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Design and in vitro evaluation of drug release and bioadhesive properties from bucoadhesive tablets of Glibenclamide for systemic delivery

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ABSTRACT

The buccal route has been used for many years to delivery drug which undergoes first pass metabolism within the oral mucosal cavity, the buccal region often attractive route of administration for local or systemic drug delivery. Due to its high potential a bioadhesive system place a major role in controlling drug release. Recent interest has been expressed in the delivery of drug via mucus membrane by the use of adhesive materials on which studies are been intensively undertaken. The objective of this work was to design a mucoadhesive tablet with a potential use in the treatment of Diabetes mellitus. A Bi-layered tablet (Core layered + Backing layered) containing Glibenclamide has been formulated. Carbopol-940, Polyvinylpyrrolidone (PVP), and Sodium corboxymethyl cellulose were used as polymer. Tablets were obtained through direct compression. Properties such as in vitro mucoadhesion, water uptake, surface pH, and drug release were evaluated. The core layer constituents were Glibenclamide (5mg), Carbopol, Na-CMC and PVP in 3 different ratios. The backing layer does not contain drug, it is meant to prevent tablet from disintegration in buccal cavity. The mixture CP: Na-CMC (2:3) showed good water absorption. The CP : PVP (1:4) formulations(F5) showed the best drug release pattern and bioadhesion property. The analysis of in vitro release data showed zero

order release pattern associated with Higuchi diffusion which might be the possible drug release mechanism.

Keywords: Mucoadhesive buccal tablets, bilayered tablets, Glibenclamide; Carbopol 940; PVP, Sodium CMC.

INTRODUCTION

Conventional routes of drug administration such as oral, intramuscular and intravenous have, in many cases, been supplanted by the advent of new, novel drug delivery systems. The systemic delivery of drugs through novel methods of administration is one area in which significant changes and improvements have been made. Consequently, precise control of drug input into the body by a variety of routes is now possible. Controlled and sustained release formulations have been developed and are gaining in popularity and medical acceptance[1]. Oral mucosal drug delivery is an alternative method of systemic drug delivery that offers several advantages over both injectables and enterable methods[2]. Not all drugs, however, can be administered through the oral mucosa because of the characteristics of the oral mucosa and the physicochemical properties of the drug.

Buccal delivery of drugs provides an attractive alternative to the oral route of drug administration, particularly in overcoming deficiencies associated with the latter mode of administration problems such as high first pass metabolism, drug degradation in harsh gastrointestinal environment can be circumvented by administering a drug via buccal route[3-4]. More over buccal drug absorption can be terminated promptly in case of toxicity by removing the dosage form from the buccal cavity. It is also possible to administer the drug to patients who cannot be dosed orally to prevent accidental swallowing. Therefore mucoadhesive dosage forms were suggested for oral drug delivery which includes adhesive tabletsadhesive gelsand adhesive patches[5].

In present study, the mucoadhesive tablets were developed using hydrophilic polymers Carbopol-940, Polyvinylpyrrolidone (PVP), and Sodium corboxymethyl cellulose) to get controlled and zero order drug release.

Glibenclamide is a second generation Sulfonylurea compound used as an oral hypoglycemic or antidiabetic agent[6] Therapy with Glibenclamide is usually initiated with 2.5mg given once daily. The maximal recommended daily dose is 20mg. Glibenclamide is 200 times more potent than tolbutamide in evoking pancreatic secretion of insulin. It differs from other oral poglycemic drugs where in tolerance to this action apparently does not occur. It also upregulates insulin receptors in the periphery, which seems to be the primary action. It has a special status in the treatment of non-insulin-dependent diabetes mellitus because it is effective in many cases which are resistant to all other oral hypoglycemic drugs. It differs from other oral hypoglycemic drugs ie more effective during eating than during fasting.

About 50% of Glibenclamide is metabolized to its inactive metabolites in liver. With a view to bypass the hepatic first pass effect and thereby improving bioavailability of drug an attempt to develop a buccal mucoadhesive dosage form for Glibenclamide has been made in the study[9].
The aim of this study was, design, development and characterization of a buccoadhesive controlled-release tablet of Glibenclamide using some selective polymers like Carbopol-940, Polyvinylpyrrolidone (PVP) and sodium carboxymethyl cellulose (NaCMC). Also the interaction between polymers and drug-polymers, bioadhesion and *in vitro* release characteristics of Glibenclamide from different buccoadhesive matrix tablets was evaluated to assess the suitability of such formulations.

EXPERIMENTAL SECTION

Glibenclamide (Sun Pharmaceuticals Mumbai) Sodium Carboxy Methyl Cellulose (Loba Chemie Pvt. Ltd., Mumbai) Carbopol-940 and Polyvinyl Pyrrolidone (Himedia Laboratories Pvt. Ltd Mumbai) Magnesium Stearate (New Modern Chemicals Corporation, Mumbai). All other chemicals, reagents and solvents were used are of Analytical grade.

Preparation of Buccal Tablets: [10,11]

Buccal tablets were composed of two layers i.e.

- ✓ Core layer
- ✓ Backing layer

Core layer contains drug Glibenclamide, different mucoadhesive polymers and Magnesium stearate as a lubricant. This layer weighed about 150 mg.

Backing layer contains water impermeable compound Magnesium stearate, Polyvinyl pyrrolidone, Carbopol 940, Saccharin sodium as a sweetener, peppermint oil as a flavouring agent and Amaranth as a coloring agent. This layer weighed about 75 mg. Therefore total weight of the tablet was 225mg.composition of core tablet was shown in Table 1

Preparation:
Buccal tablets were prepared in 3 stages:-

Stage-I: Preparation of Core Layer's Mixture:
All ingredients such as Glibenclamide, polymers and lubricant (2%) were mixed well by using glass mortar and pestle. This mixture was used for the preparation of core layer of the tablet.

Stage-II: Preparation of Backing Layer's Granules:
All ingredients such as Carbopol 940, Polyvinyl pyrrolidone, Magnesium stearate, Saccharin sodium were mixed well using glass mortar and pestle. In a separate glass beaker solution of Amaranth was prepared, using ethanol as a solvent. By gradually adding the color solution to a dry mixture; a wet mass/lump was prepared. Peppermint oil was added to this lump and mixed properly. Then this lump was passed through the sieve (Sieve No.40). Then wet granules were dried in a Hot Air Oven at a temperature 50^0C for 20 minutes. To this dried granules, magnesium stearate lubricant was added. These granules were used for the preparation of backing layer of the tablet. The composition of backing layer is shown in Table 2

Stage-III : Compression*:*[12]
For this purpose an I.R. hydraulic press and Die Punch Set having diameter of 10mm was used. Firstly, the mixture of drug and polymers (weighed quantity-150mg) was compressed using a pressure of 50kg/cm^2 for 5 seconds. Then upper punch was removed and then granules of backing layer (weighed quantity –75mg) were added over the first layer and compressed at a pressure of 200kg/cm^2 for 15 seconds

By this way, the bilayer tablet was prepared. The prepared buccal tablets of different formulations are shown in Fig No 8

Table 1: Composition of Buccal Tablets Core Tablets

S.No	Ingredients	F_1	F_2	F_3	F_4	F_5	F_6
1.	Glibenclamide (mg)	5	5	5	5	5	5
2.	Carbopol-940 (mg)	47.66	28.60	57.20	47.66	28.60	57.20
3.	Sodium Carboxy Methyl Cellulose-H (mg)	95.34	114.4	85.8	--	--	--
4.	Polyvinyl Pyrrolidone-K30 (mg)	--	--	--	95.34	114.4	85.8
5.	Magnesium stearate (mg)	2	2	2	2	2	2
6.	Average weight	150	150	150	150	150	150

Table – 2: Composition of Buccal Tablet Backing Layer

Sl.	**Ingredients**	**Quantity (mg)**
1.	Magnesium stearate	33.75
2.	Carbopol-940	9.37
3.	Polyvinyl Pyrrolidone K30	28.099
4.	Amaranth	0.03
5.	Peppermint oil	0.001
6.	Saccharin sodium	3.75

Composition same for all formulations

General Appearance:
In this study, tablets were tested for size, shape, color, presence or absence of an odour, taste, surface texture, physical flaws and consistency and legibility of any identifying markings.

Weight Variation Test[13].
The weight variation test was done by weighing 20 tablets individually, calculating the average weight and comparing the individual tablet weights to the average. From this, percentage weight difference was calculated and then checked for USP specifications.

Hardness
Hardness of the tablets was determined using a hardness testing apparatus (Monseto Type). A tablet hardness of about 5-6 kg/cm2 is considered adequate for mechanical stability.[13]

Friability
The friability of the tablets was measured in a Roche friabilator (Camp-bell Electronics, Mumbai, India).

Tablets of a known weight (W0) or a sample of tablets are dedusted in a drum for a fixed time (100 revolutions) and weighed (W) again. Percentage friability was calculated from the loss in weight as given in equation as below. The weight loss should not be more than 1% w/w.10

$$\% \text{ Friability} = (W0-W)/ W0 \times 100$$

Content Uniformity Test: [14].
Six tablets were randomly taken and triturated using a glass mortar and pestle. An accurately weighed quantity of triturated powder equivalent to 25 mg of drug was taken into 50 ml volumetric flask and dissolved in a minimum amount of methanol and volume was made up to the mark with phosphate buffer (pH 7.4). This gives the concentration of 500 µg/ml. From above solution, 1 ml was withdrawn and further diluted to 50 ml with phosphate buffer (pH 7.4). This gives the concentration of 10 µg/ml; which is in Beer's range. This was then assayed for drug content using UV spectrophotometer at 226 nm. This was done in triplicates and the average drug contents were estimated in the prepared buccal tablets.

Tablet Disintegration Test: [15]
The disintegration pattern of each bioadhesive buccal tablet was observed by immersing the tablet in a glass Petri dish of 9.2 cm diameter containing 25 ml of water at room temperature (28^0C). The morphological changes of each tablet was observed for 20 hrs.

Measurement of Surface pH: [16].
The method used to determine surface pH of the formulation was similar to that used by Bottenberg et al.

A combined glass electrode was used for this purpose. The tablet was allowed to swell by keeping them in contact with 1ml of distilled water (pH 6.6±0.05) for 2 hr. and pH was noted by bringing the electrode in contact with the surface of the formulation and allowing it to equilibrate for 1 min. This test was done in triplicates and mean was calculated.

Water Absorption Study: [17].
This was done on 1% agar gel plates. The tablets were placed with the core facing the gel surface and incubated for 6 hr. at 37^0C. The tablets were weighed before and after standing on the agar plate, from that % water absorption was calculated and examined for any physical change. Three replications of this test was carried out and average was calculated.

Measurement of Bioadhesive Strength: [18].
Bioadhesive strength of the buccal tablets was measured on modified physical balance using the method described by Gupta et al. In the present study, Sheep intestine skin was used as a model mucosal surface for bioadhesion testing. The two sides of the balance were balanced with a 5 gm weight on the right hand side. A fresh piece of Sheep intestine skin membrane was fixed with the mucosal surface upwards using thread over the protrusion in the rubber block which is covered with inert aluminium surface. The block was then lowered into the glass container, which was then filled with isotonic phosphate buffer (pH 6.6) kept at 37º+1ºC, such that the buffer just reaches the surface of mucosal membrane and keeps it moist. This was then kept below the left hand set up of the balance. The tablet was then glued (Evobond) at the border adhered to a aluminium surface hanging on left hand side and beam raised, with the 5gm weight on the right pan removed. This lowered the aluminium surface along with the tablet over the mucosa, with a weight of 5gm.

The balance was kept in this position for 10 min and then slowly water was added to the glass container in the right pan by pipette. The addition water was stopped as soon as the detachment of two surface was obtained. Weight of water was measured. The excess weight in the pan i.e. total weight minus 5gm is the force required to separate the tablet from the mucosa. This gave the bioadhesive strength of the tablet in grams.

Sheep intestine skin membranes were obtained from slaughter shop and three tablets were tested on each. After each measurement, the tissues were gently and thoroughly washed with phosphate buffer (pH 6.6) and left for 5 minutes before the next experiment. Fresh membrane was used for each batch of tablets.

Dissolution Studies: [19].
The dissolution of the buccal tablet was performed using USP XXIII dissolution apparatus (paddle method) using 500 ml of phosphate buffer (pH 7.4) as the dissolution medium, which was maintained at 37^0C and stirred at 50 r.p.m. Tablet was glued with Cyanoacrylate adhesive (Evobond) from backing layer side to the glass slide and it was placed at the bottom of jar of dissolution apparatus to avoid movement of tablet. Aliquots of 5ml of samples were withdrawn with a bulb pipette at different time intervals of 30, 60, 120, 180, 240, 300 and 360 minutes and replaced with equal volume of phosphate buffer (pH 7.4) at each withdrawal, filtered it through Whatmann Filter Paper No.1.

The samples were then analyzed spectrophotometrically at 226 nm and the cumulative amount of drug released at various time intervals was calculated. This test was done in triplicates.

In-vitro Diffusion Study: [20].
These studies were carried out using Keshary-Chien type glass diffusion cell.

In this study, Cellophane membrane was used as a barrier membrane. Cellophane membrane firstly dip into boiling water for 30 min, then into ethanol for 4hr and finally 6.6 phosphate buffer for 24 hr.

Keshary Chien cell consisted of upper cylindrical chamber open from above. Lower chamber in a form of a closed cylinder containing the sample port. Lower chamber was covered by outer jacket to maintain the desired temperature. The junction between the two chambers was designed in such a manner that mucosa did not shift from its place.

Firstly, the Teflon coated magnetic bead was kept in lower chamber, then the mucosal membrane was placed between the two chambers. The two chambers were tied with the help of clamp. The tablet was kept on the Cellophane membrane in such a way that Core layer of the tablet was facing the membrane. The upper chamber was filled with 12 ml of isotonic phosphate buffer (pH 6.6) and the lower chamber with 12 ml of isotonic phosphate buffer (pH 7.4).

The outer jacket of cell was filled with water and the whole assembly was kept on the magnetic stirrer and maintained at 37 ± 1^0C temperature and at 100 r.p.m. speed of magnetic bead.

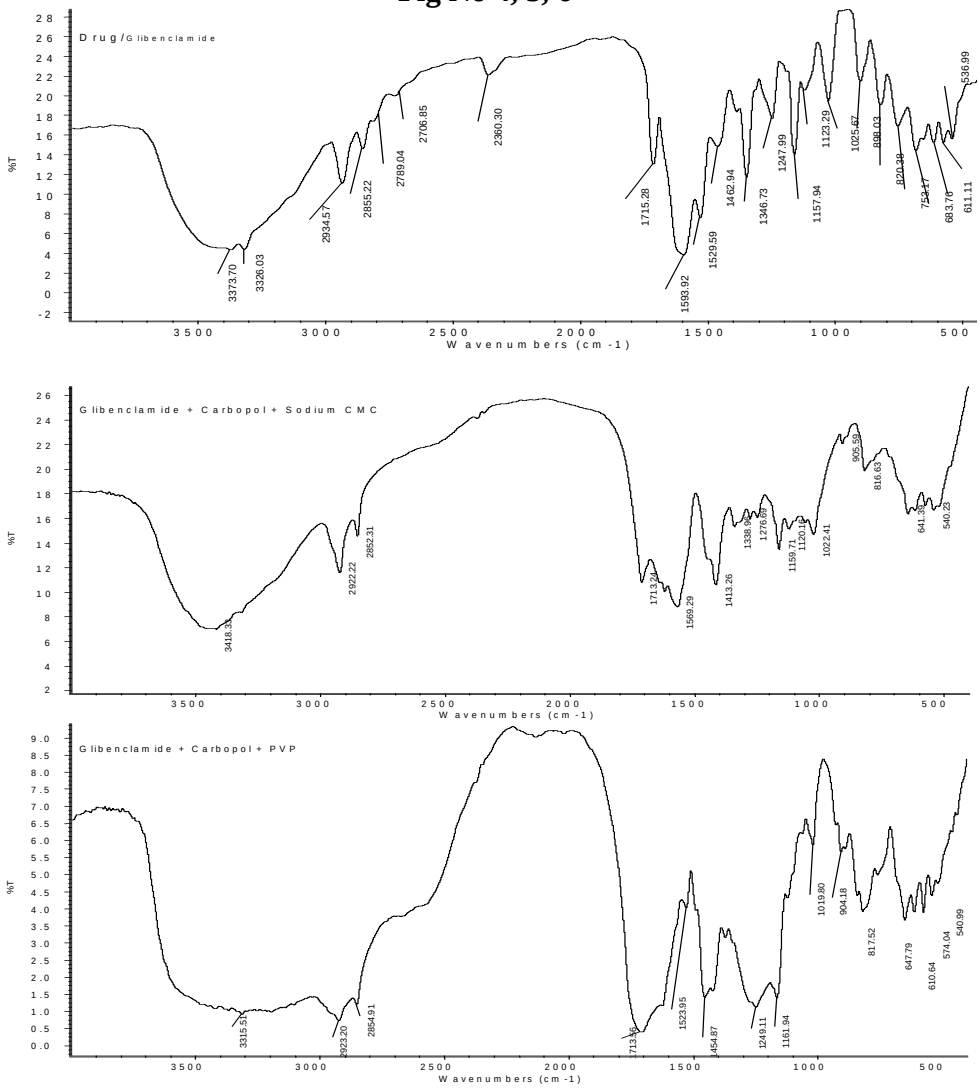
Aliquotes of 1ml samples were withdrawn from the lower chamber at different time intervals of 30, 60, 120, 180, 240, 300 and 360 minutes and replaced with equal volume of phosphate buffer (pH 7.4) at each withdrawal. 1 ml of sample was diluted to 25 ml with isotonic phosphate buffer (pH 7.4) and analyzed spectrophotometrically at 226 nm and the cumulative amount of drug permeated through membrane at various time intervals was calculated. Three replications of this test was carried out.

RESULT AND DISCUSSION

Preformulation studies for Drug-Excipients Compatibility
The preformulation studies between the drug and various polymers under experimental conditions were done using I.R spectrum.

The I.R characteristics of Glibenclamide with the individual polymer resembles almost the I.R structural characteristics of pure Glibenclamide when compared with the spectra of pure sample of Glibenclamide (Figure No. 5, 6, 7).

I.R. Spectra Of Glibenclamide, Glibencladide+ Carbopol 940 And Glibenclamide+ Pvp Respectively
Fig No 4, 5, 6



Physical Evaluation of Buccoadhesive Bilayered Tablets

Tablets of all formulations were round in shape, small in size (10mm diameter) with flat surface and having a good physical appearance. Due to the colour difference between two layers (pink and white), tablet became easily distinguishable and easy for application. The assayed content of drug in various formulations varied between 97.3% and 99.8% (mean 98.58%). Tablets weights varied between 224.87 and 226.79 mg (mean 225.27 mg), Hardness between 3.96 and 5.21 Kg/cm²(mean 4.49 Kg/cm²) and Friability ranged between 0.92% and 1.09 % (mean1.006%). Thus all the physical parameters of the bilayered bucoadhesive compressed matrices were shown in Table 3.

Table 3: Physical Evalution of Bilayered Bucoadhesive Matrix Tablets

S.No	Formulation	Hardness (kg/cm^2) n=3	Disintegration Time (hrs)	Avg.wt (Mg)	% Friability	%Drug Content
1.	**F1**	3.97 ± 0.081	13.30	225.15±0.15	1.09	98.6%
2.	**F2**	4.06 ± 0.040	13.00	224.97±0.19	1.06	98.0%
3.	**F3**	4.21 ± 0.070	13:30	224.92±0.78	1.01`	97.3%
4.	**F4**	4.52 ± 0.040	12.00	224.87±0.12	1.01	98.2%
5.	**F5**	5.21 ± 0.187	16:00	224.92±0.45	0.92	99.8%
6.	**F6**	4.98 ± 0.041	17:30	226.79±0.25	0.95	99.6%

The disintegration time was found to be 13.30, 13.00, 13.30, 12.00, 16:00, and 17.30 hrs for tablets F1 to F6 respectively. The results of surface pH values for all formulations were found to be 6.11, 6.38, 6.06, 6.64, 6.68, and 6.95 for formulation F1 to F6 respectively. There was no considerable difference in surface pH of tablets. Percentage water absorption of all formation were found to be 64.86%, 57.66%, 96.44%, 56.93%, 70.53%, and 55.43% for the tablets F1 to F6 respectively. The percentage water absorption of the respective tablets were determined at 360 minute. The values indicated that formulations F1 to F3 showed higher water absorption as compared to the formulations F4 to F6. It revealed that incorporation of Sodium CMC was found to be maximum water absorption. In formulations F1 to F3, extent of water absorption was in order of F2< F1< F3 and in formulations F4 to F6 extent of water absorption was in order of F6< F4< F5. This indicated that an increase in concentration of Carbopol 940 in formulations was found to maximize water absorption and thus increase in concentration of PVP decreases the water absorption. The mean bioadhesive strength values were found to be 14.73, 13.27, 17.47, 13.70, 22.40, and 14.74 gm for the buccal tablets F1 to F6 respectively. This study showed that addition of PVP to the Carbopol 940 was found to maximize the bioadhesive property of buccal tablets, when compared with Sodium CMC. Formulation F5, which contain Carbopol-940 and PVP in a ratio, 1:4 was found to be the best ratio of these polymers and exhibited strongest bioadhesive strength. The value of surface pH, water absorption and weight required for detachment is shown in Table No 4

Table No 4: Surface Ph, Percentage Water Absortionand Weight Required For Detachment Of Different Buccoadhesive Tablets Of Glibenclamide

S.No	Formulation	Surface pH	% water absorption	Weight required for detachment
1.	**F1**	6.11 ± 0.105	64.86 ± 2.898	14.73 ± 0.812
2.	**F2**	6.38 ± 0.112	57.66 ± 1.486	13.27 ± 0.830
3.	**F3**	6.06 ± 0.061	96.44 ± 3.354	17.47 ± 0.399
4.	**F4**	6.64 ± 0.200	56.93 ± 3.451	13.70 ± 0.322
5.	**F5**	6.68 ± 0.196	70.53 ± 1.159	22.40 ± 0.239
6.	**F6**	6.95 ± 0.035	55.43 ± 1.212	14.74 ± 0.166

In-Vitro Dissolution Study Of Different Buccoadhesive Tablets Of Glibenclamide

The in-vitro dissolution was studied in phosphate buffer pH 7.4 and Cumulative percentage drug released has been found to be 70.79, 54.37, 83.53, 81.28, 85.64, and 77.53 for the tablets F1 to F6 respectively at the end of 6 hrs. The in vitro release data was fitted in zero-order, first-order, Higuchi, Korsmeyer-Peppas and bidha's model. The R2 values of zero-order release model were in between 0.9995 and 1.0). Thus, the release of drug from glibenclamide bilayered bioadhesive tablets follows zero-order kinetics. It was revealed by the peppas plot that the drug release from different buccal tablets fitted well to the *erosion mechanism.* Drug release from the various controlled release formulations is indicated in Fig 1. The correlation coefficient (r) values of the formulations is indicated in Table 5.

Table No 5: Kinetic Values Obtained From Different Plots Of In-Vitro Dissolution Study Of Different Buccoadhesive Tablets Of Glibenclamide (F1 – F6)

Formulation	Zero order	First order	Huguchi's	peppas	bidhas
F1	0.9809	0.9574	0.9443	0.9066	0.9674
F2	0.9851	0.9937	0.9929	0.9527	0.9915
F3	0.9932	0.9460	0.9703	0.9736	0.9939
F4	0.9764	0.9852	0.9870	0.9809	0.9889
F5	0.9905	0.9649	0.9879	0.9810	0.9843
F6	0.9564	0.8933	0.8894	08496	0.9175

The 'n' of F1 to F6 was found to be -0.00043, -0.0003, -0.00084, -0.00083, -0.00092 and -0.00065 which were less than 0.5 for all formulations. So all formulation follows the Fickian release. In-vitro dissolution studies clearly showed that the formulation(F5) containing Carbopol 940 and PVP showed higher drug release as compared to the formulations containing Carbopol 940 and Sodium CMC.

Fig No 1: In-Vitro Dissolution Profile Profile Of Glibenclamide Bilayered Buccoadhesive Tablets

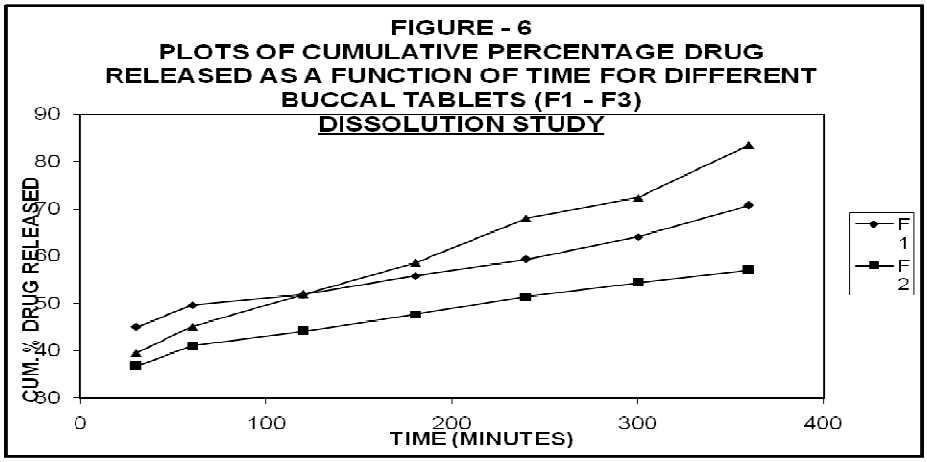
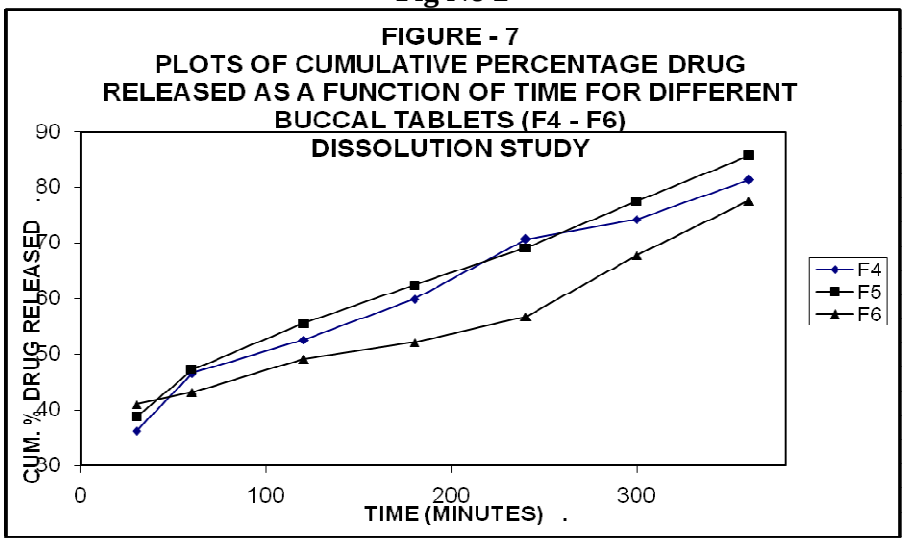


Fig No 2



In-Vitro Diffusion Study of Different Buccoadhesive Tablets Of Glibenclamide

In vitro diffusion studies were carried out with cellophane sheet as a barrier. The studies were carried out in triplicate and results shown in the Fig No. 3 and 4 are mean of the replicate values.

Fig No 3: In-Vitro Diffusion Profile of Glibenclamide across Synthetic Membrane (Cellophane Sheet)

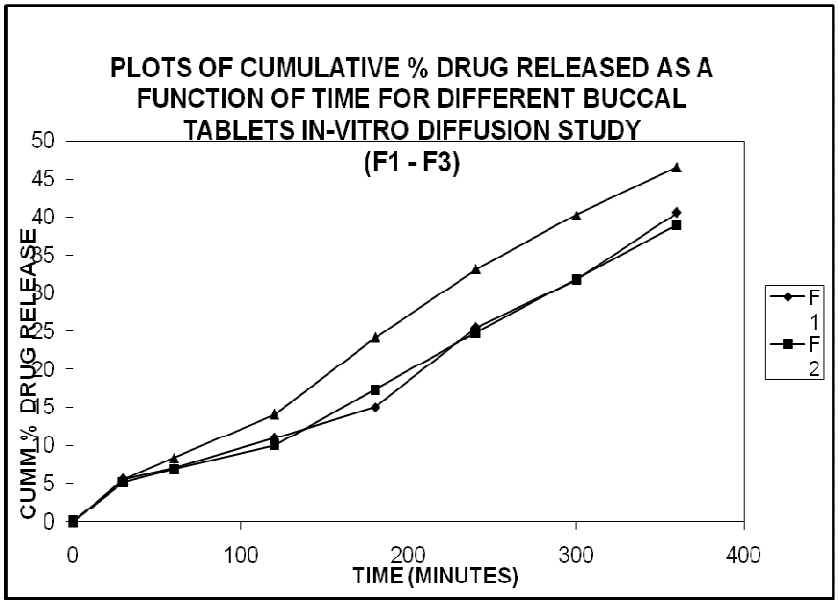
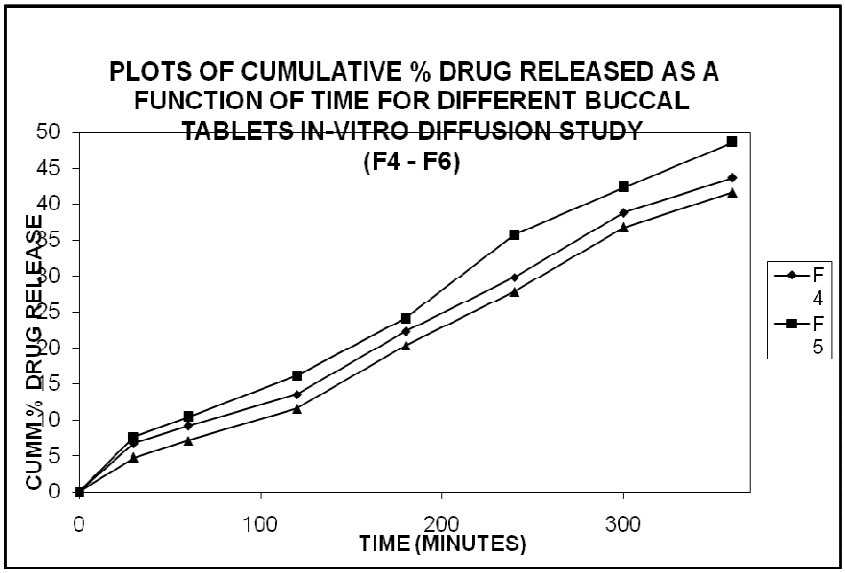


Fig No 4



The kinetic data depicts that the drug release was mainly due to *diffusion* and *erosion* mechanism as the strong positive values of regression coefficient (r) obtained form the graph. Regression coefficient values indicated that the drug release pattern from tablets matches nearly *zero order* release pattern with *Fickian* release behaviour.

CONCLUSION

From the foregoing investigation it may be concluded that the release rate of drug from the bilayered bioadhesive matrix tablets can be governed by the type of the polymer and the concentration of the polymer employed in the preparation of the tablets. Slow, controlled and complete release of glibenclamide over a period of 6hr was obtained from the matrix tablets formulated employing Carbopol 940 and PVP. The mucoadhesive buccal tablets of glibenclamide can help to bypass extensive hepatic first-pass metabolism and hence improve bioavailability. The buccal bi-layer tablets showed a mucoadhesion time of more than 6 hours.

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