IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 3, October 2025
Impact Factor: 7.67

Formulation and Evaluation of Metformin Hydrochloride Sustained Release Tablet

Kajal R. Rokade, Payal A. Ekshinge, Miss. Jagruti Salve
Sahkar Maharshi Kisanrao Varal Patil Collage of Pharmacy, Nighoj

Abstract: *Metformin hydrochloride (MET) is a widely used oral hypoglycemic agent that improves glucose tolerance in patients with type 2 diabetes by lowering basal plasma glucose levels. However, its relatively short plasma half-life and low bioavailability necessitate frequent administration (2–3 times daily), which may reduce patient compliance and increase dose-dependent side effects. To address these limitations, sustained-release (SR) matrix tablets of MET were developed using the wet granulation technique with Polyvinyl pyrrolidone K30 and hydroxypropyl methylcellulose (HPMC) of varying viscosity grades (K4M, K15M, and K100M). The impact of different polymer ratios on drug release was evaluated, with results indicating that while HPMC K100M alone was insufficient to achieve the desired release profile, its combination with PVP K30 provided optimal kinetics. Among all formulations, batch F3 demonstrated superior performance, achieving controlled release over 8–12 hours. Such a formulation has the potential to reduce dosing frequency, enhance patient adherence, and minimize adverse effects. This the promise of matrix-based sustained release systems as an effective strategy for optimizing the therapeutic performance of metformin hydrochloride.*

Keywords*:* Sustained-release drug delivery, Matrix tablet formulation, Diffusion mechanism, Rate-controlling polymer, Antidiabetic agent, Metformin hydrochloride, HPMC K100M, Wet granulation method

I. INTRODUCTION

Diabetes mellitus is one of the leading causes of morbidity and mortality worldwide. It is a chronic metabolic disorder that alters the body's ability to convert food into energy due to impaired insulin secretion, insulin resistance, or both. Insufficient insulin levels result in persistent hyperglycemia, which is associated with severe complications such as cardiovascular disease, nephropathy, retinopathy, and neuropathy. Diabetes mellitus is broadly classified into two main types: Type I (juvenile or insulin-dependent diabetes mellitus) and Type II (non-insulin-dependent diabetes mellitus), the latter being the most prevalent for Among various drug administration routes (oral, nasal, ophthalmic, rectal, transdermal, and parenteral), the oral route remains the most widely utilized due to its convenience, cost-effectiveness, patient compliance, and ease of manufacturing. In recent decades, novel drug delivery systems (NDDS) have been designed to provide continuous and predictable drug release profiles, thereby maintaining therapeutic plasma concentrations for extended periods. Sustained-release (SR) formulations reduce dosing frequency, minimize fluctuations in plasma drug concentration, improve patient adherence, and decrease the risk of dose-related adverse effects. Controlled drug delivery systems, in particular, are engineered to modulate the rate, duration, and site of drug release. [1]

These systems provide more consistent plasma concentrations compared to conventional immediate-release dosage forms, which often lead to peaks and troughs in drug levels. By maintaining steady therapeutic levels, controlled systems enhance efficacy and safety. Metformin hydrochloride (MET), a first-line oral antihyperglycemic agent, is widely prescribed for the management of Type II diabetes mellitus, especially in patients who fail to achieve adequat glycemic control with lifestyle modifications alone.[2]

Unlike sulfonylureas, Metformin does not cause hypoglycemia or hyperinsulinemia and is particularly useful in overweight and patients as it does not promote weight gain. Its mechanism of action involves the reduction of hepatic glucose production, suppression of intestinal glucose absorption, and enhancement of peripheral glucose by muscle and adipose tissues. , Despite its clinical efficacy, Metformin presents challenges due to its short biological half-life (~2.6 h), high water solubility, and requirement for multiple daily doses (up to 2.5 g/day), which may lead to gastrointestinal side effects and poor patient adherence. Modified-release formulations of Metformin have been developed to overcome these limitations, providing extended therapeutic coverage, reduced dosing frequency, and minimized gastrointestinal intolerance .Among various sustained-release approaches, matrix tablets prepared using hydrophilic polymers have gained considerable attention. These systems entrap the drug within a polymeric network, allowing gradual release through swelling, diffusion, and erosion mechanisms. Hydrophilic polymers such as Hydroxypropyl Methylcellulose (HPMC) and natural polymers like Xanthan Gum are commonly employed as rate-controlling agents in matrix systems.[3] In the present research, sustained-release matrix formulations of Metformin hydrochloride were developed using HPMC (K4M/K100M) and Xanthan Gum as rate-modifying polymers. Tablets were prepared by the wet granulation technique with excipients such as polyvinylpyrrolidone K30 and magnesium stearate. The objective was to design a once-daily oral dosage form capable of maintaining controlled plasma concentrations of Metformin over 24 hours, thereby improving therapeutic efficacy, patient compliance, and safety. [4-5]

II. MATERIALS AND METHODS

Materials :

Metformin hydrochloride was obtained from Aarti Drugs. Polyvinylpyrrolidone (PVP K-30), Microcrystalline Cellulose (PH101), and Xanthan gum were procured from Loba Chemie, while Hydroxypropyl methyl cellulose (HPMC) was supplied by Anhui Sunhere Pharmaceutical Excipients Co. Ltd. Talc and Magnesium stearate were also obtained from Loba Chemie. All other chemicals, solvents, and reagents used in the study were of analytical grade.[6]

Methods :

Drug–excipient compatibility study

Prior to the development of a prototype formulation, it is essential to evaluate the physicochemical properties of the active pharmaceutical ingredient (API), Metformin Hydrochloride, in combination with the selected excipients. The drug–excipient compatibility study was therefore conducted to ensure the stability and suitability of the components for formulation development. [7]

Preparation of Matrix Tablets :

Metformin hydrochloride sustained release matrix tablets were prepared by the wet granulation method, employing polyvinylpyrrolidone (PVP K30) as the granulating agent. Various formulations were designed using different proportions of hydrophilic polymers, either alone or in combination. The general procedure for tablet preparation involved the following steps:

Step 1 Sifting : The accurately weighed drug and excipients were passed through appropriate mesh sieves (Metformin hydrochloride through 60#, while microcrystalline cellulose, xanthan gum, and HPMC K4M through 40#) to ensure uniform particle size.

Step 2 Dry mixing : The sifted materials were blended in a polybag for 30 minutes to obtain a homogeneous drug–excipient mixture. Samples were withdrawn to evaluate loss on drying (LOD) and blend uniformity.

Step 3 Preparation of binder solution : Polyvinylpyrrolidone (PVP K30) was dissolved in purified water under continuous stirring to obtain a clear binder solution.

Step 4 Wet granulation : The binder solution was gradually incorporated into the dry mixture with continuous mixing until a coherent wet mass was achieved. The granulation endpoint was determined visually based on the formation of uniform granules.

Step 5 Wet screening : The wet mass was passed through a 10# mesh to obtain granules of uniform size.

Step 6 Drying : The screened granules were initially air-dried for 10 minutes and subsequently dried in a tray dryer at 50 °C until the desired LOD was attained.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 3, October 2025
Impact Factor: 7.67

Step 7 Dry screening : The dried granules were rescreened through a 20# mesh and collected in double polythene-lined containers.

Step 8 Lubrication : Talc and magnesium stearate were added to the dried granules and blended thoroughly to obtain a lubricated mixture suitable for compression.

Step 9 Compression : The lubricated blend was compressed into tablets using a single rotary tablet press capsule-shaped punches (19.5 × 9.0 mm), featuring a break-line on one side. A constant compression force was applied to achieve a hardness of approximately 5–7 kg/cm². The prepared tablets were stored in airtight container . [8-12]

Table : Composition of matrix tablets of metformin hydrochloride [13]

Ingredients per tablets (mg)	**Composition (mg/s) of the formulation**		
	F1	**F2**	**F3**
Metformin HCl	500	500	500
Microcrystalline cellulose (PH 101)	150	140	120
Hydroxypropyl methyl cellulose (HPMC K4M)	180	180	200
Xanthan Gum	-	-	–
Polyvinylpyrrolidone (PVP K30)	10	20	20
Purified water	q.s	q.s	q.s
Talc	5	5	5
Magnesium stearate	5	5	5
Total weight	850	850	850

Pre-compressional Evaluation

Angle of Repose

The angle of repose is an important parameter used to evaluate the flow properties of powders. It indicates the influence of interparticle friction and cohesion. It is defined as the maximum angle formed between the surface of a powder heap and the horizontal plane. The static angle of repose was determined using the fixed funnel (or fixed cone) method. The angle of repose (θ) was calculated using the following equation . [14]

$$\tan \theta = h / r$$

Where,

θ = angle of Repose

h = height of the pile

r = radius of pile base

Bulk Density (BD)

For the determination of bulk density, an accurately weighed quantity of the powder blend from each formulation was transferred into a measuring cylinder after gently shaking to disperse any agglomerates. The initial volume occupied by the powder was recorded as the bulk volume. Bulk density was calculated using the following expression:[15]

Bulk Density (BD) = Total Weight of powder / Total volume of powder

Tapped Bulk Density (TBD)

Tapped bulk density was evaluated by transferring an accurately weighed sample of the powder blend into a measuring cylinder, which was then tapped mechanically until a constant volume was achieved. The final volume was recorded as the tapped volume. Tapped bulk density was determined using the formula: [16]

TBD= Total Weight Of Power/ Total Volume Of tapped Powder.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 3, October 2025
Impact Factor: 7.67

Compressibility Index

Powder flow property can be measured by Compressibility index also known as Carr's Index. So, it is defined by the equation .[17]

$$\text{Carrs index} = \frac{\text{Tapped density} - \text{Bulk density} \times 100}{\text{Bulk density}}$$

Where, Bulk density is the ratio of mass of powder to the bulk volume and Tapped density is the ratio of mass of powder to the tapped volume.

III. EVALUATION OF METFORMIN HYDROCHLORIDE SUSTAINED-RELEASE MATRIX TABLETS

Disintegration Test

The purpose of the disintegration test is to evaluate whether the sustained-release Metformin tablets maintain their physical integrity while ensuring controlled release of the active ingredient. [18]

Method: The test is typically carried out using a disintegration apparatus, which holds the tablets in a basket or mesh screen. The apparatus is immersed in a dissolution medium, such as water or a suitable buffer solution, maintained at a controlled temperature.

Weight Variation

Weight variation testing is performed to assess the uniformity of tablet weight, which reflects consistency in the formulation and manufacturing process. In this test, twenty tablets are randomly selected, individually weighed, and the mean weight is calculated. The deviation of each tablet from the average is then determined. According to the Indian Pharmacopoeia standards, tablets with an average weight between 80–250 mg should not deviate by more than ±7.5 [19]

Friability

Friability testing is conducted to evaluate the mechanical strength of tablets, particularly their ability to withstand abrasion and shock during handling, packaging, and transportation. The test is commonly performed using a Roche friabilator (e.g., Electro Lab USP EF-2), where a pre-weighed sample of tablets is subjected to standardized rotational impact. Typically, tablets are rotated at 25 rpm for 4 minutes, corresponding to 100 revolutions, during which they fall repeatedly from a height of 6 inches within a rotating plastic chamber. After completion, the tablets are dedusted and reweighed, and the percentage weight loss is calculated. A friability value below 1% is generally considered acceptable, indicating ×adequate resistance to mechanical stress..The friability (F) is expressed. [20]

$$F = \frac{(W0 - W)}{W}$$

where W_0 is the initial tablet weight and W is the final weight after testing.

Uniformity of Thickness

The thickness and diameter of tablets are critical parameters to ensure uniformity in tablet size. These dimensions were determined using a digital vernier calliper. [21]

Hardness Test

Twenty tablets were randomly selected from each batch, and the hardness of each tablet was measured using a Monsanto hardness tester. The test was carried out by placing the tablet between the fixed jaw and the sliding jaw of the instrument. Tablet hardness is an important parameter as it influences the ability of the tablets to withstand handling, storage, transportation, and shipping without breaking or chipping. [22]

Uniformity of Drug Content

For each formulation, ten tablets were randomly selected, weighed, and finely powdered using a mortar and pestle. An accurately weighed portion of the powder, equivalent to 500 mg of metformin hydrochloride, was transferred to a 100 ml volumetric flask containing pH 6.8 phosphate buffer. The solution was filtered through Whatman filter paper to obtain a clear filtrate. Appropriate dilutions were prepared with the same buffer, and the drug content was analyzed . [23]

In Vitro Dissolution Studies

The in vitro dissolution behaviour of all formulated tablets, along with a marketed formulation, was evaluated using the USP type II dissolution apparatus (paddle method). The study was conducted in 900 mL of 0.1 N HCl maintained at 37 ± 2 °C, with the paddle rotating at 100 rpm for a duration of 8 hours. At predetermined time intervals, 10 mL of the dissolution medium was withdrawn and immediately replaced with an equal volume of fresh medium pre-equilibrated at 37 ± 2 °C, thereby maintaining sink conditions and a constant volume. The collected samples were analyzed using a UV–Visible spectrophotometer, and the percentage drug release was calculated from the concentration of the drug present in the samples.[24]

IV. RESULTS

In the present study, sustained-release tablets of metformin hydrochloride were successfully developed using the wet granulation method, owing to its simplicity and feasibility. The formulations were designed with varying concentrations of polymers in order to evaluate their influence on the drug release profile. The blended powder mixtures were subjected to pre-compression evaluations, and the results indicated that the powders possessed satisfactory characteristics, making them suitable for tablet compression. The sustained-release tablets of metformin hydrochloride successful compression, the drug–excipient blend is

required to exhibit acceptable flow properties. Therefore, the flow characteristics of the powder mixture were evaluated by determining the angle of repose, compressibility index. The results revealed that the blends demonstrated good flowability, indicating their suitability for tablet formulation.

REFERENCES

[1]. Mahesh Hemnani, Upendra Patel, Ghanshyam Patel, Dhiren Daslaniya, Amarish Shah, Bhavin Bhimani. Matrix tablets: a tool of controlled drug delivery. Am J Pharm Tech Res. 2011;1(4):127-43.

[2]. Kamboj S, Gupta GD. Matrix tablets: an important tool for oral controlled-release dosage forms. Pharm Rev. 2009;7(6);1.

[3]. Eswaraiah C, Jaya S. Formulation and in vitro evaluation of metformin hydrochloride sustained release tablets. J Drug Delivery Ther. 2019;9(4):24-

[4]. Lieberman HA, Lachman L, Schwartz JB. Pharmaceutical dosage forms: tablets. 2nd ed. Vol. 3. P. 199-287.

[5]. Higuchi TA. Mechanism of sustained action medication. J Pharm Sci 1963;52:1145-9. Or type 2 diabetes. Diabetol Metab Syndr. 2013; 5 (1):6.https://doi.org/10.1186/1758-5996-5-6

[6]. Brahmankar DM, Jaiswal SB. Biopharmaceutics andpharmacokinetics a treatise. 1st ed. New Delhi: Vallabh Prakashan; 1995.

[7]. Chein YW. Noval drug delivery systems. 2nd ed. New York: Marcel Dekker; 1992. P. 1-42.

[8]. Jain NK. CBS publishers and distributors. 1st ed. New Delhi: Pharmaceutical Product Development; 2006. P. 419-24.

[9]. Vyas SP, Khar RK. Controlled drug delivery concepts and advances. 1st ed. New Delhi: Vallabh Prakashan; 2010.

[10]. Robinson JR, Lee VHL. Controlled drug delivery: fundamentalsand applications. 2nd ed. New York: Marcel Dekker; 1987. P. 253-60.

[11]. Lalla JK. Introduction to controlled release and oral controlleddrug delivery system. East Pharm. 1991;45:25-8.

[12]. Jantzen GM, Robinson JR. Morden pharmaceutics. 4th ed. New York: Marcel Dekker; 1996. P. 492-520.

[13]. Modi SA, Gaikwad PD, Bankar VH, Pawar SP. Sustained releasedrug delivery system: a review. Int J Pharm Res Dev.2011;2(12)

[14]. Basavaraj K, Mhase SR, Manvi FV. Formulation of extended-release metformin hydrochloride matrix tablets. Trop J Pharm Res 2011

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 3, October 2025
Impact Factor: 7.67

[15]. Colombo R, Bettini P, Santi P, Peppas NA. Swellable matrices for controlled drug delivery, Gel-layer behavior, mechanisms and optimal performance. Pharm Sci Tech Today. 2000; 3:198-204.https://doi.org/10.1016/S1461-5347(00)00269-8

[16]. Chowdary P, Sravani T, Basheeruddin MD. Formulation and evaluation of sustained release tablets of nateglinide by using natural polymers. Int J Adv Pharm Sci. 2017; 9(1):8-13.https://doi.org/10.5138/09761055.206

[17]. Wise DL. Handbook of pharmaceutical controlled releasetechnology. 1st ed. New York: Marcel Dekker, Inc; 2005. p. 5-24.

[18]. International Diabetes Federation. (2020). IDF Diabetes Atlas, 10th edition.

[19]. Bailey, C. J., & Day, C. (2019). Metformin: its role in type 2 diabetes treatment. Diabetes, Obesity and Metabolism, 21(1), 5-15.

[20]. Liu, F., et al. (2019). Patient preferences for oral antidiabetic medications in type 2 diabetes: a

[21]. British Pharmacopoeia Commission, British Pharmacopoeia, Great Britain: Stationery Office, 2020.

[22]. Sastry SV, Nyshadham JR, Fix JA. Recent technological advances in oral drug delivery- a review. Pharm Sci Technol Today.2000;3(4):138-45. doi: 10.1016/s1461-5347(00)00247-9, PMID 10754543

[23]. Yadav NK, Shukla T, Upmanyu N, Pandey SP, Khan MA, Jain DK. Concise review: therapeutic potential of flupirtine maleate. J Drug Deliv Therap. 2019; 9(1-s):467-71.https://doi.org/10.22270/jddt.v9i1-s.2350

[24]. Tucker GT, Casey C, Phillips PJ, Connor H, Ward JD, Woods HF. Metformin kinetics in healthy subjects and in patients with diabetes mellitus. Br J Clin Pharm. 1981; 12:235-246.https://doi.org/10.1111/j.1365-2125.1981.tb01206.x