Preparation of Glimepiride Sustained Release Matrix Tablets using *Hibiscus rosa-sinensis* Leaves Mucilage and Povidone

Hindustan Abdul Ahad*[1], Sreeramulu J[2], Narasimha Reddy D[3], Sravanthi M[1] and Suma Padmaja B[1]

[1] Department of Pharmaceutics, College of pharmacy, Sri Krishnadevaraya University, Anantapur- 515003, Andhra Pradesh, India

[2] Department of Chemistry, Analytical lab, Sri Krishnadevaraya University, Anantapur- 515003, Andhra Pradesh, India

[3]Department of Pharmaceutics, Vivekananda College of Pharmacy, Bangalore, Karnataka India

ABSTRACT

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The main purpose of the present work was to develop matrix tablets of Glimepiride with *Hibiscus rosa-sinensis* leaves mucilage and Povidone and to study its functionality as a matrix forming agent for sustained release tablet formulations. Mucilage from *Hibiscus rosa-sinensis* leaves was extracted, isolated, purified and characterized. Physicochemical properties of the dried powdered mucilage of *Hibiscus rosa-sinensis* leaves were studied. Various formulations of Glimepiride *Hibiscus rosa-sinensis* leaves mucilage and Povidone were prepared. The formulated tablets were tested for mechanical properties, friability, swelling behavior, *in vitro* drug release pattern and the dissolution data was subjected to mathematical modeling and the optimized formulation was tested for accelerated stability studies. The formulated tablets were found to have good mechanical properties, good swelling properties. The *in vitro* dissolution data was fitting to zero order and the release of drug from the formulation followed Higuchi's release. The accelerated stability studies revealed that the tablets retain their characteristics even after stressed storage conditions. From this study it was concluded that the dried *Hibiscus rosa-sinensis* leaves mucilage and Povidone combination can be used as an effective matrix forming material for making sustained release matrix tablets of Glimepiride.

Keywords: Glimepiride, *Hibiscus rosa-sinensis*, Povidone, matrix tablets, sustained release.

INTRODUCTION

Hibiscus rosa-sinensis, which is commonly known as China rose (family: *Malvaceae*), is a popular landscape shrub, creates an impressive effect with its medium-textured, glossy dark green leaves and with 4-6 inch wide and up to 8 inch long, showy flowers, produced throughout the year and grows up to 7-12 feet[1]. Glimepiride is an oral hypoglycemic agent, which is a commonly prescribed drug for the treatment of patients with type II diabetes mellitus. It belongs to the class of sulfonyl ureas. Glimepiride is a weak acid with PKa of 5.3. Glimepiride is practically insoluble in water and acidic solutions but highly permeable (class 2) according to the Biopharmaceutical classification System (BCS) [2]. The oral absorption is uniform, rapid and complete with nearly 100% bioavailability. The pharmacokinetics and dosage schedule supports once daily sustained release formulations for Glimepiride for better control of blood glucose levels to prevent hypoglycemia, enhancing clinical efficacy and patient compliance[3, 4]. The purpose of present work was to design and evaluate sustained release matrix tablets of Glimepiride using *Hibiscus rosa-sinensis* leaves mucilage and Povidone combination as release retardant.

*Address for Correspondence:

Hindustan Abdul Ahad, Department of Pharmaceutics, College of pharmacy, Sri Krishnadevaraya University, Anantapur- 515003, Andhra Pradesh, India

E-mail: abdulhindustan@rediffmail.com

MATERIALS AND METHODS

Materials:

Glimepiride was obtained as a gift sample from Dr. Reddy's Laboratories, Hyderabad, India. *Hibiscus rosa-sinensis* leaves were collected from plants growing in local areas of Anantapur, India. The plant was authenticated at the Department of Botany, Sri Krishnadevaraya University, Anantapur, India. Povidone, Micro crystalline cellulose (Avicel**)** and Magnesium stearate were procured from SD Fine chemicals (Mumbai, India). Tri chloro acetic acid, Acetone, Ethanol (95%), diethyl ether and all other chemicals used were of analytical reagent grade and double distilled water was used throughout the experiments.

Extraction of mucilage:

The fresh *Hibiscus rosa-sinensis* leaves were washed with water. The leaves were crushed and soaked in water for 5–6 h, boiled for 30 m and left to stand for 1 h to allow complete release of the mucilage into the water. The mucilage was extracted using a multi-layer muslin cloth bag to remove the marc from the solution. Acetone (in the quantities of three

times the volume of filtrate) was added to precipitate the mucilage. Later the mucilage was separated, dried in an oven at 40^{0}C, collected, ground, passed through a # 80 sieve and stored in desiccator at 30^{0}C & 45% relative humidity till use[5].

Purification of the Mucilage:

The crude mucilage (1%) was homogenized (Potter homogenizer, Sartorius AG, Germany) with cold dilute tri chloro acetic acid solution (5%). The solution was centrifuged (3500 rpm for 20 m), neutralized with sodium hydroxide by drop wise addition and then dialyzed for 30 h against distilled water. The mucilage was precipitated by adding three volumes of 95% ethanol and washed successively with ethanol, acetone and diethyl ether[5,6].

Drug-excipient compatibility studies:

Differential scanning calorimetric (DSC) analysis

The DSC analysis was carried out using Differential Thermal Analyzer (Shimadzu DSC-60, Shimadzu Limited, Japan)[7]. A 1:1:1 ratio of Glimepiride: *Hibiscus rosa-sinensis* leaves mucilage: Povidone were weighed into aluminum crucible and the DSC thermo grams were recorded at a heating rate of 10^{0}C/min in the rage 20^{0}C to 280^{0}C, at a nitrogen flow rate of 20 ml/m.

Fourier Transform Infrared (FTIR) spectral analysis

FTIR spectrums were recorded on samples prepared in potassium bromide (KBr) disks using FTIR spectrophotometer (Model-1601 PC, Shimadzu Corporation, Japan)[7]. Samples were prepared in KBr disks by means of a hydrostatic press at 6-8 tons pressure. The scanning range was 500 to 4000 cm^{-1}. The FTIR spectrums of pure Glimepiride, 1:1:1 ratio of Glimepiride: *Hibiscus rosa-sinensis* leaves mucilage: Povidone and formulation blend (F-5) were taken.

Preparation of matrix tablets:

Sustained release matrix tablets of Glimepiride with *Hibiscus rosa-sinensis* leaves mucilage and Povidone were prepared by using different drug: mucilage ratios. *Hibiscus rosa-sinensis* leaves mucilage and Povidone were used as matrix forming materials while microcrystalline cellulose as a diluent and Magnesium stearate as a lubricant. All ingredients used were passed through a # 100 sieve, weighed and blended. The granules were prepared by wet granulation technique and evaluated for its flow properties. The granules were compressed by using 10 mm flat faced punches[8, 9]. The compositions of formulations are shown in Table 1.

Evaluation for granules:

The granules so obtained were evaluated for flow properties[10-12] viz., Angle of repose, Loose Bulk Density, Tapped Bulk Density, Carr's Index and Hausner ratio.

Table 1: Formulae of matrix tablets

Ingredients (mg)	Formulation				
	F-1	F-2	F-3	F-4	F-5
Glimepiride	2	2	2	2	2
Hibiscus rosa-sinensis leaves dried mucilage	2.5	5.0	7.5	10.0	12.5
Povidone	5.0	5.0	5.0	5.0	5.0
Micro crystalline cellulose (Avicel)	85.5	183	180.5	178	175.5
Magnesium stearate	5	5	5	5	5
Total weight of tablet	200	200	200	200	200

Evaluation of tablets:

The formulated tablets were evaluated[13-16] for uniformity in thickness, uniformity in weight, hardness, Friability and uniformity in drug content.

Swelling behavior of matrix tablets:

One tablet from each formulation was kept in a Petri dish containing phosphate pH 7.4. At the end of 2 h, the tablet was withdrawn, kept on tissue paper and weighed, repeated for every 2 h till the end of 12 h. The swelling index was calculated by following equation[17].

$$S.I = \{(M_t - M_0) / M_0\} \times 100$$

Where, S.I = Swelling Index, M_t = Weight of tablet at time 't' and M_o = Weight of tablet at time 0.

***In vitro* drug release studies:**

Release of Glimepiride from the matrix tablets was studied in 900 ml phosphate buffer (pH 7.4) using United States Pharmacopoeia (USP) 6-station Dissolution Rate Test Apparatus (Model Electro lab, TDT- 06T, Mumbai, India) with a rotating paddle stirrer at 50 rpm and at 37 ± 0.5^{o}C. A sample of Glimepiride matrix tablets equivalent to 2 mg of Glimepiride was used in each test. Samples from dissolution fluid were withdrawn at regular intervals filtered (0.45 μm) and absorbance was measured at 229 nm for Glimepiride content[18] using a UV/ visible double-beam spectrophotometer (Elico SL210, India). The drug release studies were conducted in triplicate (n = 3).

Drug release kinetics:

To analyze the mechanism of drug release from the prepared formulations, the data obtained from *in vitro* release studies were subjected to Zero order[19], First order[19], Higuchi's[20], Korsmeyer Peppa's[21] and Hixson Crowell models[19].

Scanning Electron Microscopy:

The optimized formulation (F-5) was selected for Scanning Electron Microscopy (SEM) analysis. The tablet surface morphology was studied at zero time and 4th h of dissolution.

Accelerated Stability Studies of optimized matrix tablets:

The promising formulation (F-5) was tested for a period of 3 months at accelerated storage conditions (temperatures of 40^0C with 75% RH) and the drug content was estimated[22].

RESULTS AND DISCUSSION

The thermogram of Glimepiride showed a short endothermic peak at 209.13^0C (Figure 1). The thermogram of formulated matrix tablets with *Hibiscus rosa-sinensis* leaves mucilage and Povidone showed an endothermic peak at 193.20^0C (Figure 2) indicating a slight change in terms of shifting towards the lower temperature. Thus these minor changes in the melting endotherm in the drug could be due to the mixing of the drug and excipients which lower the purity of each component in the mixture (may not indicate the potential incompatibility).

Fig.1: DSC thermo gram of Glimepiride

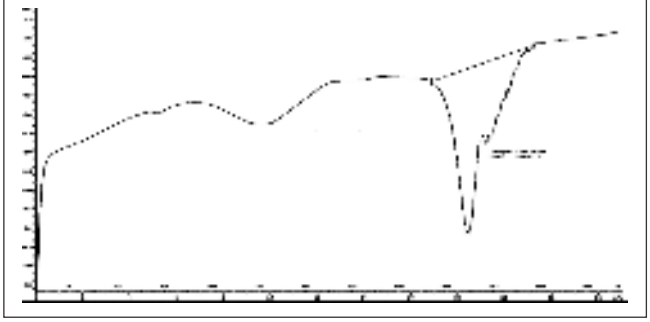
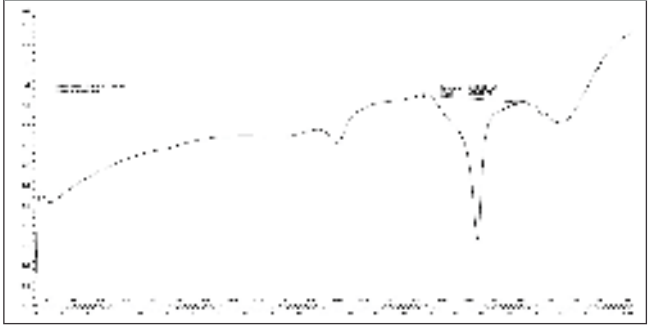


Fig.2: DSC thermo gram of Glimepiride: Hibiscus rosa-sinensis mucilage: Povidone (1:1:1)



The FTIR spectrum of Glimepiride showed characteristic peaks at wave numbers were 3344.3 (3300-3500) (N-H), 2900.7 (2850 – 3000) (C-H), 2900.7 (3300 - 2500 (O-H), 1427.2 and 1342.4 (1350 –1550) (N=O), 1072.3 (1220 -1020) (C-N) and 1033.8 (1000 –1300) (C-O) (Figure 3). Infrared absorption spectrum of *Hibiscus rosa-sinensis* leaves mucilage and Povidone (1:1) spectrum shows prominent peaks at wave numbers 2920.0 (2850 – 3000) (C-H), 3379.1 (3300 – 3500) (NH), 1029.1 (1000 – 1300) (C-O) (Figure 4). The major FTIR peaks observed in matrix tablets were 3344.3

Fig.3: FTIR spectrum of Glimepiride

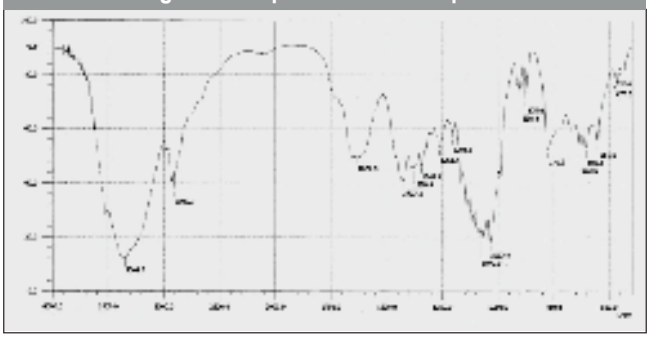
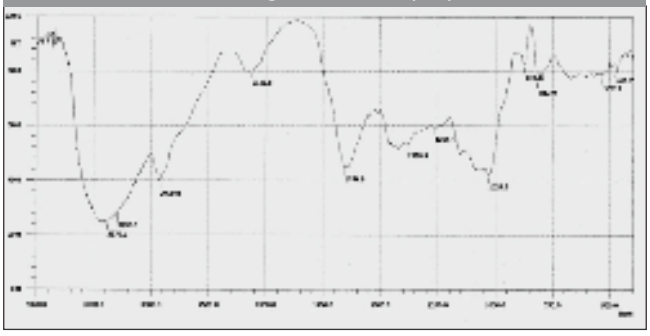


Fig.4: FTIR spectrum of Hibiscus rosa-sinensis leaves mucilage: Povidone (1:1)



(3300-3500) (N-H), 2900.7 (2850 – 3000) (C-H), 2900.7 (3300 - 2500 (O-H), 1427.2 and 1342.4 (1350 –1550) (N=O), 1072.3 (1220 -1020) and (C-N) 1033.8 (1000 –1300) (C-O). (All these values were represented as cm^{-1}). This indicates that there were no chemical incompatibility between Glimepiride and the polymers (*Hibiscus rosa-sinensis* leaves mucilage and Povidone) used.

The Angle of repose of granules was found to be 27.83^0±1.266 indicating that the granules had excellent flow properties. The Loose Bulk density and Tapped Bulk density were found to be 0.58±0.014 and 0.79±0.154 g/ml respectively which was used to calculated the Carr's index and Hausner ratio. The values of Carr's index and Hausner ratio were found to be 26.58±2.16 % and 1.25±0.12 respectively. All the values of flow properties have been shown in Table 2.These trials were conducted in triplicates (n=3).

The thickness of formulated matrix tablets ranged from 2.850.035 to 3.480.074 mm and the hardness ranged from 6.50±1.45 to 8.10±1.40 kg, which was more than 4 kg and passes the hardness test[14]. The loss on friability was ranged from 0.44±0.03 to 0.85±0.05 % (less than 1%). The formulated tablets were found to have good hardness and minimal weight loss on friability indicating that the tablets can with stand the mechanical shocks during their handling and transport. The drug content in the tablets was ranged from 99.5±2.56 to 100.5±3.67 %. These trials were conducted for five times and shown in Table 3. The tablets showed increase

Table 2: Flow properties of granules

Parameters	Value				
	F-1	F-2	F-3	F-4	F-5
Angle of repose (^{0})	29.45±1.114	28.20±0.015	25.26±0.022	27.62±0.121	27.83±1.266
Bulk density (g/ml)	0.62±0.001	0.58±0.002	0.59±0.002	0.62±0.001	0.58±0.014
Tapped density (g/ml)	0.85±0.001	0.84±0.001	0.88±0.001	0.87±0.001	0.79±0.154
Carr's index (%)	27.0±0.021	30.9±0.124	32.9±0.014	28.7±0.512	26.58±2.160
Hausner's ratio	1.371±0.001	1.448±0.002	1.491±0.001	1.403±0.012	1.25±0.120

Number of experiments (n) =3

Table 3: Physical properties of formulated matrix tablets

Formulation	Thickness (mm)	Hardness (kg)	Friability (%)	Drug content (%)
F-1	3.16±0.065	7.50±1.25	0.50±0.02	100.2±3.95
F-2	2.88±0.103	8.10±1.40	0.85±0.05	101.2±5.25
F-3	3.05±0.050	6.80±1.35	0.44±0.03	99.5±2.56
F-4	3.48±0.074	6.50±1.45	0.62±0.06	99.9±2.16
F-5	2.85±0.035	7.40±1.30	0.73±0.07	100.5±3.67

Number of trials (n) = 5

in swelling index as the concentration of *Hibiscus rosa-sinensis* leaves mucilage was increased (Figure 6).

The drug release rate was faster in F-1 and slower in F-5. The release of Glimepiride was sustained as the proportion of *Hibiscus rosa-sinensis* leaves mucilage increased and the overall time of release of the Glimepiride from the matrix tablet was also increased. The release of Glimepiride form the optimized formulation (F-5) showed zero order release and the formulations gave slope (n) and regression coefficient (r) values, which were 0.0067, 0.9952 respectively and shown in Table No. 4. The *In-vitro* drug release profile of Glimepiride from formulated matrix tablets was further studied using first order, whose slope and regression coefficient values of F-5 were -0.0017 and -0.9823 respectively and represented in Table No. 4. The slope and regression coefficient values of F-5 for Higuchi model were 3.3085 and 0.9939 respectively, for Korsmeyer Peppa's they were 0.3045 and 0.9685 and for Hixson-Crowell's Model they were -0.0009 and -0.9921 respectively. These values are represented in Table No.5 and shown in Figures 7, 8, 9, 10 and 11. The *in vitro* drug release data was fitted perfectly to zero order release and Higuchi's matrix models. Drug releases from matrix tablets were by drug dissolution, drug diffusion or a combination of both.

The surface morphology of optimized formulation (F-5) at zero time and at 4th h of dissolution was observed which indicates that the release of drug from dosage form was by diffusion mechanism. The SEM photographs of tablet (F-5) are shown in Figure 12.

Fig.5: FTIR spectrum of formulation (F-5) blend

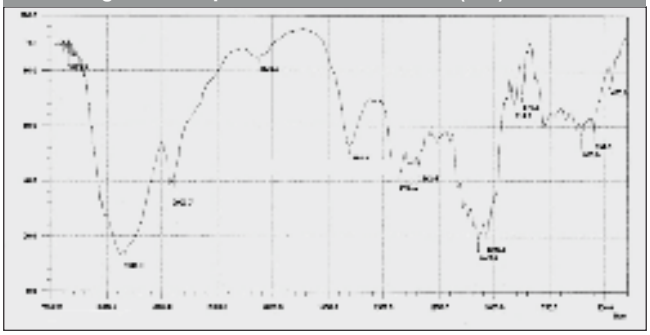
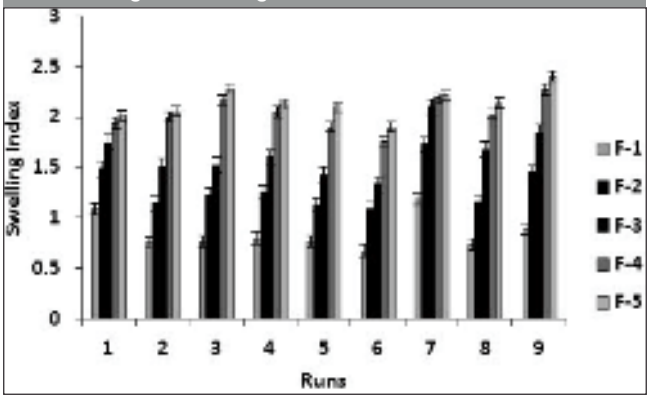


Fig. 6: Swelling behavior of matrix tablets



The accelerated stability studies further proved that the formulation (F-5) was stable even at accelerated storage conditions. The physicochemical properties of F-5 tablets, before and after stability studies were shown in Table 6.

Fig. 7: Zero order release plots

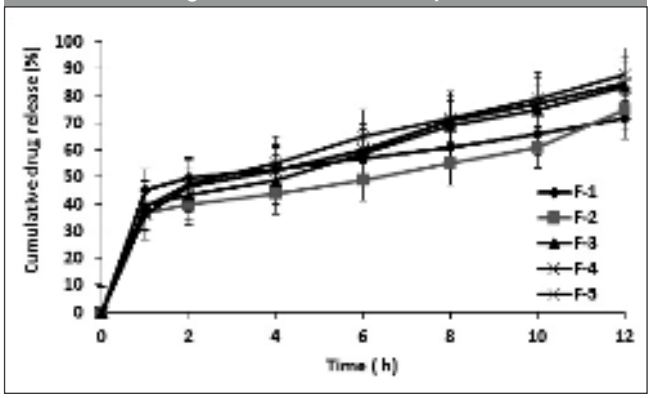


Fig. 8: First order release plots

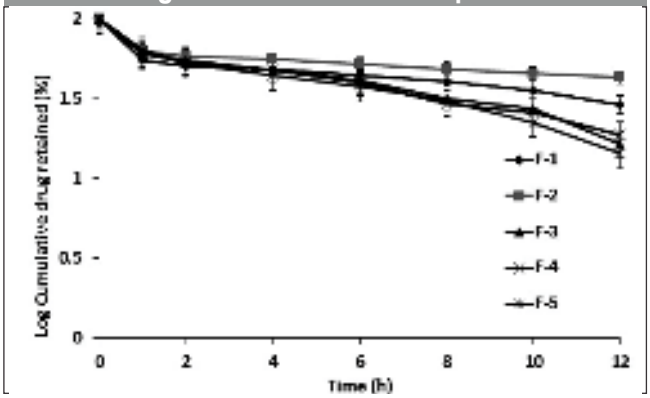


Fig. 9: Higuchi plots

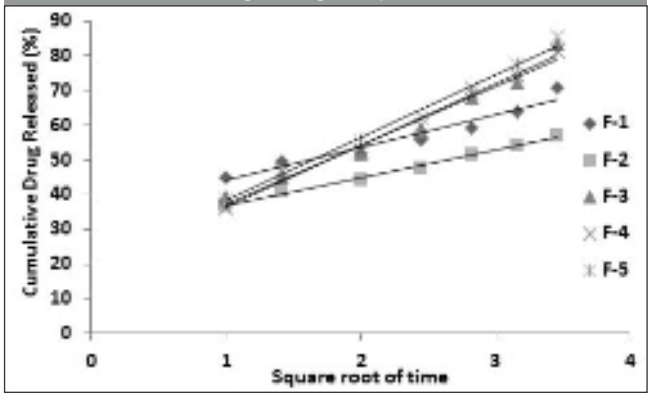


Fig.10: Korsmeyer Peppa's plots

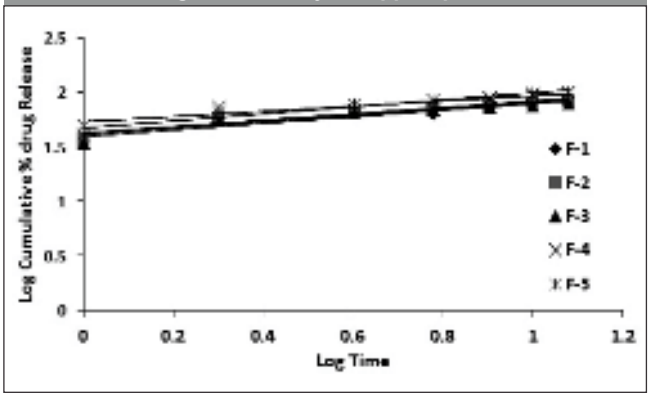


Fig.11: Hixson Crowell's plots

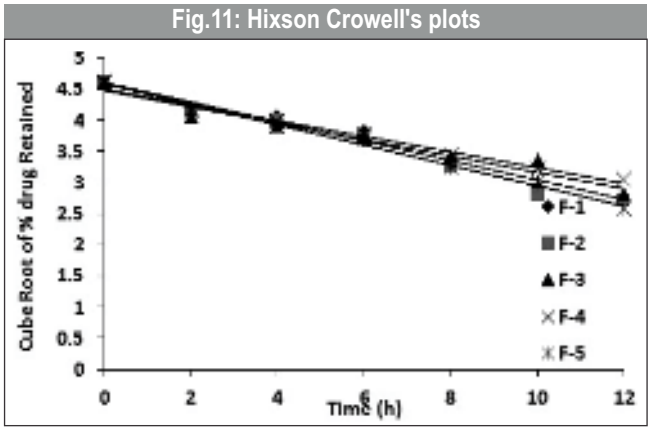


Table 4: Kinetic Values for dissolution Profile of Glimepiride Matrix Tablets

Formulations	First Order values		Zero Order values	
	Slope (n)	Regression Co-efficient®	Slope (n)	Regression Co-efficien(R)
F-1	-0.0007	-0.9784	0.0035	0.9903
F-2	-0.0004	-0.9968	0.0029	0.9925
F-3	-0.0015	-0.9726	0.0059	0.9966
F-4	-0.0015	-0.9925	0.0064	0.9881
F-5	-0.0017	-0.9823	0.0067	0.9952

Fig.12: Surface morphology of matrix tablet (F-5) at zero time and at 4th h of dissolution

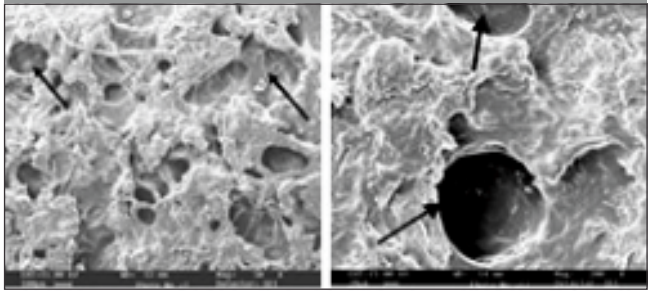


Table 5: Kinetic values for Glimepiride matrix tablets

Formulation	Higuchi's values		Korsmeyer Peppa's values		Hixson Crowell ' s values	
	Slope (n)	Regression Coefficient(R)	Slope (n)	Regression Coefficient(R)	Slope (n)	Regression Coefficient(R)
F-1	1.7250	0.9717	0.1624	0.9302	-0.0004	-0.9835
F-2	1.8658	0.9964	0.1715	0.9556	-0.0003	-0.9957
F-3	3.1034	0.9850	0.2875	0.9473	-0.0006	-0.9951
F-4	3.2276	0.9934	0.3131	0.9744	-0.0008	-0.9944
F-5	3.3085	0.9939	0.3045	0.9685	-0.0009	-0.9921

Table 6: Summary of physical properties of F-5 before and after accelerated stability studies

Parameter	Before stability studies	After stability studies
Thickness (mm)	2.85±0.035	2.85±0.027
Hardness (kg)	7.40±1.30	7.40±1.10
Friability (%)	0.73±0.07	0.72±0.08
Drug content (%)	100.5±3.67	100.5±4.35
Number of trials (n) = 5		

CONCLUSIONS

The present study revealed that *Hibiscus rosa-sinensis* leaves mucilage and Povidone combination appears to be suitable for use as a release retardant in the manufacture of sustained release matrix tablets because of its good physicochemical and swelling properties and suitability for matrix formulations. The *in vitro* dissolution data, mathematical modeling and accelerated stability studies have revealed that the dried *Hibiscus rosa-sinensis* leaves mucilage in combination with Povidone can be used as a release retardant for making sustained release matrix tablets.

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