IJPSR (2016), Vol. 7, Issue 11 (Research Article)

INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES AND RESEARCH

Received on 03 June, 2016; received in revised form, 07 October, 2016; accepted, 24 October, 2016; published 01 November, 2016

GASTRORETENTIVE SUPERPOROUS HYDROGEL TABLETS OF DEXLANSOPRAZOLE

Nikunja B Pati *, Swapna Velivela, Vinyas Mayasa and V. R M Gupta

Pulla Reddy Institute of Pharmacy, Annaram, Jinnaram, Medak, Hyderabad, Telangana- 502313, India.

Keywords:

Proton Pump Inhibitor, Superporous Hydrogel, Gastroretentive, Swelling, Sustained Release.

Correspondence to Author:
Nikunja B. Pati, M.Pharm(PhD),

Assistant Professor
Pulla Reddy Institute of Pharmacy, Annaram, Jinnaram, Medak, Hyderabad, Telangana -502313, India.

E-mail: nikunjapatipharmacy@gmail.com

ABSTRACT: Superporous hydrogels (SPHs) were developed to retain the drug in the gastric medium. These systems swell very rapidly in the stomach and maintain their integrity for longer time even in the acidic environment of stomach, while releasing the pharmaceutical active ingredient. The present work focuses on concept of development of superporous hydrogel tablets of Dexlansoprazole, their comparativeness to the marketed delayed release dosage forms. The aim of this study was to prepare Gastroretentive dosage form based on SPH using Dexlansoprazole, a proton pump inhibitor as a model drug for swelling & prolonged drug release characteristics in acidic pH. The formulation is based on preparation of third generation SPHs with three different polymers, such as, sodium alginate, pectin, chitosan and acrylic acid were used with different concentrations by crosslinking technique using formaldehyde as cross linking agent to get the desired sustained release profile over a period of 8-12 hrs. The characterization studies for SPH were performed by measurement of apparent density, porosity, swelling studies, mechanical strength, scanning electron microscopy (SEM) and FT-IR. All formulations were evaluated for stability, drug content, and kinetic drug release & *in-vitro* drug release profile. It was concluded that the proposed gastroretentive drug delivery system based on SPHs is promising for stomach specific delivery of Dexlansoprazole.

INTRODUCTION: Hydrogels have long been established in this field to control the release of a drug from a conventional solid dose formulation. It gradually swells in the aqueous medium and controls drug release by both diffusion and erosion. These types of hydrogels are non-crosslinked and ultimately dissolve over time in the presence of sufficient water or the swelling medium [1, 2]. Superporous hydrogels (SPHs) are porous hydrophilic crosslinked structures with the ability of absorbing aqueous fluids up to a few hundred times their own weight. Maximum swelling is generally reached in a fraction of a minute with SPHs having average pores of 200 mm in size [3].

QUICK RESPONSE CODE

DOI: 10.13040/IJPSR.0975-8232.7(11).4678-85

Article can be accessed online on: www.ijpsr.com

DOI link: http://dx.doi.org/10.13040/IJPSR.0975-8232.7 (11).4678-85

In the preparation of SPHs certain ingredients, including initiators, crosslinkers, foam stabilizers, foaming aids and foaming agents, are added into a water-diluted monomer. The foaming of SPHs is then driven by the interaction of acids and carbonates. For instance, acetic, acrylic and hydrochloric acids are commonly used with sodium, potassium and ammonium carbonates. Since the acid–carbonate interaction is only effective in aqueous media, the solution technique is the preferred method of polymerization in the preparation of SPHs [4, 5, 9].

The third generation superporous hydrogels are the SPH hybrid (wherein a water-soluble counterpart, a hybrid agent is employed) [5]. Depending on the agent type and its associated treatment, various third generation SPHs can be created, ranging from high modulus to highly elastic and rubbery (in their water-swollen states). Water-soluble hydrocolloids, including sodium alginate, sodium carboxymethyl cellulose, pectin and chitosan, have been used

alone or in combination as the preferred hybrid agents. Overall, these third generation SPHs are elastic superporous hydrogels having enhanced mechanical properties [5-11].

Dexlansoprazole is a proton pump inhibitor used as an antiulcer drug in the treatment and maintenance of healing of duodenal or gastric ulcers, erosive and reflux esophagitis, NSAID-induced ulcer, Zollinger-Ellison syndrome, and Barrett's esophagus [12, 13]. It lasts longer than lansoprazole, to which it is chemically related, and needs to be taken less often, making it possible to better control gastric acid. It is active against Helicobacter pylori with a bioavailability of 80% or more and protein binding of 97%. Its half life is 1-1.5 hrs with poor absorption may be because of degradation and poor solubility [13]. The solubility and absorption can be improved with an increase in the gastric residence time. Superporous hydrogels are a good alternative for providing gastroretentive drug delivery systems for therapeutic management of peptic ulcer [14].

MATERIALS & METHODS: Dexlansoprazole was obtained as gift sample from MSN Laboratories Pvt Ltd, Hyderabad. Sugar Spheres were obtained from Arun Pharma Pvt Ltd. chitosan from Central Institute of Fisheries Technology, Kochi, India. Sodium alginate, Pectin, Formaldehyde, Sodium bicarbonate, Microcrystalline cellulose, Magnesium stearate were obtained from SD fine chemicals Mumbai.

Preparation of drug loaded SPHs: Hydrocolloid polymer solution (2%w/v) was prepared by stirring in 0.1M glacial acetic acid solution using a homogenizer until the chitosan dissolves in acid completely. A 10% w/w aqueous PVA solution was prepared and mixed to the polymer solution. To this solution, 0.2 ml of formaldehyde solution (10% w/w of the dry weight of chitosan) was mixed. Further, 0.2 ml of tween 80 was added and mixed thoroughly followed by 50 mg of sodium bicarbonate. The prepared mixture was stirred well and kept aside overnight.

10 ml of 0.1 N HCL was taken. To this 20 mg of drug and 100 mg of superporous hydrogel were added and mixed for 1 h at 50°C. Then acetone of 2ml was added and the hydrogel was repeatedly washed with distilled water to remove any unreacted material. Further it was dried at 40°C for 24h, finally powdered and stored in a well closed container [15 -18]. Different formulations are shown in **Table 1.**

Procedure for the preparation of superporous hydrogel tablets: 20 mg drug equivalent of drug loaded SPHs, microcrystalline cellulose and PVP (5% w/v solution), except magnesium stearate were weighed accurately and transferred to a clean mortar and pestle. The powder blend was mixed for 5 minutes after which magnesium stearate was added and mixed for few more minutes to ensure complete mixing. After obtaining a uniform blend, it was passed through sieve no 60. The prepared powder blend was compressed into tablets.

TABLE 1: FORMULATIONS WITH HYDROCOLLOID POLYMER-SUPERPOROUS HYDROGEL.

Ingredients (% w/w)	F1	F2	F3	F4	F5	F6	F7	F8	F9
Chitosan	2	---		3	---	---	4	---	---
Pectin	---	2	---	---	3	---	---	4	---
Sodium alginate	---	---	2	---	---	3	---	---	4
Poly Vinyl Alcohol	4	4	4	4	4	4	4	4	4
Formaldehyde	10	10	10	10	10	10	10	10	10
Tween 80	0.2ml	0.2ml	0.2ml	0.2ml	0.2ml	0.2ml	0.2ml	0.2ml	0.2ml
Sodium Bicarbonate	50 mg	50 mg	50 mg	50 mg	50 mg	50 mg	50 mg	50 mg	50 mg
Dexlansoprazole	20 mg	20 mg	20 mg	20 mg	20 mg	20 mg	20 mg	20 mg	20 mg

Swelling studies: Completely dried superporous hydrogel was weighed and then immersed in excess of 0.1 N HCl. At various time intervals, the hydrogel was removed from the solution, blotted to remove excess of medium and then weighed [16 -18]. Swelling ratio was calculated according to the following equation:

$$Q = (M_s - M_d) / M_d$$

Where, Q is the swelling ratio, Ms the mass in the swollen state and M the mass in the dried state.

Porosity measurement: Dried hydrogels were immersed overnight in absolute ethanol and weighed after excess ethanol on the surface was

blotted. The porosity was calculated from the following equation:

$$\text{Porosity} = (M_2 - M_1 / \rho V)$$

Where, M_1 and M_2 are the mass of the hydrogel before and after immersion in absolute ethanol, respectively; ρ is the density of absolute ethanol and V is the volume of the hydrogel [16-18].

Determination of void fraction: The void fraction was calculated by the following equation:

Void Fraction = Dimensional volume of the hydrogel /Total volume of pores

The void fraction inside superporous hydrogels was determined by immersing the hydrogels in 0.1 N HCl up to equilibrium swelling. The dimensions of the swollen hydrogels were measured and thereby dimensional volume was determined. In the meantime, the amount of absorbed buffer into the hydrogels was determined by subtracting the weight of dried SPHs from the weight of swollen SPHs and the resulting values were assigned as the total volume of pores in the SPHs [16-18].

Water retention capacity: The following equation was used to determine the water retention capacity (WR_t) as a function of time:

$$W_{Rt} = (W_p - W_d) / (W_s - W_d)$$

Where, W_d is the weight of the dried SPHs, W_s is the weight of the fully swollen SPHs (after exposure for 1day), and W_p is the weight of the SPHs after exposure time of 6 hours. For determination of the water-retention capacity of the SPHs at 37°C, the water loss of the fully swollen polymer was determined by gravimetry [16-18].

Mechanical Properties: The tensile strength (T) of superporous hydrogel formulations, which is a measure of the stress necessary to cause diametral fracture of the compact, was determined from the mean data obtained from the hardness test carried out on the SPHs (n = 3) using the Mosanto hardness tester. The T values were computed from equation below,

$$T = 2P / \pi D t$$

Where, P is the load applied on the SPH that causes tensile fracture of the SPH of diameter, D, and t is the SPH thickness [19, 20].

Determination of drug content: A weight of superporous hydrogel containing 5 mg of drug in 100 ml volumetric flask was treated with about 10 ml 0.1 N HCl of pH 1.2 mixed well and made up to volume. The mixture was filtered and drug content was determined using UV-Vis spectrophotometer at 286 nm.

FT-IR spectroscopy: FT-IR spectroscopy was employed to ascertain the compatibility between the drug and the polymers. It was also used to investigate the chemical structure of the synthesized SPHs. The FTIR spectrum was recorded over the range of 400–4000 cm^{-1}using KBr pellet method by Fourier-Transform Infrared (FT-IR) spectrophotometer, (Bruker- Alpha-T-1020).

Scanning electron microscopy: The dried superporous hydrogels were used for scanning electron microscopy (SEM) studies to determine the morphology of the dried samples. A JEOL JSM-840 scanning electron microscope (Jeol USA, Inc., Peabody, MA) was used after coating the samples with gold using a Hummer Sputter Coater (Technics, Ltd.). Images were captured using a digital capture card and Digital Scan Generator 1 (JEOL).

Precompression characterization: Powder blend of Dexlansoprazole SPHs was evaluated for various physiochemical parameters. Bulk density, tapped density, angle of repose and powder flow studies of the different formulations were studied. The results are shown in **Table 3.**

Weight Uniformity Test: The 20 tablets were taken and their weight was determined individually and collectively on a digital weighing balance. The average weight of one tablet was determined from the collective weight. Test was performed as per Indian Pharmacopeia (IP) 2010 [21].

Hardness: Hardness was determined by taking six tablets from each formulation, using a Monsanto hardness tester, which applies force to the tablet diametrically with the help of an inbuilt spring.

Friability: The friability test was performed using Roche friabilator (Electrolab, Mumbai, India) as per IP 2010.

Sample comprising the tablets equivalent to 6.5 g were rotated at 25 rpm for 4 min. Tablets were reweighed after removal of fines (dedusted) and the percentage of weight loss was calculated. Friability below 1% was considered acceptable [21].

***In-vitro* drug release study:** The *in-vitro* drug release study of tablets was performed using United State pharmacopeia (USP) Type 2 apparatus at 37°C ± 0.5°C using 0.1N HCl (900 mL) as a dissolution medium at 50 rpm. At the predetermined time intervals, 5 ml samples were withdrawn and replaced with fresh dissolution media. Withdrawn samples was filtered through a 0.45 µm membrane filter, diluted and assayed at 286 nm using a T60 UV-VIS double-beam spectrophotometer. Cumulative percentage drug release was calculated using an equation obtained from a calibration curve [22].

RESULTS & DISCUSSION:

Compatibility studies: The FTIR studies revealed that there was no drug polymer interaction in any of the formulation as indicated by the principal FTIR peaks of the drug observed at wave numbers of 3176, 1581. 1402, 1257, 1113, 1007 and 669 cm^{-1} confirming the purity of the drug. FTIR spectrum of Dexlansoprazole in pure state is shown in **Fig.1.** Which was observed to be almost similar in all the formulations indicating no significant drug interactions. In the FTIR spectra of sodium alginate SPHs of Dexlansoprazole (F9) peaks were observed at 1581, 1403, 1039, 750 cm^{-1}.

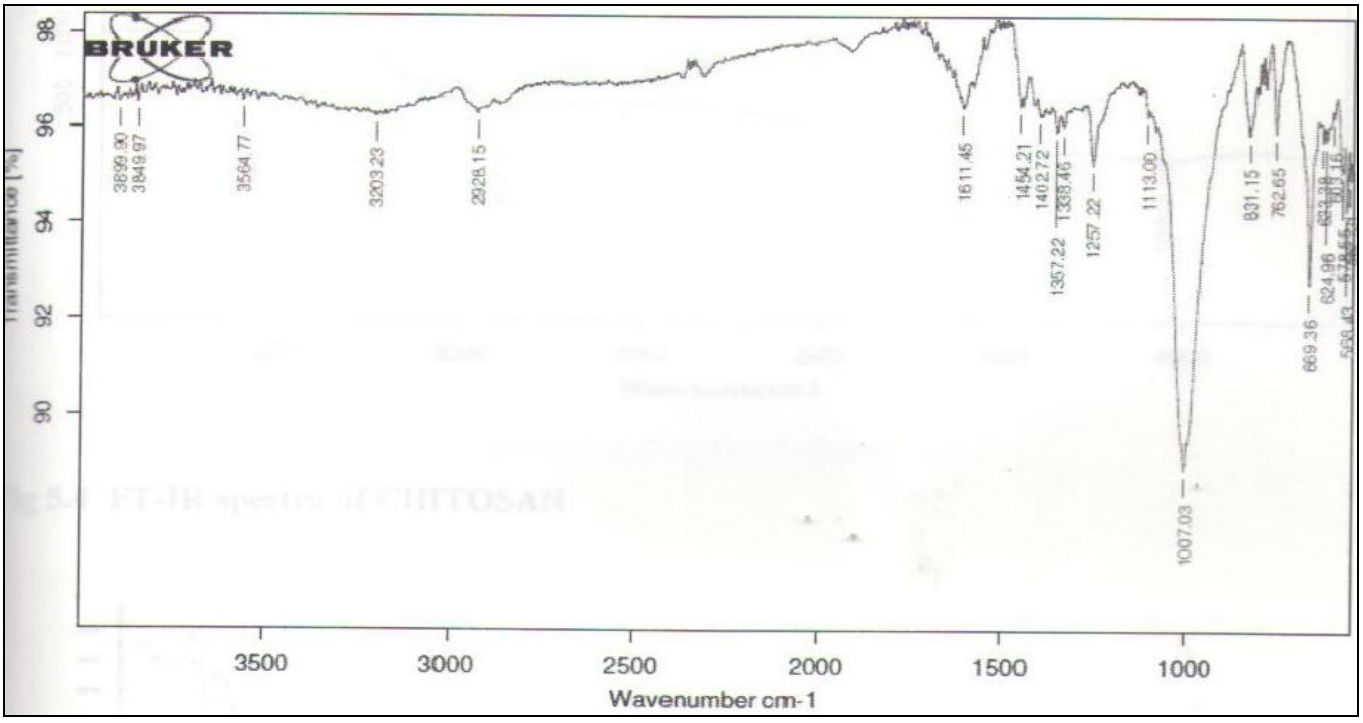

FIG. 1: FTIR SPECTRUM OF DEXLANSOPRAZOLE IN PURE STATE

TABLE 2: PHYSICAL CHARACTERIZATION OF ALL SPHS FORMULATIONS

Formulations	Swelling ratio	Porosity (%)	Void Fraction (ml/gm)	Water retention capacity	Tensile strength (kPa)
F1	47.35 ± 0.23	36.3 ± 2.2	1.42 ± 0.04	0.634	09.63 ± 3.56
F2	58.00 ± 0.09	58.3 ± 3.1	1.25 ± 0.06	0.775	08.18 ± 2.57
F3	40.00 ± 0.12	66.4 ± 2.5	1.15 ± 0.00	0.528	11.53 ± 3.42
F4	72.60 ± 0.80	73.2 ± 4.2	0.98 ± 0.12	0.974	12.03 ± 1.76
F5	52.75 ± 0.56	44.2 ± 3.3	1.33 ± 0.06	0.704	08.79 ± 2.98
F6	74.50 ± 0.20	79.2 ± 1.5	0.85 ± 0.11	0.709	12.09 ± 1.26
F7	48.48 ± 0.26	89.2 ± 2.1	0.72 ± 0.16	0.653	15.42 ± 5.87
F8	69.40 ± 0.32	68.4 ± 2.5	1.15 ± 0.05	0.930	09.03 ± 2.94
F9	68.50 ± 0.16	80.2 ± 4.2	0.95 ± 0.11	0.919	17.45 ± 3.27

Porosity of superporous hydrogels depends on the amount of crosslinking agent. It increases with decrease in hydrocolloid polymer to crosslinking agent ratio. This is due to the incorporation of the higher crosslink density within the polymer structure leading to the decrease in the occupied volume. In case of chitosan, among all hydrocolloid polymers, maximum porosity was found. Additionally, the void fraction of the superporous hydrogels decreased with increased amount of crosslinking agent. The decrease in void volume led to a decrease in the amount of uptake of water into the structure, resulting in decrease in the swelling ratio.

Kinetics of swelling is important because of the gel barrier formed with water permeation. Swelling is also a vital factor to ensure floating [23, 24]. The swelling ratio was in the range 40.00 ± 0.12 to 74.50 ± 0.20. F6 formulation is having higher swelling index. The reason for higher swelling ratio value can be attributed to the work by channeling agent, which allows more penetration of water into the gel layer thereby enhancing the water penetration or retention property. This could be the reason for more water uptake by formulation from F4, F8 and F9 as shown in the **Table 2.**

Mechanical strength was measured in terms of tensile strength i.e, the measure of stress required to fracture the piece of formed SPH. To make the third generation superporous hydrogels for their effective applications, appropriate mechanical strength is necessesary. The results as shown in the **Table 2** indicate that increase in amount of crosslinking agent increased the stress required for fracture, thus increasing the mechanical stability. The presence of PVA increased the overall crosslinking density of the superporous hydrogels by inducing additional PVA- polymer chains. This entanglement significantly improved the structural integrity of the hydrogel and decreased stress relaxation, which enhanced its ability to withstand pressure. Compared to other hydrocolloid polymers, sodium alginate gave most strong SPHs. SEM studies revealed highly porous structure of Superporous hydrogels of F9 as shown in the **Fig.2.**

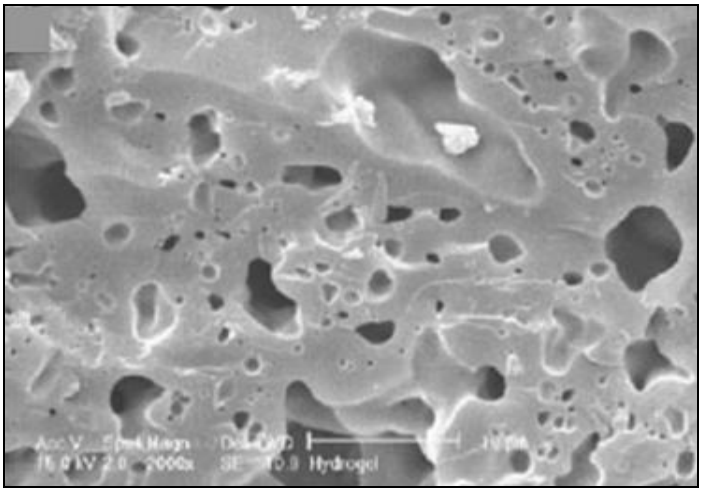

FIG. 2: SCANNING ELECTRON MICROGRAPHS OF SPHS OF SODIUM ALGINATE (F9). The magnification of the micrographs is ×200, and the scale bar indicates 10 µm.

TABLE 3: PRE-COMPRESSION PARAMETERS OF ALL SPHS FORMULATIONS:

Formulations	Angle of repose	Bulk density (gm/ml)	Tapped density (gm/ml)	Carr's Index	Hausner's Ratio
F1	32.31 ± 0.512	0.533 ± 0.033	0.407 ± 0.013	14.18 ± 0.19	1.16 ± 0.11
F2	33.39 ± 0.739	0.537 ± 0.008	0.418 ± 0.017	14.13 ± 0.41	1.16 ± 0.45
F3	34.36 ± 0.629	0.541 ± 0.421	0.454 ± 0.121	14.11 ± 0.32	1.17 ± 0.19
F4	32.38 ± 0.321	0.532 ± 0.296	0.399 ± 0.073	15.03 ± 0.84	1.18 ± 0.02
F5	33.07 ± 0.631	0.539 ± 0.583	0.407 ± 0.066	14.05 ± 0.71	1.16 ± 0.07
F6	31.38 ± 0.145	0.559 ± 0.271	0.471 ± 0.033	13.50 ± 0.18	1.13 ± 0.12
F7	31.16 ± 0.642	0.554 ± 0.326	0.399 ± 0.091	14.98 ± 0.78	1.13 ± 0.02
F8	32.35 ± 0.550	0.538 ± 0.173	0.422 ± 0.038	13.05 ± 0.23	1.17 ± 0.12
F9	33.19 ± 0.162	0.554 ± 0.118	0.443 ± 0.031	14.28 ± 0.27	1.18 ± 0.03

The flow properties of the powder blend was found to be good for all formulations, as the angle of repose, carr's index and hausner's ratio were in good range. There were no flow problems (flow obstruction, segregation, irregular flow, flooding, etc) observed during the tests.

The Compressibility index (or carr's index) and Hausner's ratio are measures of the propensity of a powder or the measures of the powder ability to settle and they permit an assessment of the relative importance of inter-particulate interactions. In a free flowing powder, such interactions are less significant, and the bulk and tapped densities will be closer in value as seen in the results from **Table 3.** Good flow of powder blends ensures content uniformity and dose precision of tablets.

TABLE 4: POST-COMPRESSION PARAMETERS OF ALL SPHS TABLETS

Formulations	Hardness (kg/cm^2)	Friability (%)	Wt. uniformity (%)	Drug content (%)
F1	4.6 ± 0.13	0.501 ± 0.040	1.030 ± 0.005	98.97 ± 0.88
F2	4.6 ± 0.19	0.504 ±1.150	0.987 ± 0.180	100.1 ± 0.83
F3	4.8 ± 0.21	0.603 ±0.150	1.009 ± 0.009	99.72 ± 0.87
F4	4.5 ± 0.11	0.571±0.910	1.009 ± 0.016	95.8 ± 0.64
F5	4.0 ± 0.63	0.521±1.000	0.987 ± 0.034	99.42 ± 0.80
F6	4.4 ± 0.30	0.460±0.610	0.987 ± 0.190	92.98 ± 0.50
F7	4.9 ± 0.26	0.502±0.201	0.966 ± 0.024	96.80 ± 0.68
F8	3.4 ± 0.16	0.602±0.310	1.030 ± 0.061	94.90 ± 0.51
F9	3.5 ± 0.18	0.704±0.123	1.009 ± 0.003	98.85 ± 0.24

The tablets obtained by compression of powder blends containing SPHs of all formulations were found to have good hardness and acceptable % loss in friability test. The weight uniformity was also in acceptable range as per I.P 2010. The drug content in all the formulations were in agreeable quantities. The post compression evaluation results are illustrated in **Table 4.**

TABLE 5: *IN-VITRO* DRUG RELEASE STUDIES:

Time (hrs)	Cumulative % drug release								
	F1	F2	F3	F4	F5	F6	F7	F8	F9
1	10.62	16.89	10.36	15.83	18.97	16.88	14.12	18.76	17.19
2	35.84	29.82	16.07	36.24	33.86	26.97	29.24	26.12	23.93
3	42.58	40.15	32.69	48.29	41.02	39.96	33.26	23.73	21.58
4	55.38	53.39	47.23	64.19	56.29	51.18	49.26	43.75	40.69
5	68.77	65.03	59.29	76.87	72.39	69.39	61.02	56.72	50.76
6	76.95	72.90	67.38	84.39	80.49	79.46	72.14	68.09	65.68
7	89.93	81.23	79.14	95.01	87.8	83.14	84.20	76.29	73.18
8	98.96	92.84	85.69	98.12	93.47	85.64	93.08	84.22	77.76
9		98.58	92.19		99.39	91.83	96.37	92.48	84.28
10			100.02			98.80	99.53	96.49	90.45
11								98.9	95.83
12									99.89

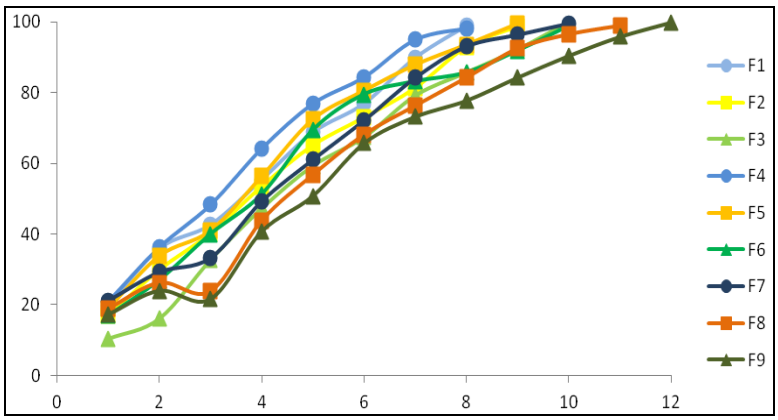

FIG. 3: %CUMULATIVE DRUG RELEASE VS. TIME GRAPH OF ALL FORMULATIONS

TABLE 6: DRUG RELEASE KINETICS STUDIES

Formulations	Zero order		First order		Higuchi	Korsemeyer		Mechanism of release
	K	R^2	K	R^2	R^2	R^2	n	
F1	11.218	0.996	0.093	0.928	0.984	0.994	0.769	Non-fickian diffusion
F2	10.292	0.992	0.088	0.904	0.993	0.813	0.999	Case -II
F3	10.355	0.982	0.103	0.858	0.989	1.047	0.980	Case -II
F4	11.379	0.976	0.090	0.890	0.993	0.995	0.768	Non-fickian
F5	10.304	0.973	0.084	0.888	0.988	0.991	0.774	Non-fickian
F6	10.702	0.980	0.092	0.899	0.986	0.992	0.846	Non-fickian
F7	10.288	0.986	0.085	0.954	0.964	0.964	0.752	Non-fickian
F8	9.777	0.974	0.092	0.934	0.942	0.914	0.795	Non-fickian
F9	9.234	0.980	0.092	0.949	0.956	0.952	0.804	Non-fickian

The *in-vitro* dissolution study was performed for all formulations and the results are shown in **Table 5** and **Fig. 3**. *In-vitro* drug release studies showed that SPHs were the appropriate tool for extending the drug release. All formulations containing SPHs showed more than 8 hrs of drug release.

The drug release profiles of the drug from the SPHs are shown in figure. The release of the drug was found to be dependent to the amount of hydrocolloid polymer and crosslinking agent and as the amount of hydrocolloid polymer increased.

Drug release was found to be inversely related to the amount of crosslinking agent or low amount of hydrocolloid polymer where the openings are less and release is also low. Among all formulations, F9 showed extended release of drug upto 12 hrs.

In-vitro drug release data of all the formulations was subjected to goodness of fit test by linear regression analysis according to zero order and first order kinetic equations, Higuchi‟s and Korsmeyer–Peppas models to ascertain the mechanism of drug release [25]. The results of linear regression analysis including rate constants and regression coefficients are summarized in **Table 6**.

The F9 was found to follow zero order kinetics with non-fickian diffusion type of mechanism of drug release since the value of n, the time exponent, calculated from this equation was found to be in between 0.45 to 0.89. In drug release profiles of all formulations except in F2 and F3, the release mechanism is assumed to be non-fickian.

CONCLUSION: There results conclusively demonstrate that superporous hydrogel tablets of Dexlansoprazole were effectively prepared with desired properties. The superporous hydrogel tablets of Dexlansoprazole were prepared by direct compression method. The directly compressed formulations exhibited better in-vitro drug release profiles if compared to the marked delayed release tablets of Dexlansoprazole. The Formulation F9 prepare by direct compression containing SPH of sodium alginate cross linked with formaldehyde exhibited good swelling index as well as mechanical strength with maximum rate of drug release. The formulation was thus considered as the optimized formulation. The prepared tablet formulations of F9 revealed good pre-compression as well as post-compression properties as per prescribed limits of IP 2010.

Thus, formulated superporous hydrogel tablets of Dexlansoprazole offer a superior alternative over conventional marketed dosage forms in regards to localized action and sustained release of drugs.

REFERENCES:

1. Allan SH, Hydrogels for biomedical applications. Adv. Drug Deliver. Rev. 2002; 43: 3-12.
2. Ullah F, Othman MB, Javed F, Ahmad Z, Md Akil H. Classification, processing and application of hydrogels: A review. Mater Sci Eng C Mater Biol Appl. 2015; 57:414-33.
3. Omidian, H., Rocca, J. G., Park, K. Advances in superporous hydrogels. J. Control. Release 2005a; 102: 3–12.
4. Chavda HV, Patel RD, Modhia IP, Patel CN.Preparation and characterization of superporous hydrogel based on different polymers.Int J Pharm Investig. 2012; 2(3):134-9.
5. Buwalda SJ, Boere KW, Dijkstra PJ, Feijen J, Vermonden T, Hennink WE. Hydrogels in a historical perspective: from simple networks to smart materials. J Control Release. 2014; 190:254-73.
6. Omidian, H., Qiu, Y., Yang, S., Kim, D., Park, H., Park, K. Hydrogels having enhanced elasticity and mechanical strength properties. US Patent 6960617; 2005.
7. Chen J, Park H, Park K. Synthesis of superporous hydrogels: Hydrogels with fast swelling and superabsorbent properties. J. Biomed. Mater. Res. A. 1999; 44: 53-62.
8. Park K. Superporous hydrogels for pharmaceutical and other applications. Drug Deliver Technol. 2002;38:40–4
9. Omidian, H., Rocca, J. G. Formation of strong superporous hydrogels. US Patent 7056957; 2006.

10. Mastropietro DJ, Omidian H, Park K. Drug delivery applications for superporous hydrogels. Expert Opin Drug Deliv. 2012; 9(1):71-89.
11. Hossein Omidian, Kinam Park and Jose G. Rocca. Recent developments in superporous hydrogels. J. Pharm. Pharmacol. 2007, 59: 317–327.
12. Barbara Skrzydło-Radomańska and Piotr Radwan. Dexlansoprazole – a new-generation proton pump inhibitor. Prz Gastroenterol. 2015; 10(4): 191–196.
13. VA Pharmacy Benefits Management Services, Medical Advisory Panel, and VISN Pharmacist Executives. Dexlansoprazole dual delayed-release capsules (Dexilant™). National Abbreviated Drug Review. June 2011.
14. Garg T, Kumar A, Rath G, Goyal AK. Gastroretentive drug delivery systems for therapeutic management of peptic ulcer. Crit Rev Ther Drug Carrier Syst. 2014; 31(6):531-57.
15. Matricardi P, Di Meo C, Coviello T, Hennink WE, Alhaique F. Interpenetrating Polymer Networks polysaccharide hydrogels for drug delivery and tissue engineering. Adv Drug Deliv Rev. 2013; 65(9):1172-87.
16. Omidian, H., Rocca, J. G., Park, K. Elastic superporous hydrogel hybrid of polyacrylamide and sodium alginate. Macromol. Biosci. 2006; 6: 703–10.
17. Nagpal M, Singh SK, Mishra D. Synthesis characterization and in vitro drug release from acrylamide and sodium alginate based superporous hydrogel devices. Int J Pharm Investig. 2013; 3(3):131-40.
18. Vishal Gupta N, Shivakumar HG. Preparation and characterization of superporous hydrogels as gastroretentive drug delivery system for rosiglitazone maleate. Daru. 2010; 18(3):200-10.
19. Pradeep Kumar and Inderbir Singh. Evaluation of oleo-gum resin as directly compressible tablet excipient and release retardant. Acta Pol Pharm. 2010; 67(3):307-13.
20. M. P. Summers, R. P. Enever and J. E. Carless. Influence of crystal form on tensile strength of compacts of pharmaceutical materials. J. Pharm. Sci. 1977; 66(8):1172-5.
21. Indian Pharmacopoeia : Indian Pharmacopoeia Commission (IPC), Ministry of Health and Family Welfare, Govt. of India; Ghaziabad 2010.
22. Dissolution methods, Drug Databases. U.S. Food and Drug Administration. New Hampshire Avenue Silver Spring. http://www.accessdata.fda.gov/scripts/cder/dissolution/.
23. U.V. Bhosale, V. Kusum Devi, Nimisha Jain and P.V. Swamy. Effect of polymer concentration and viscosity grade on atenolol release from gastric floating drug delivery systems. Indian J.Pharm. Educ. Res. 2010; 44(3):267-73.
24. Satish H Patil, Gokul S Talele. Formulation development and in vitro and in vivo evaluation of gastroretentive floating drug delivery system of Lafutidine. Asian J. Pharm. 2013; 7(2):68-74.
25. Suvakanta Dash, Padala Narasimha Murthy, Lilakanta Nath And Prasanta Chowdhury. Kinetic modeling on drug release from controlled drug delivery systems. Acta Pol Pharm. 2010; 67(3):217-223.

How to cite this article:
Pati NB, Velivela S, Mayasa V and Gupta VRM: Gastroretentive superporous hydrogel tablets of dexlansoprazole. Int J Pharm Sci Res 2016; 7(11): 4678-85.doi: 10.13040/IJPSR.0975-8232.7(11).4678-85.