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DESIGN AND DEVELOPMENT OF FLOATING DRUG DELIVERY SYSTEM BY USING NATURAL POLYMERS

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ABSTRACT

The present research work attempted to formulate and evaluate the floating tablet metoprolol succinate. Floating drug delivery system mainly aims at increase in drug gastric retention time. Metoprolol succinate is ß2 selective blocking agent which is used in management of hypertension. Metoprolol succinate floating drug delivery system was prepared using natural polymers like guar gum, xanthan gum and gas forming agent Sodium bicarbonate. Tablets were using directly compression and were evaluated for buoyancy test, swelling study, drug content and *In Vitro* release profile. The prepared tablets showed acceptable physicochemical characteristics. All the prepared batches showed fine *In Vitro* buoyancy. The drug release kinetic study was carried out and most of the batches follows korsmeyer peppas model. The formulations had shown significant result with increased concentration. The singular polymer comparison of guar gums had shown more consistent release than xanthan gum. The most optimized result obtained in combination batch of both polymers.

Key words: Floating drug delivery system, Natural polymers.

INTRODUCTION

Floating systems or dynamically controlled systems are low-density systems that have sufficiently buoyancy to float over the gastric contents and remain buoyant in the stomach without affecting the gastric emptying rate for a prolonged period of time. This results in an increased gastric retention time and a better control of the fluctuations in plasma drug concentration [1]. Floating drug delivery system is used to prolong the gastric residence time of dosage form. The systems to be remain buoyant in the stomach for prolonged period of time without affecting the gastric emptying rate of other contents [2]. A floating dosage form is useful for those drugs that act locally in the proximal gastrointestinal tract, are unstable in lower parts of GIT, or are poorly absorbed in the intestine. These systems help in continuously releasing the drug before it reaches the absorption window, thus ensuring optimal bioavailability. Thus the present drug was chosen as suitable candidate for formulation of floating drug delivery system [3]. Hypertension is a chronic medical condition in which the blood pressure in the arteries is elevated. It is classified as either primary or secondary. Hypertension affects almost all organs of the body like kidneys, arteries, heart, or endocrine system. Hence, there is growing need for development of suitable medication to treat or manage hypertension. Anti-hypertensive are a class of drugs which are used to manage hypertension. There are various classes of drugs which are used as antihypertensive like beta blockers, calcium channel blockers, ACE inhibitors etc. Among all these, beta blockers are still being used as first line agents used for the management of hypertension [4]. Metoprolol succinate is a beta1-selective (cardio selective) adrenergic receptor blocking agent. This favoured effect is not absolute, however, at higher plasma concentrations. Metoprolol succinate also inhibits beta 2-adrenoreceptors, primarily located in the bronchial and vascular musculature. Metoprolol succinate has no intrinsic sympathomimetic activity and membrane-stabilizing activity is detectable only at plasma concentrations much greater than required for beta-blockade. Because of these desired pharmacodynamic properties, Metoprolol succinate is used popularly for management of hypertension [5].

Metoprolol succinate belongs to class I category in BCS classification system freely soluble & highly permeable. Because of good solubility and permeability, its bioavailability is more and half life is less. This results in multiple doses of Metoprolol succinate every day.

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Hence, continuous efforts are being made whereby number of doses of Metoprolol succinate can be minimized.

MATERIALS AND METHODS

Metoprolol Succinate was received as gift samples from Wockhardt Pvt Ltd Aurangabad. Guar gum, Xanthan gum, Sodium Bicarbonate, Magnesium stearate and Lactose were obtained from Ozone International Ltd, Mumbai. All other reagents used in this study were of analytical grade and obtained from standard sources

METHODS

Powder characteristics of powder blend of MS with other excipients [6,7]

Physical mixtures of drug with excipients were evaluated for Angle of repose, Bulk density, Tapped density, Hausner ratio and Carr's index.

Angle of repose

The angle of repose for powder of each formulation was determined by the fixed funnel method. The powder was allowed to flow out of the funnel orifice on a plane paper kept on horizontal surface. This forms a pile of angle of powder on the paper. The angle of repose was calculated by substituting the values of the base radius 'r' and pile height 'h' in the following equation.

$\tan \theta = h / r$; Therefore, $\theta = \tan (h / r)$

Bulk density

The powder weighing 20 gm flow in a fine stream into a graduated cylinder and final volume was noted. The bulk density was obtained by dividing the weight of the sample in grams by final volume in cm^3 and it was determined by equation given below,

Bulk density = Bulk mass/ Bulk volume

Tapped density

The powder weighing 20 gm was allowed to flow in a fine stream into a graduated cylinder of a mechanical tapping device. The measuring cylinder was tapped for 100 times and final tapped volume was noted. The tapped density was calculated by using equation given below,

Tapped density = Bulk mass/ Tapped volume

Carr's index

The percentage compressibility of a powder was a direct assessment of the potential powder arch or bridge strength and stability. Carr's index of each formulation was calculated according to equation given below,

$$\text{Carr's index} = \frac{\text{Tapped density} - \text{Bulk density}}{\text{Tapped density}} \times 100$$

Hausner's ratio

It is essential to determine the compressibility strength of powders. It was determined by using following equation,

Hausner's ratio = Tapped density/ Bulk density

Preparation of floating tablet

The tablets were prepared by direct compression technique using 8 mm punch .The tablet of different concentration were prepared. All ingredients were mixed and punched in single punch machine (CADMACH). Each Tablet containing 50 mg of metoprolol succinate, polymers and sodium bicarbonate and ingredients are listed in table 1.

Evaluation of Tablet

Hardness

Tablet hardness has been defined as, "the force required breaking a tablet in a diametric compression test". For each formulation, the hardness of three tablets was determined using Monsanto hardness tester [8].

Uniformity of weight

To study weight variation 20 tablets of each formulation were weighted using an electronic balance and the test was performed according to the official method in Indian Pharmacopoeia. The test passes if the weights of not more than 2 of tablets differ by more than the percentage listed in table-4 and no tablets differ in weight by more than double that percentage [9].

Friability

Six tablets from each batch were selected randomly and weighed. These tablets were subjected to friability test using Roche Friabilator for 100 revolutions. Tablets were removed dusted and weighed again [10].

Following formula was used to calculate the friability

$$F = (1- W/Wo)\ 100$$

Where, Wo - Weight of tablet before test. W- Weight of tablet after test.

Uniformity of content

20 tablets were weighted individually and powdered. The powder equivalent to about 0.2 gm of Metoprolol Succinate transferred to a 100 ml volumetric flask. Then 100 ml of 0.1 N HCl was added, mixed and filtered. Then 1 ml of filtrate diluted with 10ml of 0.1 N HCl. Concentration of drug was determined by measuring absorbance by UV.

In Vitro Buoyancy Studies

The *In Vitro* buoyancy was estimated by floating lag time, per the method described by the tablets were placed in a 100-mL beaker containing 0.1N HCl. The time required for the tablet to rise to the surface and float was determined as floating lag time.

Swelling behavior of Floating tablets

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The extent of swelling was measured in terms of percentage weight gain by the tablets. The swelling behavior of all the formulations was studied. One tablet from each formulation was kept in petry dish containing phosphate buffer pH 6.8. At the end of 1, 4, 8, and 12hr tablets were withdrawn, soaked on tissue paper and weighed, and then percentage weight gain by the tablet was calculated using formula.

$$\text{Swelling Index} = \frac{W_t - W_o}{W_o} \times 100$$

Where,

Wt = Weight of tablet at time't' and Wo = Weight of tablet at time '0'.

Drug content

Five tablets were weighed and triturated then transfer an accurately weighed portion of the powder equivalent to about 45mg of metoprolol succinate to a 100ml volumetric flask containing buffer solution and then absorbance is measured by UV.

Total floating time

Floating time of tablet was determined before coating and after coating of tablet. Floating lag time and total floating time was determined as per method described by Rosa et al. Tablets were placed in a 100 ml beaker containing 0.1 N HCl. The time required for the tablet to raise the surface and float was determined as floating lag time. The duration of time the dosage form constantly remained on the surface of medium was determined as the total floating time [11].

***In Vitro* dissolution studies**

The dissolution medium was 900ml 0.1N HCl maintained at 37± 0.5^0C. The *In Vitro* dissolution studies were carried out by using USP apparatus type II at 50 rpm. Sample of dissolution medium were withdrawn at predetermined intervals and content of metoprolol succinate was determined spectrophotometrically.

Kinetic drug release modeling

The Kinetics of the drug release of floating tablet were described by using mathematical models such as, zero order, first order, Hixson crowell, matrix, Korsmeyer-peppas. The most appropriate model was chosen on the basis of goodness or fit test through software PCP disso V3.

RESULTS

Formulation of Floating Tablets

In present study, the floating tablet of metoprolol succinate was prepared using different concentrations of natural and synthetic polymers, used alone and in combinations with each other in different concentrations. The tablets were prepared by direct compression, using 8 mm punch. All batches were found good in appearance.

Evaluation of powder blend

The evaluation of various powder blend was performed with regards to bulk density, Tapped density, Carr's Compressiblity index, Hausner's ratio and Angle of repose was performed for drug as well as for excipients and result were indicated in Table No.2. The results of all these tests were complied with specification in I.P Standards.

Evaluation of Metoprolol Succinate Floating Tablets

The evaluation results of floating tablet for preliminary formulation were reported and subsequent results were discussed as follow

Swelling index of floating tablet

The swelling measured in terms of percentage weight gain by tablets in 6.8 phosphate buffer solution at the end of 1, 4, 8, 12 hours. The swelling behavior was studied for all formulations.

Table 1. Formulation of floating Tablet by direct compression

Ingredients	FM1	FM2	FM3	FM4	FM5	FM6	FM7	FM8	FM9
Metoprolol Succinate(mg)	50	50	50	50	50	50	50	50	50
Guar gum(mg)	40	50	60				20	25	30
Xanthan gum(mg)				40	50	60	20	25	30
Sodium Bicarbonate(mg)	50	50	50	50	50	50	50	50	50
MCC (mg)	20	20	20	20	20	20	20	20	20
Lactose (mg)	38	28	18	38	28	18	38	28	18
Magnesium Stearate(mg)	2	2	2	2	2	2	2	2	2

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Table 2. Evaluation of API and Excipients blend

Formulations	Angle of repose ±SD	Bulk Density ±SD (gm/ml)	Tapped Density ±SD (gm/ml)	Hausner's Ratio(hr)	Carr's Index
FM1	20.04±0.238	0.441±0.0116	0.505±0.0707	1.153	10.43
FM2	22.73±0.751	0.435±0.0078	0.500±0.0108	1.143	11.84
FM3	20.43±0.167	0.447±0.0115	0.507±0.0169	1.141	10.67
FM4	19.03±0.564	0.433±0.0095	0.495±0.0159	1.154	13.87
FM5	21.92± 1.21	0.439±0.0078	0.477±0.0750	1.098	08.93
FM6	22.17±0.945	0.443±0.0128	0.515±0.4300	1.118	13.13
FM7	20.43±0.198	0.449±0.0115	0.512±0.0169	1.115	14.55
FM8	19.03±0.791	0.441±0.0095	0.531±0.0159	1.143	13.63
F M9	20.92± 1.753	0.444±0.0078	0.477±0.0750	1.134	11.65

***In Vitro* Buoyancy Study**

Table 4. Floating and buoyancy time of Metoprolol Succinate Tablets.

Formulations	Floating Time ±SD (hrs)	Floating Lag Time (sec)
FM1	20±1.54	44±1
FM2	20±2.32	45±2
FM3	20±2.43	43±3
FM4	24±1.74	42±2
FM5	21±1.95	48±2
FM6	21±2.24	49±1
FM7	22±1.56	45±3
FM8	21±1.74	43±2
F M9	22±1.51	41±1

Table 5. Swelling index of formulations

Formulations	Swelling index (%)			
	Time (hr)			
	1	4	8	12
FM1	7	19	51	127
FM2	10	24	53	133
FM3	12	26	57	137
FM4	8	20	63	121
FM5	11	23	66	126
FM6	13	26	67	130
FM7	10	25	61	100
FM8	13	27	64	103
F M9	17	30	66	106

Table 6. Model Fitting Analysis of *In Vitro* Dissolution

Formulation	Korsmeyer peppas			Zero order	First order	Hixson crowell	Matrix	Best fit model
	n	k	r^2					
FM1	0.801	3.82	0.927	0.969	0.983	0.981	0.927	Korsmeyer peppas
FM 2	0.954	2.45	0.986	0.978	0.972	0.976	0.878	Korsmeyer peppas
FM 3	0.790	3.31	0.952	0.976	0.964	0.970	0.859	Zero order
FM 4	0.823	3.42	0.973	0.975	0.974	0.976	0.888	Hixson crowell
FM5	1.03	2.36	0.985	0.963	0.972	0.971	0.894	Korsmeyer peppas
FM6	1.00	2.47	0.977	0.959	0.961	0.962	0.879	Korsmeyer peppas
FM7	0.868	4.46	0.979	0.878	0.918	0.907	0.931	Korsmeyer peppas
FM8	1.00	3.09	0.974	0.893	0.912	0.907	0.898	Korsmeyer peppas
FM9	0.843	4.22	0.967	0.892	0.920	0.912	0.914	Korsmeyer peppas

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Fig. 1. Floating time of formulations

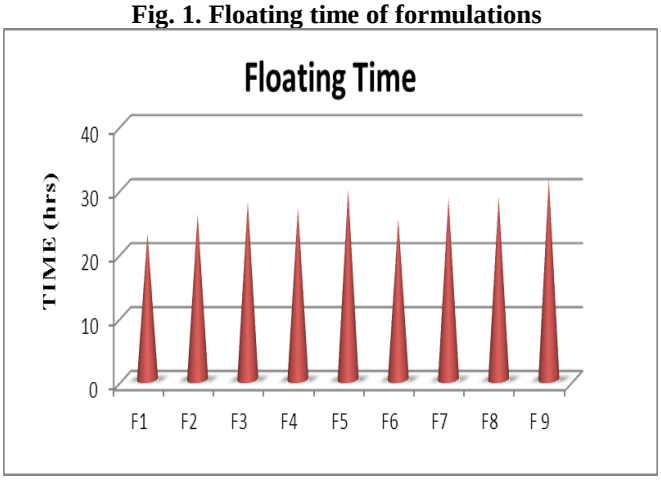


Fig. 2. Swelling index of formulations

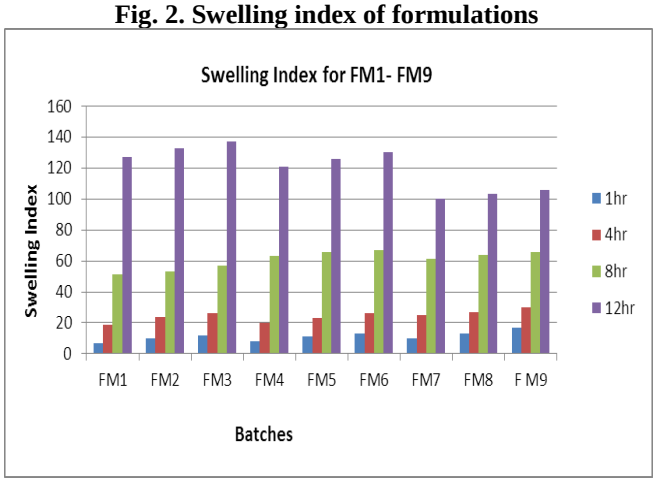


Fig. 3. *In Vitro* drug release of batch FM1-FM3 (Guar gum)

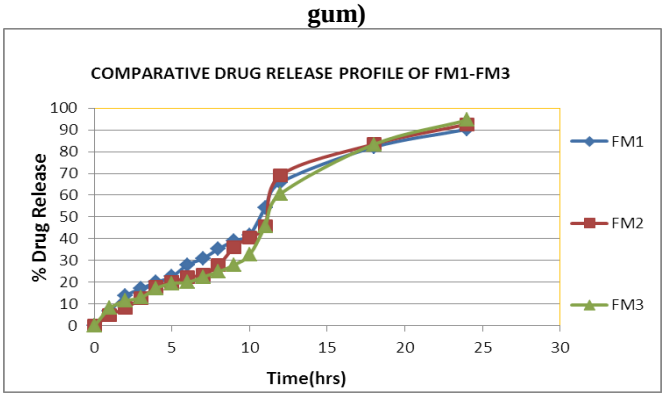


Fig. 4. *In Vitro* drug release of batch FM4-FM6 (Xanthan gum)

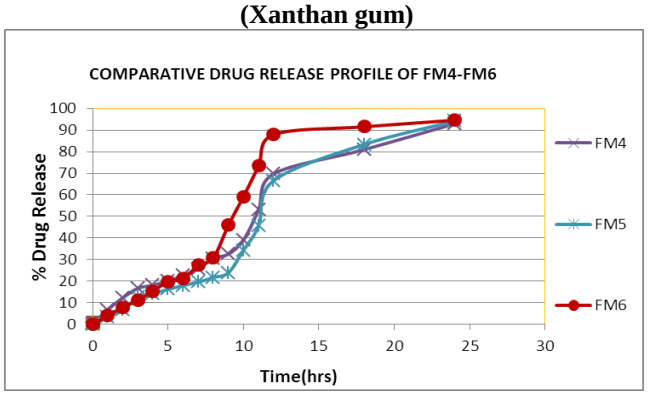
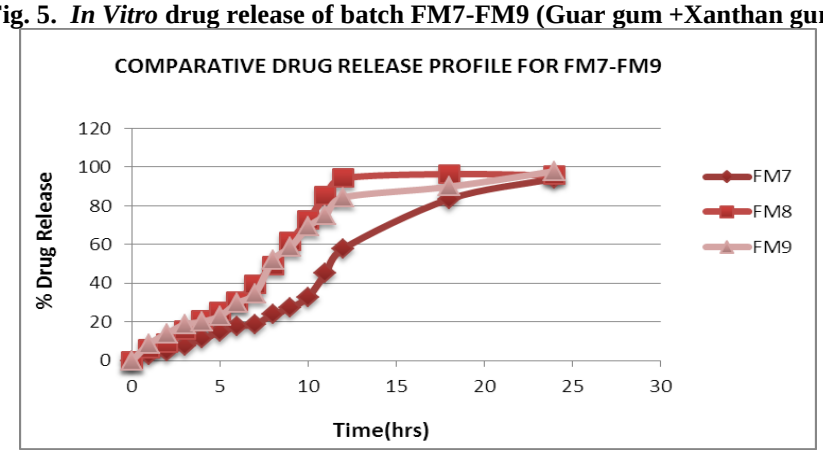


Fig. 5. *In Vitro* drug release of batch FM7-FM9 (Guar gum +Xanthan gum)



DISCUSSION AND CONCLUSION

In the present study, floating drug delivery systems of metoprolol succinate were prepared by using synthetic and natural polymers such as Xanthan gum, Guar gum. Different drug to polymer ratios along with a gas generating agent, sodium bicarbonate were used in the formulation. The prepared tablets were evaluated for hardness, friability, uniformity of weight, uniformity of drug content, swelling index, floating lag time, *In Vitro* floating time, *In Vitro* dissolution. The hardness of the prepared floating tablet of metoprolol succinate was found to be in the range of 5.76 to 6.9 Kg/cm². The friability of all tablets was less than 1% i.e., in the range of 0.69 to 0.97%. The percentage deviation from the mean weights of all the batches of prepared. Floating Tablets were found to be within the prescribed limits as per IP. Most of the designed formulations have displayed a floating time of more than 24 hours.

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In Vitro drug release study was performed using USP XXIII dissolution test apparatus-II at 50 rpm using 900 ml of 0.1N HCl maintained at 37±0.5ºC as the dissolution medium. From the above data, it is evident that as the proportion of polymer in the formulation increases, cumulative percent drug release in 10 hours decreases.

In Vitro floating studies were performed by placing tablets in USP XXIII dissolution the apparatus-II containing 900 ml of 0.1N HCl maintained at a temperature of 37±0.5ºC. The floating lag time and floating time was noted visually. For all formulation, lag time is in the range of 28 sec to 53 sec.

In Vitro drug release data of all the floating tablet formulations was subjected to goodness of fit test by linear regression analysis according to zero order and first order kinetic equations, Hixson crowell and Korsmeyer-Peppas models to determine the mechanism of drug release. The results of model fitting analysis are summarized in Table and the regression coefficient value was determined for each model. From all the batches Korsmeyer-Peppas model showed maximum regression value. Hence it was concluded that formulation follows Korsmeyer-Peppas dissolution kinetics.

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