



## SUSTAINED RELEASE MATRIX TABLET OF GLIPIZIDE

Gedar Sushma\*, Kataria Mahesh Kumar, Bilandi Ajay

Department of Pharmaceutics, Seth G. L. Bihani S. D. College of Technical Education, Sri Ganganagar, Rajasthan, India.

### ABSTRACT

Glipizide is one of the most commonly used anti-diabetic drugs for treatment of type 2 diabetes mellitus. It is effective in pancreatic secretion of insulin. Glipizide is used for patients with type 2 diabetes who have failed diet and exercise therapy and it appears to be the most effective in first phase insulin secretion. Glipizide have short biological half-life i.e. 2 to 5 hrs, and is rapidly eliminated, so requiring it to be administered in 2 to 3 doses of 2.5 to 15mg per day. Hence once daily sustained release matrix tablet of glipizide is developed. Many methods are used for preparing sustained release preparations of glipizide. The review article comprises of the research materialized in the field of sustained release tablets of glipizide.

**Keywords:** Sustained release, Diabetes, Glipizide, Matrix tablet, Granulation method.

### INTRODUCTION

Oral route is the most oldest and convenient route for the administration of therapeutic agents because of low cost of therapy and ease of administration leads to higher level of patient compliance. Approximately 50% of the drug products available in the market are administered orally and historically, oral drug administration has been the predominant route for drug delivery. Tablets are the most commonly and widely used dosage form. This type of drug delivery system is called conventional drug delivery system and is known to provide an immediate release of drug. Such immediate release (IR) products results in relatively rapid drug absorption and onset of accompanying pharmacodynamic effects. However, after absorption of drug from the dosage form is complete, plasma drug concentrations decline according to the drug's pharmacokinetics profile. Eventually, plasma drug concentrations fall below the minimum effective plasma concentration (MEC), resulting in loss of therapeutic activity. Before this point is reached another dose is usually given if a sustained therapeutic effect is desired [1]. Conventional formulations are required to be administered in multiple doses and therefore have several disadvantages. Sustained release dosage forms have been demonstrated to improve therapeutic efficiency by maintenance of a steady drug plasma concentration [2]. Sustained release,

prolonged release, modified release, extended release or depot formulations are terms used to identify drug delivery systems that are designed to achieve or extend therapeutic effect by continuously releasing medication over an extended period of time after administration of a single dose [3]. The goal in designing sustained or sustained delivery systems is to reduce the frequency of the dosing or to increase effectiveness of the drug by localization at the site of action, reducing the dose required or providing uniform drug delivery. So, sustained release dosage form is a dosage form that release one or more drugs continuously in a predetermined pattern for a fixed period of time, either systemically or to a specified target organ. Sustained release dosage forms provide a better control of plasma drug levels, less dosage frequency, less side effect, increased efficacy and constant delivery [4]. Various approaches are used to Sustained Release Drug Delivery System. These are: Diffusion sustained systems, Dissolution sustained systems, Dissolution and diffusion sustained systems, Ion exchange resin- drug complexes, pH dependent formulation, Osmotic pressure controlled systems, Swelling and expansion systems, Floating systems and Bio adhesive or Mucoadhesive systems.

Matrix tablet is one of the most widely used approaches to sustain the drug action. Matrix tablets may be defined as the "oral solid dosage forms in which the

drug or active ingredient is homogeneously dispersed throughout the hydrophilic or hydrophobic matrices which serves as release rate retardants". Matrix drug delivery systems release the drug in continuous manner. These release the drug by both dissolution controlled as well as diffusion controlled mechanisms [5].

Glipizide is an oral hypoglycemic agent, which is a commonly prescribed drug for the treatment of patients with type II diabetes mellitus. It is used adjunct to diet to the management of type II (non-insulin dependent) diabetes mellitus in patients whose hyperglycemia cannot be controlled by diet and exercise alone. Glipizide stimulates insulin secretion from the  $\beta$  cells of pancreatic islets tissue, increases the concentration of insulin in the pancreatic vein and may increase the number of insulin receptors [6]. Glipizide is a weak acid ( $pK_a = 5.9$ ) which is practically insoluble in water and acidic solutions but as per the Biopharmaceutical Classification System (BCS) it has lower solubility and higher permeability (class 2). The oral absorption is uniform, rapid and complete with a bioavailability of nearly 100% and an elimination half-life of 2–4 h. It has a short biological half-life and is rapidly eliminated, so requiring it to be administered in 2 to 3 doses of 2.5 to 10 mg per day. Hence once daily sustained release matrix tablet of Glipizide is prepared. The pharmacokinetics and dosage schedule supports once daily sustained release formulations of Glipizide for better control of blood glucose levels to prevent hypoglycemia, enhance clinical efficacy, to reduce G.I. disturbances, to prolong its duration of action and to enhance patient compliance [6].

## METHODS FOR TABLET PREPARATION

1. Granulation method
  - Wet granulation
  - Dry granulation.
2. Direct compression method [7].

### Dry granulation

The dry granulation process is used to form granules without using a liquid solution because the product to be granulated may be sensitive to moisture and heat. Forming granules without moisture requires compacting and densifying the powders. Dry granulation can be conducted on a tablet press using slugging tooling or on a roller compactor commonly referred to as a chilsonator. When a tablet press is used for dry granulation, the powders may not possess enough natural flow to feed the product uniformly into the die cavity, resulting in varying degrees of densification. The roller compactor uses an auger-feed system that will consistently deliver powder uniformly between two pressure rollers. The powders are compacted into a ribbon or small pellets between these rollers and milled through a low-shear mill. When the product is compacted properly, then it can be passed through a mill and final blend before tablet compression. Roller-

compaction or dry-granulation equipment offers a wide range of pressures and roll types to attain proper densification. This equipment is loud and dusty compared with other process machinery. Material feed rates are critical for attaining the final objective. The process may require repeated compaction steps to attain the proper granular end point. Typically, a percentage of product does not get compacted and may require screening to remove excessive fines. Again, successful compaction depends on the compatibility of the products being compressed. If fines are not removed or reprocessed, then the batch may contain too many of them, a situation that can contribute to capping, laminating, weight, and hardness problems on the tablet press. The need for screening large amounts of fines is common to roller compaction, and the degree to which it can be managed depends on the nature of the ingredients. Any product that is removed from the rest of the batch because of particle size must be analyzed to determine what is being removed. Roller compacting the complete formula is not usually necessary. The object is to densify powders and form granules of the products in the formula that must be compacted, mill the granules, and then blend them back in with the rest of the formula's ingredients. Most dry-granulated products do not have problems with picking and sticking because moisture is not present [8].

**Wet Granulation-** involves the massing of dry primary particles using a granulating fluid (the process of adding a liquid solution to powder). The fluid contains a solvent which must be volatile so that it can be removed by drying, and be non-toxic. Typical liquids include water, ethanol and iso propanol, either alone or in combination. The granulation liquid may be used alone or more usually as a solvent containing a dissolved adhesive (also referred to as a binder or binding agent) which is used to ensure particle adhesion once the granule is dry. The density of each granule is increased by increasing the amount of binding solution as well as mechanical action of mixer. Therefore, controlling the amounts of solution, binder and mechanical action allows one to control the strength and density of the granule. Water is commonly used for economical pharmacological reasons. Its advantages as a solvent are that it may adversely affect drug stability, causing hydrolysis of susceptible products, and it needs a longer drying time than do organic solvents. It increases the length of process and again may affect the stability because of the extended exposure to heat. The primary advantage of water is that it is non-inflammable, which means that expensive safety precautions such as the use of flameproof equipment need not be taken. Organic solvents are used when water-sensitive drugs are processed, as an alternative to dry granulation or when a rapid drying time is required. Water mixed into powders can form bonds between powder particles that are strong enough to lack them together. However once the water dries, the powders may fall apart. Therefore water may not be strong enough to create and

hold a bond. In such instances a liquid solution that includes a binder is required. Povidone is one of the most commonly used pharmaceutical binders. PVP is dissolved in water or solvent and added to process. When PVP and a solvent or water mixed with powders, PVP forms a bond with the powders during the process and the solvent/water evaporates. Once the solvent/water has been dried and the powders have formed a more densely held mass, than the granulation is milled. This process results in the formation of granules

### **SUSTAINED RELEASE MATRIX TABLET OF GLIPIZIDE**

Sustained release systems include any drug delivery system that achieves slow release of drug over an extended period of time and prolongs the therapeutic activity of drug. Sustained drug delivery system reduced the fluctuation in circulating drug plasma levels. It has many other advantages like: improve the bioavailability of some drugs, reduction in dosing frequency, more uniform effect and increased the patient convenience and compliance and reduction in cost and toxicity [8].

Glipizide is a second generation sulphonyl urea and used to treat type 2 diabetes. Glipizide have short biological half-life (2 to 5 hrs.) and is rapidly eliminated, so requiring it to be administered in 2 to 3 doses of 2.5 to 15mg per day. Hence once daily sustained release matrix tablet of glipizide is developed. The pharmacokinetics and dosage schedule supports once daily sustained release formulations of Glipizide for better control of blood glucose levels to prevent hypoglycaemia.

Several sustain release formulation are prepared for glipizide by different scientist. A few of them are described as mentioned below;

Lakshmana M. G. et al [9] designed sustained release matrix tablet of Glipizide using synthetic (sodium alginate, carbopol) and natural (chitosan, xanthan gum) polymers by wet granulation method, at different ratios 1:5, 1:6, 1:7, 1:8 (Drug : Polymers). Release kinetics was studied by using United State of pharmacopeia (USP) – 22 type I dissolution apparatus. Furthermore in Vitro and In Vivo datas of newly formulated sustained release glipizide tablets were compared with conventional marketed tablet (Glipizide, India). The in vitro release study revealed that formulation containing chitosan shoed sustained release of 96.4% up to 12 hrs. Sustained release formulation of Glipizide containing chitosan showed god bioavailability and pharmacokinetic profile from the in-vivo study carried out on rat and the result showed that the developed sustained release tablet of glipizide performed therapeutically better than conventional dosage forms, leading to improved bioavailability, therapeutic efficacy with better patient compliance [10].

Giri S. et al, 2013 designed Sustained release matrix tablet of glipizide using different hydrophilic polymers (HPMC different grades and sodium CMC) in

various proportions as release retarding agent by direct compression method. The work was to study the effect of various hydrophilic polymers on in vitro release rate from sustained release tablet of Glipizide. The sustained release drug delivery was a promising approach to achieve a prolonged therapeutic action of drug. Different types of matrix forming polymers HPMC K4M, HPMC K15M, HPMC K100M, HPMC E15 and sodium CMC alone & combination were studied. The prepared matrix tablets were subjected to thickness, friability, weight variation test, drug content, hardness, swelling index and in vitro release studies. Formulation containing HPMC K100 & E15 in combination showed controlled drug release for 12h, emerging as best formulation. The cumulative percentage drug was decreased by increase in polymer concentration. Mechanism of drug release of optimized formulation found to be zero order Non-Fickian diffusion. FTIR & DSC studies proved the no chemical interaction in drug and polymer of the developed matrix tablets. The stability studies were carried out according to ICH guideline and selected formulation was stable at 40°C/75% RH up to 3 months [11].

Gouthami T. J. et al [12] designed sustained release matrix tablets of the Glipizide by different polymers like HPMC – K100M, HPMC – K15M, Chitosan, and Aloe mucilage in different ratios with the drug (drug: polymer, 1:6, 1:7, 1:8) by wet granulation method. Sustained release tablets of Glipizide which on oral administration prolongs its release thereby increasing bioavailability, diminishing side effects and enhanced patient compliance. The prepared formulations were evaluated with pre-compression parameters like bulk density, compressibility index, hausner's ratio, angle of repose and post-compression parameters like weight variation, thickness, hardness, friability. In vitro drug release studies were carried out using USP XXIV dissolution apparatus type II at 50 rpm. From the all observations it is concluded that slow and controlled release of Glipizide over a period of 12 hours was obtained from matrix tablets. The dissolution medium consisted of 900 ml of pH 7.4 phosphate buffer, maintained at 37± 0.5 °C. Among all the formulation the HPMC – K100M shows the better retarding of drug release from the Glipizide sustained release tablets

The cumulative percentage drug was decreased by increase in polymer concentration. The mechanism of drug was diffusion coupled with erosion. The stability studies show that there was no significant change in hardness, friability, and drug content of selected formulation. The controlled and efficient drug delivery system developed in the present study will maintain plasma Glipizide levels better, which will overcome the drawbacks associated with the conventional therapy [13].

Reddy S.P. et al [14] designed Sustained Release Matrix Tablets with *Azadirachta indica* fruit mucilage and Poly Vinyl Pyrrolidone by wet granulation technique. The

polymers were studied for its functionality as a matrix forming property to sustain the Glipizide release from the dosage form. Physicochemical properties of dried powdered mucilage of *Azadirachta indica* fruit mucilage and Poly Vinyl Pyrrolidone blend were studied. Various formulations of Glipizide *Azadirachta indica* fruit mucilage and Poly Vinyl Pyrrolidone were prepared. The prepared tablets were found to have better pharmacopoeial parameters with low standard deviation values. The swelling behaviour and release rate characteristics were studied. The in-vitro dissolution study proved that the dried *Azadirachta indica* fruit mucilage and Poly Vinyl Pyrrolidone combination can be used as a matrix forming polymers for making sustained release matrix tablets [15].

Ahed H. A. et al, 2010 prepared matrix tablets of Glipizide with Prosopis juliflora gum by direct compression method. They formulated tablets found to have better uniformity of weight and the drug content with low SD values. The swelling behavior and release rate characteristics were studied. The dissolution study proved that the dried Prosopis juliflora gum can be used as a matrix forming material for making once daily Sustained release matrix tablets [16].

Nazir I. et al, 2009 designed SR matrix tab of Glipizide using ethyl cellulose (hydrophobic), high viscosity grades of hydroxypropyl methylcellulose (hydrophilic) and Kollicoat SR (hydrophobic-hydrophilic mixed) by wet granulation method. All the polymers were incorporated separately in the matrix system. In vitro dissolution studies were conducted in 450 ml 0.1M NaOH solution for 12 hrs testing intervals. Dissolution data indicated that as the amount of various polymers increased, the release rate of glipizide form matrix tablet was decreased. However, more sustaining effect was produced by HPMC based matrix tablets compared to EC or Kollicoat SR-based matrix tablets. However, HPMC based formulation comprising 10% glipizide, 50% HPMC, 39% lactose, and 1.0% magnesium stearate produced more linear release profile and comparable to reference product, Glipizide XL [17].

Boddeda B. et al [18] designed a sustained release (SR) matrix tablet of glipizide by employing two hydrophobic polymers (ethyl cellulose and ethylene vinyl acetate copolymer) and two natural hydrophilic gum resins (olibanum resin and colophony) by wet granulation technique. Different batches of glipizide sustained release tablets were prepared by using lactose and dicalcium phosphate as diluents by wet granulation technique. The prepared tablets were evaluated for various parameters. In vitro drug release study was carried out and compared with the commercial Glynase XL tablets. The independent model method, Lin Ju and Liaw's difference factor ( $f_1$ ) and similarity factor ( $f_2$ ) were used to compare various dissolution profiles. The dissolution profiles of an ideal formulation (SR F3) containing olibanum resin and lactose as diluents was found to be comparable with the reference

product. The kinetics of drug release was best explained by Korsmeyer and peppas model and the mechanism of drug release from these tablets was by non-fickian diffusion mechanism. The ideal formulation (SR F3) was stable when it was stored at  $4\pm 2^\circ\text{C}$ ,  $27\pm 2^\circ\text{C}$  and  $45\pm 2^\circ\text{C}$  for 6 months. The results of the study indicated that the hydrophilic natural gum resins (olibanum and colophony) were more suitable (at the concentration used) for obtaining sustained release of Glipizide over 24 hrs [19].

Venkateswarlu K. and Shanthi, A designed sustained release matrix tablet of Glipizide using Eudragit RL 100 and ethyl cellulose direct compression method. The results of this study enable us to state that combination of these polymers with various proportions does not affect the drug release and thus the matrix tablet formulation will be the effective pharmaceutical formulations.

Timilsina S. et al designed sustained release matrix tablets of Glipizide by varying the concentration of HPMC polymers by wet granulation method. Increasing the amount of HPMC resulted in decreasing the release rate of glipizide drug. The mass of HPMC as well as viscosity grade plays the crucial role in the release of glipizide from the formulation.

Radhika P.R. et al developed a new monolithic matrix tablet to completely deliver glipizide in a zero order manner over a sustained period. Two approaches were examined using drug in a formulation that contain polymer like hydroxyl propyl methyl cellulose K 100 (HPMCK) and Eudragit L 100. The granules were prepared by wet granulation method and the granules of different formulations were evaluated for angle of repose, loose bulk density and tapped density, compressibility index, total porosity and drug content. The results of angle of repose ( $<30$ ) indicate good flow properties of the granules. This was further supported by lower compressibility index values. The granules showed satisfactory flow properties, compressibility and drug content. All of the formulations showed uniform thickness ( $C.V < 0.5\%$ ), uniform weight with little significance difference were observed with varying formulation composition. In the weight variation test, the pharmacopoeial limit for the percentage of deviation for tablets of more than 130 mg to 324 mg is 7.5 % difference. Technological characterizations (thickness, diameter, weight variation test, drug content, hardness, and friability) were conducted with the formulated matrix tablet and *in vitro* drug release was measured by means of dissolution apparatus. Of the various formulation distinguished, out of which, the formulation were preferred to be full of 30 mg of HPMCK and 35 mg of Eudragit L100 was subjected to stability were accomplished studies for three months at  $4^\circ\text{C}$ . The room temperature ( $25^\circ\text{C}$ ) and ( $45^\circ\text{C}$ ) with relative humidity  $75\pm 5\%$  were maintained and its stability with respect to release pattern.

Saumya S. and Dharmajeet P prepared a gastro retentive drug delivery system of Glipizide (Floating tablets) using Eudragit and two different grades of

Hydroxy Propyl Methyl Cellulose K4M (HPMCK4M) and Hydroxy Propyl Methyl Cellulose K100M (HPMCK100M) polymers by effervescent technique. Sodium bicarbonate was incorporated as a gas-generating agent. The Floating tablets were evaluated for uniformity of weight, hardness, friability, drug content, in vitro buoyancy and dissolution studies. The drug release profile and floating properties was investigated. The prepared tablets exhibited satisfactory physico-chemical

characteristics. All the prepared batches showed good in vitro buoyancy. The tablets showed good results for in vitro buoyancy studies and floating time. It was observed that the tablets remained buoyant for 18-20 hours. The tablets with an optimum concentration of HPMCK4M and HPMCK100M were found to float for longer duration and showed maximum drug release as compared to other formulations containing mixture of HPMC and Eudragit.

**Table 1. Steps involved in these methods.**

Wet Granulation Method	Dry Granulation Method	Direct Compression Method
Blending	Blending	Blending
Wet massing and screening	Slugging/roller compaction	-
Drying	Screening	-
Dry screening	-	-
Blending(with lubricant)	Blending(with lubricant)	Blending(with lubricant)
Compaction	Compaction	Compaction

**Table 2. Research Materialized in Sustained Release Techniques of Glipizide**

Sl. No.	Formulation	Method	Polymers	References
1.	Matrix tablet	Wet Granulation Method	Sodium alginate, Carbopol, Chitosan, Xanthan gum	Lakshmana MG et al 2011 [11]
2.	Matrix tablet	Direct Compression Method	HPMC K4M, HPMC K15M, HPMC K100M, HPMC E15 and sodium CMC	Giri S. et al 2013 [12]
3.	Matrix tablet	Wet Granulation Method	HPMC K100M, HPMC K15M, Chitosan, and Aloe mucilage	Gouthami TJ et al 2013 [13]
4.	Matrix tablet	Wet Granulation Method	<i>Azadirachta indica</i> fruit mucilage and Poly Vinyl Pyrrolidone	Reddy SP et al 2011 [14]
5.	Matrix tablet	Dry Granulation Method	Prosopis Juliflora gum	Ahed HA et al, 2010 [7]
6.	Matrix tablet	Wet Granulation Method	Hydroxypropyl methylcellulose and Kollicoat SR	Nazir I. et al 2009 [15]
7.	Matrix tablet	Wet Granulation Method	Ethyl cellulose, Ethylene vinyl acetate copolymer, Olibanum Resin and Colophony	Boddeda B. et al 2012 [16]
8.	Matrix tablet	Direct Compression Method	Eudragit RL 100 and Ethyl cellulose	Venkateswarlu K. and Shanthi A. 2012 [17]
9.	Matrix tablet	Wet Granulation Method	HPMC	Timilsina S. et al 2012 [18]
10.	Matrix tablet	Wet Granulation Method	HPMCK 100 and Eudragit L 100	Radhika PR. et al 2009 [6]

**Table 3. Sustained Release Marketed Preparations of Glipizide**

SR. NO.	BRAND NAME	COMPANY	DOSE
1.	Glynase XL	USV, Mumbai	Tablet (5mg, 10mg)
2.	Bimode-SR	Emcure, Pune	Tablet (5 mg, 10 mg)
3.	G-Trol	Orchid(mano), Chennai	Tablet (5 mg, 10 mg)
4.	Glutop-SR	RPG (Acumed), Chennai	Tablet (2.5mg, 5 mg, 10 mg)
5.	Glytop-SR	RPG-LS, Mumbai	Tablet (6.85mg, 9.35mg)

## CONCLUSION

To achieve the sustained effect in diabetes i.e. hyperglycemias, the drug availability must be ensured in the body. The sustained release formulations attempted with different investigators mentioned above may be used commercially. With sustained delivery system reduced

frequency of dosing or increase the effectiveness of the drug by localization at the site of action, reducing the dose required or providing uniform drug delivery can be achieved. Hence it improves the patient convenience and compliance.

## REFERENCES

1. Dash TR and Verma P. Matrix Tablets. An Approach towards Oral Extended Release Drug Delivery. *International Journal of Pharma Research & Review*, 2(2), 2013, 12-24.
2. Patil K, Patil P, Patil J, et al. A Basic Approach on Sustained Release drug Delivery System. *American Journal of PharmTech Resarch*, 2(5), 2012, 213-231.
3. Dusane AR, Gaikwad PD, Bankar VH, et al. A Review, on sustained release technology. *International Journal of Resarch in Ayurveda and Pharmacy*, 2(6), 2011, 1701-1708.
4. Kumar KPS, Bhowmik D, Shrivastaya S et al. Sustained Release Drug Delivery System Potential. *The Pharma Innovation*, 1, 2012, 46-56.
5. Rao NGR. Review on Matrix Tablet as Sustained Release. *International Journal of Pharmaceutical Research & Allied Sciences*, 2(3), 2013, 1-17.
6. Radhika PR, Pal TK, Sivakumar T. Formulation and Evaluation of Sustained Release Matrix Tablets of Glipizide. *Iranian Journal of Pharmaceutical Sciences*, 5(4), 2009, 205-214.
7. Ahed HA, Harika B, Leela LV et al. Formulation and In-vitro Evaluation of Once-Daily Sustained-Release Matrix Tablets of Glipizide. *Scholars Research Library*, 2(1), 2010, 265-274.
8. Dokala GK and Pallavi. Direct Compression - An Overview. *International Journal of Research in Pharmaceutical and Biomedical Sciences*, 2013, 4(1), 155-158.
9. Tousy MD. The Granulation Process 101-Basic Technologies for making Tablets, 2013.
10. Granulation process. Available at <http://formulation.vinensia.com/2011/11/methods-of-pharmaceutical-granulation.html>.
11. Lakshmana MG, Hareesha C, Gargeyi P, et al. Drug Release and Swelling Kinetic properties of Glipizide Sustained Release Matrix Tablet- Wet Granulation Technique. *International Journal of pharmacy and industrial research*, 1(1), 2011, 43-51.
12. Giri S, Velmurugan S, Chowdary S. Formulation and Evaluation of Glipizide Sustain Release Matrix Tablets. *International Journal of Pharmacy and Pharmaceutical Sciences*, 5(1), 2013, 354-360.
13. Gouthami TJ, Janshipriya MV, Naidu N. Effect of different polymers on release of the sustained release tablets of the glipizide. *Journal of Chemical and Pharmaceutical Research*, 5(5), 2013, 111-118.
14. Reddy SP, Ahad HA, Sreenivasulu R, et al. Preparation and Evaluation of Glipizide *Azadirachta indica* Fruit Mucilage Poly Vinyl Pyrrolidone Sustained Release Matrix Tablets. *Scholars Research Library*, 3(1), 2011, 138-144.
15. Nazir I, Rahman N, Assadullah M. Preparation and In Vitro Dissolution of Glipizide Sustained Release Tablets. *Turk J. Pharm. Sci.*, 6(1), 2009, 43-50.
16. Boddeda B, Kumari PVK, Chowdary KPR. Formulation and evaluation of glipizide sustained release tablets. *International Journal of Pharmaceutical and Biomedical Research*, 3(1), 2012, 44-48.
17. Venkateswarlu K and Shanthi A. Formulation and Evaluation of Sustained Release Glipizide Matrix. *IOSR Journal of Pharmacy and Biological Sciences*, 2(5), 2012, 17-23.
18. Timilsina S, Adhikari A, Yadav AK, et al. Formulation and In-Vitro Evaluation of Sustained Release Matrix Tablets of Glipizide. *Journal of Drug Delivery & Therapeutics*, 2(5), 2012, 4-8.
19. Saumya S and Dharmajeet P. Formulation and Optimisation of Gastro Retentive Drug Delivery System Containing Glipizide. *International Journal of Pharmacy and Pharmaceutical Sciences*, 4(1), 2012, 203-205.