasma were in use in a Stoppard test tubes. To this 0.5mL of dilute HCl be further with varied in favor of another 1 mins. After that to this combination 8mL of dichloromethane were additional along with agitated on behalf of 10 min through the helps of mechanical stirrers. It is subsequently centrifuged in support of 5 min. at 4000 rpm; 7mL of organic solvent film separated and detached inside a split tubes along with disappear during the attendance of nitrogen bed at small temperatures. The deposit was reconstituted among a 0.2mL of mobile phases and injected into HPLC system at 241 nm.

Stability study of optimized formulation

Stability Study was carried out for optimized formulations to assess its stability, as per ICH guidelines. The optimized formulation were enclose inside the laminated aluminum foil along with was located inside the accelerated stability chambers (6CHM-GMP, Remi Instruments Ltd., Mumbai) next to prominent temperatures in addition to humidity condition of 40^0C/ 75% RH with a control sample was placed at an ambient condition in favor of a time of 3 month. Sampling was completed next to a programmed occasion of initial 0, 1, 2 and 3 months interval respectively. By the side of the conclusion of study, sample was consider for the drug contents, *in vitro* drugs releasing in addition to extra physicochemical parameter.

Statistical analysis

The result obtain in favor of *in vivo* study were subjected to arithmetical examination by means of a computer programs PK Solutions 2.0, (Excel-2002 Windows based) Montrose, USA.

RESULTS AND DISCUSSION

Assessment of the drug-polymer interaction using FTIR

An IR spectrum of Repaglinide drug sample was taken and it was compared with the standard spectra. FTIR study was executed to confirm that there are no element interactions among the drug with excipients. As of the FTIR spectral explanation of Repaglinide the following results are obtain. The FTIR spectrum showed

powerful bands on 1720.69 (C=O), 1664.35 (C=C), 2949.54 (C-H aliphatic), 3170.87 (C-H aromatic), 1095.74 (C-O), 3497.85 (-OH) and 937.12 (C-C). The IR spectrum of repaglinide is shown in Fig 1-3.

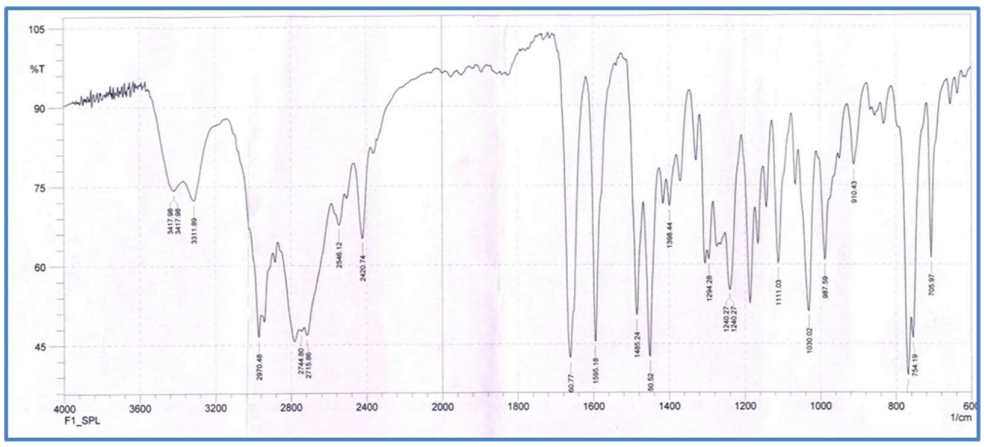

Fig 1: IR spectrum of Repaglinide

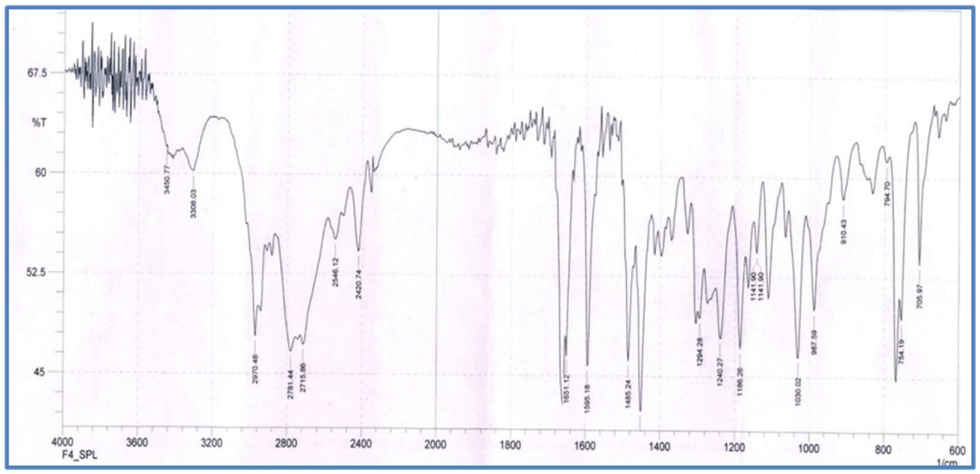

Fig 2: IR spectrum of Repaglinide with Crosscarbemellose,SodiumAc-Di-So

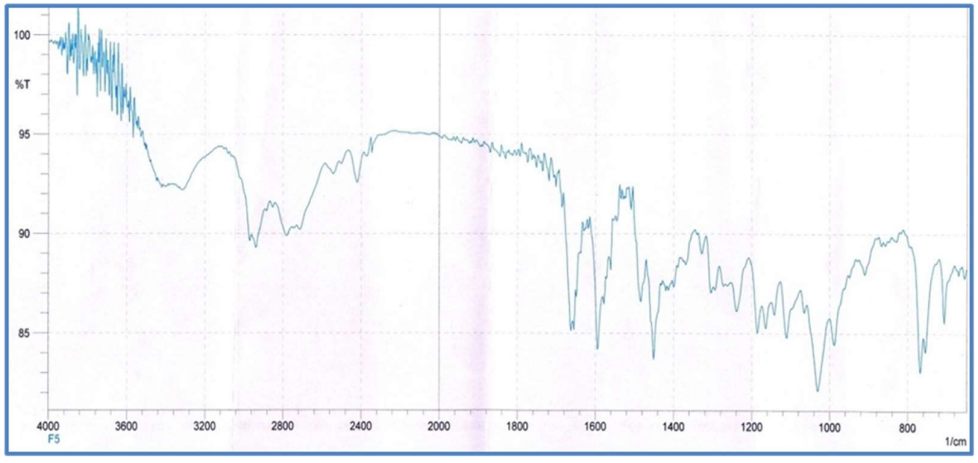

Fig 3: IR spectrum of Repaglinide Physical Mixture (Crosscarbemellose,SodiumAc-Di-So)

Assessment of the drug-polymer interaction using DSC

The DSC thermogram for Repaglinide shows a sharp melting endothermic peak at 129°C and end at 135.33 °C with onset at 131.83°C (Figure 7 - 12). While the endothermic peak of drug: polymer mixture was observed at 262.45°C and end at 265.47°C with onset at 257.47°C where most of peaks are retained in drug: polymer physical mixture as observed in Repaglinide pure drug.

Table 1: Evaluation of Repaglinide Pulsatile release granules

S.no	Parameters	F1	F2	F3	F4	F5	F6	F7	F8
1	Bulk density* (gm/cc)	0.35±0.04	0.34±0.02	0.36±0.03	0.33±0.05	0.33±0.07	0.33±0.04	0.35±0.07	0.34±0.10
2	Tapped density* (gm/cc)	0.41±0.09	0.40±0.02	0.41±0.10	0.38±0.05	0.38±0.07	0.38±0.05	0.39±0.03	0.38±0.02
3	Angle of repose*(θ)	32º91'±0.53	33º84'±0.62	34º33'±0.51	33º37'±0.42	33º76'±0.75	32º79'±0.23	34º19'±0.53	32º68'±0.47
4	Compressibility index*(%)	14.12±0.24	14.28±0.32	12.94±0.41	13.28±0.21	13.19±0.53	12.40±0.17	11.28±0.51	11.71±0.33
5	*Hausner ratio**	1.16±0.11	1.16±0.27	1.14±0.41	1.15±0.33	1.15±0.21	1.14±0.30	1.12±0.15	1.13±0.24

**All values are expressed as mean ± SD (n=3)*

Evaluation of Repaglinide Pulsatile release Tablets

The formulated Repaglinide Pulsatile release Tablets were evaluated and the results are shown in Table 1.

General appearance

The formulated tablets were evaluated for organoleptic characters. The tablets are circular is shape, yellow in colour, with no characteristic odour. All the tablets showed elegance in appearance.

Thickness

Thickness must be controlled to facilitate packing. The results showed that the tablets of all formulations showed uniform thickness.

Hardness

Oral tables normally have a hardness 4-10 g/cm^2 . The hardness of the tablets was tested using Monsanto Hardness Tester and the results are tabulated in the Table 3. The hardness of the tablets of all formulations was within the range of 4-7 Kg/cm^2. So all the formulated tablets passes the tests.

Weight variation test

Twenty tablets of each formulation were selected randomly and weighed individually. Not more than two tablets should go more than the preferred deviation. The percentage deviation was ±5% for more than 250 mg tablets. Here the actual weight of one tablet is 400 mg. So the acceptable deviation is ±5%. The result proved that the percentage deviation was within the limit (Table 2).

Friability Test

Friability test was carried out using Roche friabilitor. A maximum weight loss should be not more than 1% of the weight of the tablet being tested during the friability test. The friability of all the formulated tablets was within 1%. It revealed that good adhesion of tablet ingredients and compression.

Estimation of drug content

The entire formulations equivalent to 1 mg of repaglinide was dissolved in sufficient quantity of methanol and make up to 100 ml with methanol. The solutions were suitably diluted with phosphate butter pH 7.4 and the content of repaglinide was estimated spectrophotometrically at suitable 241 nm. The results are shown in Table 6. As per the IP, the content uniformity should be in the range of ± 10% . The result showed that the percentage of repaglinide was ranging from 95-104% in all the formulations. This revealed that the drug and other ingredients are uniformly dispersed in the formulations. So all the formulated tablets passes the test.

Table 2: Evaluation of Repaglinide Pulsatile release Tablets

S.No	Parameters	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8
1	Hardness* (kg/cm^2)	5.16±0.15	5.16±0.67	4.92±0.33	5.12±0.47	4.8±0.27	4.76±0.38	5.56±0.21	4.96±0.26

2	Friability*(%)	0.50±0.03	0.40±0.14	0.20±0.05	0.70±0.32	0.68±0.05	0.45±0.26	0.40±0.06	0.28±0.09
3	Uniformity of weight* (mg)	399.1±2.3	400±3.1	399±2.8	398±3.7	397±4.1	399.4±3.0	396±4.7	395±4.07
4	Drug content* (%)	101.9±0.60	98.03±0.90	95.68±0.22	103.92±0.14	104.3±0.26	100.7±0.5	96.89±0.33	97.64±0.29
5	Thickness* (mm)	4.1±0.02	4.3±0.01	4.1±0.04	4.02±0.06	4.3±0.03	4.1±0.07	4.2±0.04	4.2±0.01

** All values are expressed as mean ± SD (n=3)*

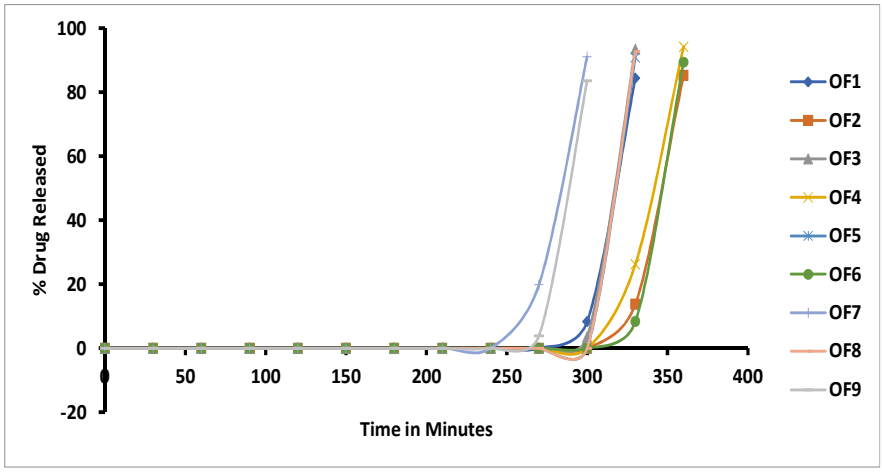

Fig 4: % cumulative drug release of repaglinide pulsatile formulations

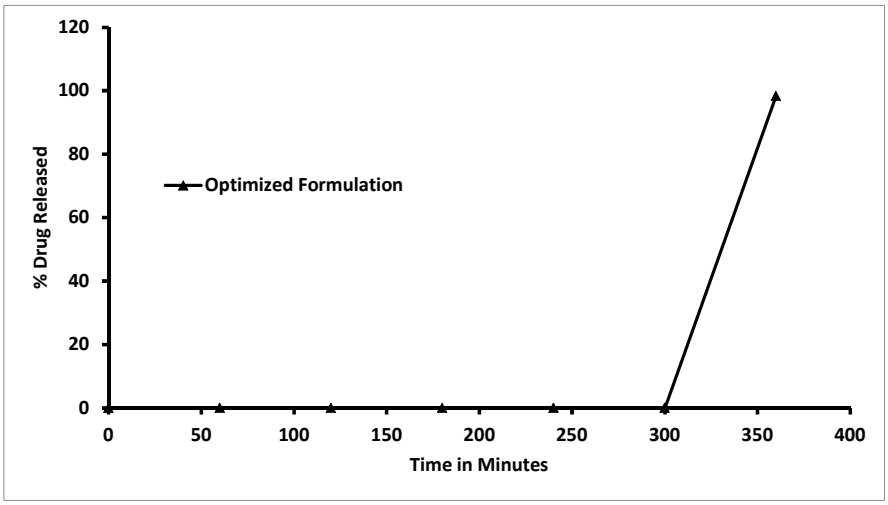

Fig 5: % cumulative drug release of repaglinide optimized formulation

In vivo Pharmacokinetic studies

The mean plasma concentration of REP verses time curves for both optimized formulation and marketed tablets are shown in **Figure 8** and pharmacokinetic parameters are shown in Table 3.

Table 3: Chronopharmacokinetics parameters of REP chronomodulated formulation and REP marketed tablets.

Pharmacokinetics parameters	REP Marketed tablet	REP chronomodulated formulation
Cmax (ng/ml)	605.01.25±5.49	560.74±3.14
T_{max}(hr)	2±1	7±1
AUC_{0-t} (ng/ml*hr)	1580.25±10.56	1639.37±8.42
Relative Bioavailability (%)	_	103.77±2.43

Peak plasma concentration of REP test and reference formulations were 605.01.25±5.49 µg/mL and 560.74±3.14 µg/mL respectively. Tmax of the test and reference formulation were 2±1 h and 7±1 h respectively. The observed AUC(0-t) of the marketed formulation was 1580.25±10.56 µg~h/mL which was higher than the AUC(0-t) of chronomodulated formulation i.e. 1639.37±8.42µg~h/mL indicating the bioavailability of test formulation was higher than the reference formulation. The *Cmax* and area under the curve (AUC0-t) of the test formulation was higher than the reference formulation. The improved bioavailability may be due to the pulsatile release nature of tablets and the combined of CCS and lactose and coating with Eudragit. The combined use of CCS and lactose showed the highly porous and absorbent in nature, their combined use with Eudragit showed the drug is release in pulsatile manner and showed the greater bioavailability of REP as compared to marketed formulation.

Stability study analysis

Table 4: Stability report of repaglinide pulsatile formulation

Evaluation Parameters	Initial	1st Month	3rd Month	6th Month
Colour	No change	No change	No change	No change
Assay	99.25±0.17	98.22±0.22	98.78±0.31	97.54±0.23
% drug release	98.17±1.04	95.34±1.21	93.45±1.12	93.23±1.13
Lag time (T; Hrs)	6±0.8	6±0.6	6±0.9	6±0.5

After six months of storage, there was no appreciable change in the drug content (assay) of the formulation and % drug release and lag time (T), indicating that the formulation is both physically stable and able to withstand changes in the ambient temperature/humidity while being handled and stored. This was confirmed when stability data from the initial samples and the stored samples were compared.

CONCLUSION

Diabetes mellitus is a condition that exhibits a circadian rhythm, with its peak hours occurring between 4 and 8 a.m. Over the course of a day, organisms undergo periodic changes in their physiology, behaviour, and biochemistry. A chronomodulated release pill has been designed to regulate the plasma sugar level in the morning. A REP tablet was made using lactose and CCS, then coated with Eudragit to allow for pulsatile drug release. To optimise the tablet, the Box-Behnken design paradigm was used. 16.14 mg of CCS, 28.91 mg of lactose, and 4.37 mg of eudragit were found to be the optimal formulation variables. The tablet's response was 94.45% drug released with a lag time of 5.99 hours (T). There was no release seen in 0.1 N HCl (pH 1.2). Significant peaks of REP were detected in tablets by FT-IR measurement, indicating that there was no interaction between the medication and the polymers. The chronomodualted tablet contained 98.89±0.5% REP, according to the assay of the REP formulation, and its bioavailability was determined to be 103.77%. A time-varying pharmaceutical administration of REP to treat diabetic mellitus (dawn phenomenon causes hyperglycemia, or elevated blood sugar). It typically takes place between 4 and 8 a.m.) was established with success. After a six-hour lag period, the system's drug release performance was deemed adequate.

Acknowledgment

This published work is a part of my Ph.D. thesis at the Tamil Nadu Dr. M. G. R. Medical University, Chennai. We thank our management and principal for providing the facilities for successful completion of the work.

REFERENCES

1. M Swetha, B Rama, V Sandhiya, G Rathnam, U Ubaidulla, PS Roy, Chronopharmacotherapeutic release of HMG-COA reductase inhibitor: using novel coating technique, World Journal of Pharmaceutical Research. 2016; 5(5):784-797.
2. B Rama, V Sandhiya, M Swetha, G Rathnam, U Ubaidulla., Pulsatile drug delivery: A comprehensive review., IJPDT. 2015;5(2):125-130.
3. U Ubaidulla, B Senthilkumar, RK Khar, FJ Ahmad., Studies on suspension of nimesulide solid dispersion: Development, characterization and in vivo evaluation, Indian journal of pharmaceutical sciences. 2005; 67(4):422-42.
4. DS Karuna, AK Rasheedhabanu, U Ubaidulla, G Rathnam, Development of artemether and lumefantrine fixed dose combination tablets: Preparation, characterization and in-vitro evaluation, Int J Pharm. 2016; 4 (4);166.

5. DS Karuna, AK Rasheedhabanu, UR Ubaidulla., Development of Artemether Lumefantrine FDC tablet preparation; Characterization and in vitro evaluation., Pharm and BioAllied Sci Jl. 2014;1(2):1-4.
6. U Uthumansha, K Prabahar, DB Gajapathy, M El-Sherbiny, N Elsherbiny, Optimization and In Vitro Characterization of Telmisartan Loaded Sodium Alginate Beads and Its In Vivo Efficacy Investigation in Hypertensive Induced Animal Model, Pharmaceutics. 2023;15(2):709.
7. G Mani, H Pushparaj, MM Peng, P Muthiahpillai, U Udhumansha, Synthesis and characterization of pharmaceutical surfactant templated mesoporous silica: Its application to controlled delivery of duloxetine, Materials Research Bulletin. 2014; 51: 228-235.
8. S Pandey, S Mattha Vijayendra Swamy, U Mansha Ubaid Ulla, A Gupta, Cell line and augument cellular uptake study of statistically optimized sustained release capecitabine loaded Eudragit S100/PLGA (poly (lacticco-glycolic acid)) nanoparticles, Current Drug Delivery. 2017;14(6):887-899.
9. NEMQ Kousalya Prabahar, Ubaidulla Udhumansha., Microneedle mediated transdermal delivery of β-sitosterol loaded nanostructured lipid nanoparticles for androgenic alopecia, Drug Delivery, 2022;29(1), 3022-34.
10. DS Karuna, G Rathnam, U Ubaidulla, M Ganesh, HT Jang., Chitosan phthalate: A novel polymer for the multiparticulate drug delivery system for diclofenac sodium., Advances in Polymer Technology 37 (6), 2013-2020, 2018.
11. V Loganathan, B Senthilkumar, MVS Reddy, N Sreekanth, U Ubaidulla., Compatibility studies between sparfloxacin and tablet excipients through differential scanning calorimetry, Indian Drugs-Bombay. 2003; 40(11):661-664.
12. UU V.Loganathan, B. Senthil kumar, M.V.S. Reddy, N. Sreekanth, Compatibility studies between Pefloxacin and Tablet Excipients through Differential Scanning Calorimetry (DSC), Indian Drugs. 2003;40(4):219-222.
13. Udayakumar.T, Chordia Mayor Ashok, Udhumansha Ubaidulla. Design and development of bioadhesive gastro retentive drug delivery system of metoprolol succinate. International Journal of Research and Development in Pharmacy and Life Sciences. 2013; 2(2):355-362. Available: http//www.ijrdpl.com