



Received on 21 December, 2015; received in revised form, 15 March, 2016; accepted, 24 April, 2016; published 01 May, 2016

FORMULATION AND EVALUATION OF LEVOCETIRIZINE LOADED MUCOADHESIVE MICROSPHERES FOR NASAL DELIVERY

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Key words:

Levocetirizine,
Mucoadhesive
Microspheres, Chitosan,
Nasal Delivery, Emulsification
Crosslinking Method

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ABSTRACT: The purpose of research work was to develop and optimize mucoadhesive microspheres of levocetirizine for nasal delivery with the aim to enhance the residence time and improve therapeutic efficacy and at the same time increase the Local absorption of drug and reducing systemic side effects and also to develop unique delivery system for patients suffering from allergy and rhinitis. Chitosan (mucoadhesive) based microspheres of levocetirizine were prepared by emulsification-crosslinking method. Glutaraldehyde was used as crosslinking agent. The mean particle size was significantly increased when high concentration of chitosan was used. Aqueous to oil phase ratio, stirring rate and dioctyl sodium sulfosuccinate (DOSS) concentration also influenced the particle size distribution of the microspheres. Microspheres were evaluated with respect to the production yield, particle size, entrapment efficiency, swelling index, FT-IR, in vitro mucoadhesion, % cumulative drug release, histological study and stability studies. Formulation Lf3 was found to be optimized. The optimized formulation Lf3 was mucoadhesive in nature which adhere onto the mucus and increase the residence time within the nasal cavity.

INTRODUCTION: The nose is considered as an attractive route for needle-free vaccination and for systemic drug delivery, especially when rapid absorption and effect are desired. In addition, nasal delivery may help address issues related to poor bioavailability, slow absorption, drug degradation, and adverse events in the gastrointestinal tract and avoids the first-pass metabolism in the liver. However, when considering nasal delivery devices and mechanisms, it is important to keep in mind that the prime purpose of the nasal airway is to protect the delicate lungs from hazardous exposures, not to serve as a delivery route for drugs and vaccines.

Nasal drug delivery possesses various advantages as a site for drug delivery, such as it provides much vascularized epithelium, large surface area for drug absorption, lower enzymatic activity compared with the gastrointestinal tract and liver and the direct drug transport into the systemic circulation, thereby avoiding hepatic first pass metabolism and irritation of gastrointestinal membrane ¹. Nasal route is non-invasive therefore, reduced risk of infection, ease of convenience and self-medication resulting in improved patient compliance. The range of compounds investigated for possible nasal application greatly from very lipophilic drugs to polar, hydrophilic molecules including peptides and proteins ².

In nasal drug delivery, the most important limitation factor is rapid mucociliary clearance, which is the cause of a limited contact period allowed for drug absorption through the nasal mucosa. Thus, mucoadhesive nano and micro-

<p>QUICK RESPONSE CODE</p>	<p>DOI: 10.13040/IJPSR.0975-8232.7(5). 2242-51</p>
	<p>Article can be accessed online on: www.ijpsr.com</p>
<p>DOI link: http://dx.doi.org/10.13040/IJPSR.0975-8232.7(5). 2242-51</p>	

particles have been formulated to overcome the rapid mucociliary clearance, thereby increasing drug absorption through nasal cavity. Chitosan is a natural polymer that has mucoadhesive properties because of its positive charges at neutral pH, which enable an ionic interaction with the negative charges of sialic acid residues on the mucus³. This highly mucoadhesive characteristics of chitosan provide a longer contact period for drug transport through nasal mucosa and prevents the clearance of the formulation via mucociliary clearance mechanism⁴. Therefore, chitosan microspheres have been extensively evaluated as a drug delivery system. In this study, we aimed to formulate levocetirizine-loaded mucoadhesive microspheres with chitosan and to investigate feasibility of levocetirizine nasal delivery with chitosan microspheres.

Levocetirizine is a third generation antihistamine acts by blocking histamine receptor. Which is used in the treatment of allergy & rhinitis⁵? It is generally given by oral route. However sometimes its oral route which makes oral treatment unsatisfactory. Intranasal route may be viable alternative for self-administration where the limitations of oral and parenteral route could be overcome. Conventional dosage forms may be unsatisfactory due to their poor residence time in nasal cavity. Mucoadhesive polymer like chitosan can be employed to increase the residence time of the formulation to enhance the bioavailability⁶.

Chitosan microspheres have received considerable attention as nasal drug delivery systems. Chitosan, being biodegradable, biocompatible, and non-toxic and bioadhesive polymer. Chitosan is a cationic polysaccharide, derived by the deacetylation of chitin. Chitosan is positively charged due to its amino group and able to interact strongly with the negatively charged mucus layer of the nasal epithelium⁷.

This is to provide a longer contact time for drug transport across the nasal membrane, before the formulation is cleared by the mucociliary clearance mechanism. In addition, chitosan has been shown to increase the paracellular transport of polar drugs by transiently opening the tight junctions between the epithelial cells. In the present study chitosan

microspheres intended for nasal delivery of levocetirizine were prepared by emulsification crosslinking technique using glutaraldehyde (GLA) as the crosslinking agent^{8, 9, 10}. Hence, in the present work, an attempt was made to formulate and evaluate mucoadhesive microspheres of levocetirizine that will increase residence time in the nasal cavity and at the same time increase the local of absorption of drug and reducing systemic side effects and also to develop unique controlled delivery system for patients suffering from allergy and rhinitis. The microspheres were prepared by emulsion cross linking method in different ratio by using mucoadhesive polymer, chitosan.

MATERIALS:

Levocetirizine was received as a kind gift from Ajanta Pharma Ltd. (Mumbai, India). Chitosan was provided by Fisher scientific, Mumbai, India. All other ingredients used were of analytical grade and were used without further purification. Spectrophotometric studies were carried out by using double-beam UV-spectrophotometer, Shimadzu, Pharma Spec 1700, Kyoto, Japan.

Methods:

Preparation of mucoadhesive microspheres:

Chitosan microspheres were prepared by simple w/o emulsification-cross linking process using liquid paraffin (heavy and light 1:1) as external Phase⁶. Briefly, chitosan was dissolved in 2% aqueous acetic acid solution by continuously stirring until a homogeneous solution was obtained (**Table 1**). Specified quantity of drug dispersed homogeneously by stirring in chitosan solution. This solution was added slowly to liquid paraffin (heavy and light 1:1) containing 0.2% (w/v) of DOSS as stabilizing agent under constant stirring at 1200 rpm-1375 rpm speed for 15 min using a Eurostar (IKA Labortechnik, Germany) high speed stirrer. To this w/o emulsion, Glutaraldehyde (GLA) was added slowly in definite concentration (2 ml) in different formulation and stirring was continued for 2 hrs. The hardened microspheres were separated by vacuum filtration and washed several time with hexane to remove oil. Finally, microspheres were washed with distilled water to remove unreacted GLA. The microspheres were dried for 24 hrs and then stored in vacuum desiccators until further use.

TABLE 1: FORMULATION COMPOSITION OF MUCOADHESIVE MICROSPHERES

Formulation & process variables			Constant parameters			
Formulations	Drug: polymer ratio	% of stabilizer used (DOSS)	Vol. of cross linking agent (Glutaraldehyde)	Aqueous to oil phase ratio	Stirring rate	Cross linking time
Lf1	1:1					
Lf2	1:2					
Lf3	1:3	0.2	2ml	10:100	1375 rpm	2 hours
Lf4	1:4					

Characterization of levocetirizine loaded microspheres:

Particle size: ^{11, 12}

The particles size of the microspheres measured by using optical microscope(OLYMPUS CH 20i) Equipped with modified software Magnus pro 3.0 and Olympus master through a camera using a quantity of microspheres suspended in glycerin and the mean particle size was calculated by measuring more than 100 microspheres were measured randomly by optical microscope.

Production yield: ¹³

The production yield of microspheres of various formulation were calculated using the weight of final product after drying with respect to the initial total weight of the drug and polymer used for preparation of microspheres.

Determination of entrapment efficiency: ¹³

Accurately weighed equivalent to 5 mg of levocetirizine microspheres were crushed and dissolved in 100 ml methanol with the help of ultrasonic stirrer and kept overnight The Solution was filtered through Whatmann filter paper No.41, suitable dilution (6,8,10 mcg/ml). The samples were assayed for drug content by UV-spectrophotometer at 231.1nm. The drug entrapment efficiency was calculated using following Equations (1).

Entrapment efficiency (%) =

$$\frac{M_{\text{actual}}}{M_{\text{theoretical}}} \times 100 \text{ Equ.....(1)}$$

Where M_{actual} is the actual levocetirizine content in weighed quantity of powder of microspheres and $M_{\text{theoretical}}$ is the theoretical amount of levocetirizine in microspheres calculated from the quantity added.

Scanning Electron Microscopy:

The surface morphology of optimized formulation (Lf3) was examined by scanning electron microscopy (JSM 6390, India). The images were recorded at the 100X magnification at the acceleration voltage of 10 kv¹⁴.

Fourier Transform Infrared Spectroscopy (FT-IR spectroscopy):

Levocetirizine, Chitosan and optimized formulation (Lf3) was examined using FTIR Spectrophotometer (Shimadzu FTIR-8400S Kyoto, Japan). The test sample diluted with KBr to get a final dilution of 1:10 was mounted into the instrument. The measurements were made in transmittance mode in the range of 400-4000 cm⁻¹ against the background spectra of pure KBr by setting resolution of 4 cm⁻¹ and 50 times accumulation ¹⁵.

Swelling ability of microspheres:

The swelling ability of microspheres was determined by allowing them to swell to their equilibrium in phosphate buffer of pH 6.4^{16, 17}. Swelling was determined in triplicate by using the equation 2.

$$\alpha = \frac{W_s - W_o}{W_s} \text{ Equ.....2}$$

Where α is degree of swelling, W_o is initial weight of microspheres and W_s is the weight of microspheres after swelling.

Mucoadhesive Testing by in-vitro wash-off test:

In Mucoadhesive properties of the microspheres were evaluated by in vitro adhesion testing method known as the wash-off method ¹⁸. In this method freshly excised nasal mucosal membrane (3×2 cm) of goat was taken and mounted on the paddle of USP dissolution test apparatus with thread Microspheres were spread onto each wet rinsed tissue specimen, and immediately therefore the

support washing onto the arm of a USP dissolution test apparatus. Operate USP dissolution test apparatus at 25 rpm of paddle in phosphate buffer 6.4 at $37^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$. At the end of 30 min, 60 min, at hourly intervals up to 6 hours.

In-vitro Release Studies:

The drug release study was performed using USP XXIV basket apparatus at $37^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$ at 50 rpm using 900 mL of phosphate buffer (pH 6.4) as a dissolution medium as per USP XXVI dissolution. Microspheres equivalent to 5 mg of levocetirizine drug were used for the test. Five milliliters of sample solution was withdrawn at predetermined time intervals, filtered through a Whatmann filter paper, diluted suitably and analyzed spectrophotometrically^{19, 20, 21}. An equal amount of fresh dissolution medium was replaced immediately after with drawl of the test sample. Percentage drug dissolved at different time intervals was calculated at 230.1 nm.

Kinetics of Drug release:

To examine the drug release kinetics and mechanism, the cumulative release data were fitted to models representing zero order (Q v/s. t), first order [Log (Q0-Q) v/s. t], Higuchi's square root of time (Q v/s. t^{1/2}) and Korsmeyer Peppas double log plot (log Q v/s. log t) respectively, where Q is the cumulative percentage of drug released at time t and (Q0-Q) is the cumulative percentage of drug remaining after time t. In short, the results obtained from in vitro release studies were plotted in four kinetics models of data treatment as follows:-

- Cumulative percentage drug release Vs. Time (zero order rate kinetics)
- Cumulative percentage drug release Vs. \sqrt{t} (Higuchi's classical diffusion equation)
- Log cumulative percentage drug release Vs. log time (Korsmeyer Peppas equation)
- Log cumulative percentage drug remaining Vs. time (First order rate kinetics)

Kinetic analysis was performed and the data was evaluated after fitting to Zero order, First order, Higuchi, Peppas values observed where Regression

co-efficient (R) and Diffusion exponent (n) value in case of Peppas model. Criteria for selecting most appropriate model were based on best reliability of fit indicated by 'R' value nearer to one. When drug release is concentration dependent, first order model is an indicator. Zero order model is independent of concentration of drug. Matrix model is applicable when matrix polymer is used and Peppas model is used when release mechanism is not well known Fickian diffusion exists when $n < 0.5$, but at $n > 0.5$ non-fickian diffusion mechanism was observed^{22, 23, 24, 25}

Histological studies:

Histological studies were conducted to determine the effect of formulation on nasal mucosa. Nasal mucosa of Goat was obtained from slaughter house in saline phosphate buffer pH 6.4. The mucosa was kept in 10% formalin solution for stabilize the mucosa. Three pieces of nasal mucosa of identical size were cut and mounted on separate glass slide. On one slide was treated with 0.5ml phosphate buffer pH 6.4 (negative control) Second slide treated with 0.5 ml isopropyl alcohol (positive control), in third slide slide formulation Lf3 (control) and all the slide kept for for 6 h. After 6 h slides were subjected to histopathology study for evaluation of nasal toxicity^{3, 26, 27}. The specimens were visualized through Microscope at 100 x magnification at Pt. Deen Dayal Upadhaya Pashu Chikitsa Vigyan Vishwavidyalya and Gau research center Mathura, India.

Stability studies:

The optimized formulation Lf3 was tested for stability studies. The formulations were divided into 3 sets of sample and stored at $4 \pm 1^{\circ}\text{C}$, $25 \pm 2^{\circ}\text{C}$ and $60 \pm 5\% \text{RH}$, $37 \pm 2^{\circ}\text{C}$ and $65 \pm 5\% \text{RH}$ ^{28, 29}. After one to six month, the drug release of selected formulations was determined by the method discussed previously *in vitro* drug release studies and percentage entrapment efficiency was also carried out for the same formulation.

RESULT AND DISCUSSION:

Preparation of microspheres:

In the present study, Emulsification-cross linking method described here approved a suitable and simple technique to prepare chitosan microspheres loaded with levocetirizine. For preparation of W/O

type of emulsion, polar organic solvent was employed as 'aqueous phase'.

Characterization of levocetirizine loaded mucoadhesive microspheres:

Particle Size: The mean particle sizes of the formulations were shown in the table 2. The mean particle size of microspheres ranged from 11-24 μm . The particle size mainly depends on the stirring rate and slow effect of concentration of mucoadhesive polymers, it is clear that stirring rate increases particle size decreases both at higher and lower concentration of polymers while concentration of mucoadhesive polymer had opposite effect on particle size.

Production yield:

The production yields of microspheres prepared by emulsion cross-linking method were found to be

between 63.96-75.2% in case of Levocetirizine as shown in table 2. It was found that production yield of microspheres prepared by 1:3 (drug: polymer) was greater than Lf1 (1:1), Lf2 (1:2), and Lf4 (1:4). The probable reason behind this may be the high viscosity of the chitosan solution wastage of the drug-polymer solution which ultimate decreased the production yields of microspheres. Another reason for that may be agglomeration and sticking of polymer to blades of stirrer and to the wall of the beaker during microsphere formation.

Entrapment efficiency:

Entrapment efficiency was high since it always exceed 75%. It was found that with increasing the ratio of drug to polymer, the entrapment efficiency was also increased (**Table 2**).

TABLE 2: PARTICLE SIZE OF LEVOCETIRIZINE LOADED FORMULATIONS

Formulation code	Particle size (μm)	Production Yield %	Encapsulation efficiency %	Mucoadhesion %	Swelling index %
Lf1	24 \pm 3.000	63.96 \pm 0.451	79.36 \pm 0.472	64.83 \pm 0.289	0.623 \pm 0.008
Lf2	20.33 \pm 4.163	68.43 \pm 0.404	83.2 \pm 0.3	70 \pm 0.500	0.828 \pm 0.037
Lf3	11 \pm 1.000	77.8 \pm 0.755	87.2 \pm 0.7	76 \pm 0.500	0.956 \pm 0.050
Lf4	16.19 \pm 8.308	75.2 \pm 0.300	84.76 \pm 0.51	78.03 \pm 0.451	1.08 \pm 0.076

N = mean of 3, SD \pm = Standard Deviation

Scanning Electron Microscopy:

The optimized formulation Lf3 was examined by SEM. SEM images of Lf3 in presented in **Fig. 1**. SEM analysis revealed that optimized formulation

Lf3 microspheres were spherical in shape and microspheres have smooth surface.

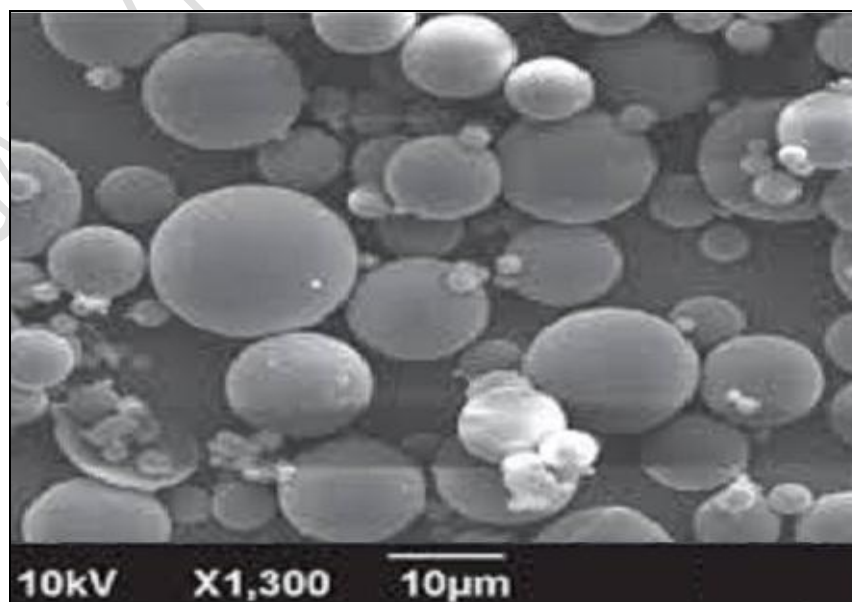


FIG 1: SEM OF FORMULATION (LF3)

Fourier transforms infrared spectroscopy (FTIR):

FTIR spectroscopy to know any possible interaction between levocetirizine, chitosan and the crosslinking agent. Levocetirizine and chitosan showed characteristic peak at range of 400-4000 cm^{-1} . The FTIR spectrum of chitosan in **Fig. 2** showed peaks corresponding to O-H stretching at

3428 cm^{-1} and amine group (NH_2) stretching at 2958.1 cm^{-1} respectively. The spectrum of drug loaded microspheres denotes that the drug was intact in the formulation and the absence of drug-polymer interaction. Changes in the intensity of the peaks indicating no interaction between drug and polymer.

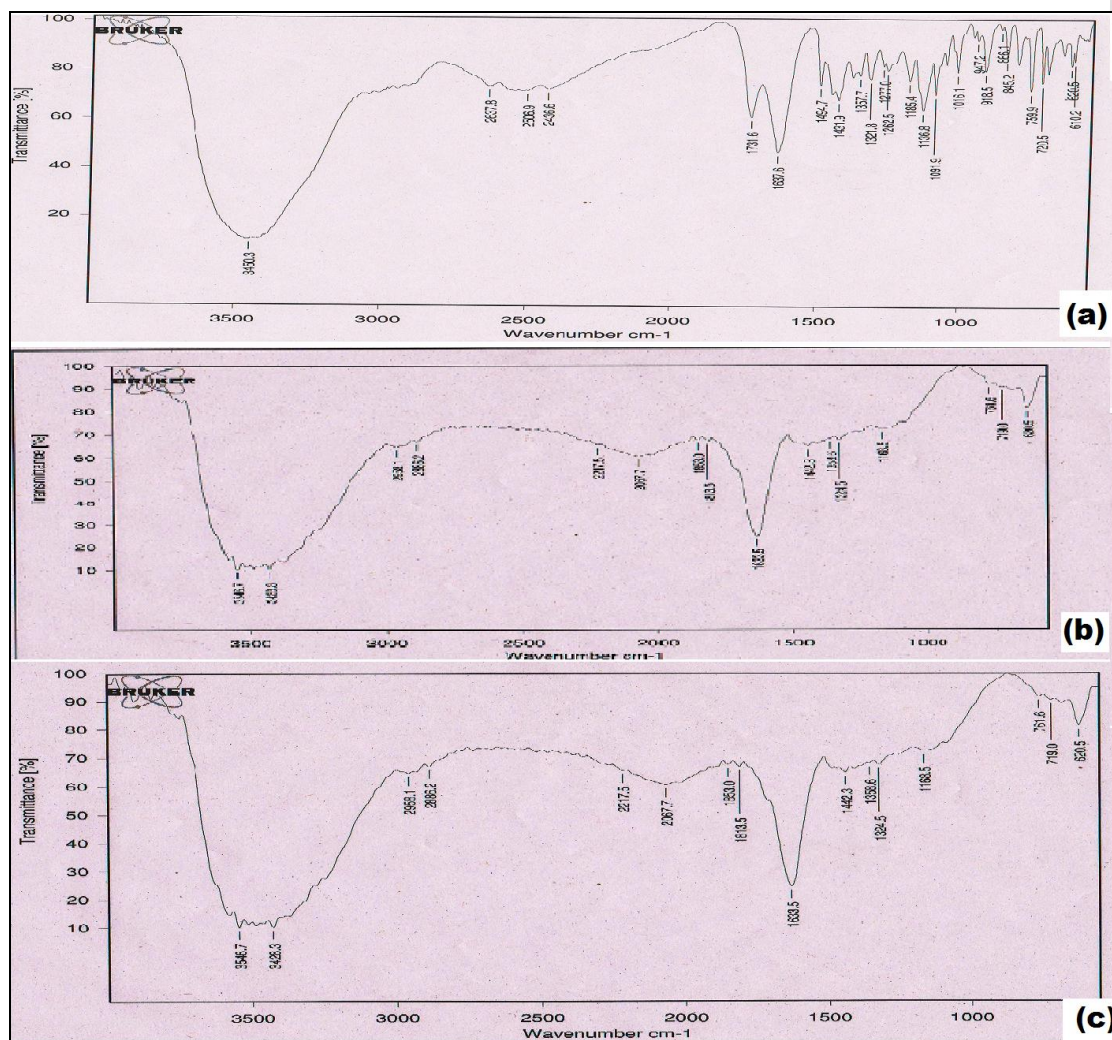


FIG.2: FTIR SPECTRA OF (a) LEVOCETIRIZINE, (b) CHITOSAN AND (c) LEVOCETIRIZINE LOADED MICROSPHERES

Swelling ability of microspheres:

The swelling index of all formulation was shown in **Table 2**. From the table, degree of swelling for chitosan microspheres varied from 0.623 ± 0.008 to 1.08 ± 0.076 . It is known that the degree of swelling increases marginally as the concentration of mucoadhesive polymer increases. Marginal decrease in swelling at lower level of mucoadhesive polymer may be due to the higher level of film forming polymer (chitosan) in those formulations which allows lesser penetration of

water inside the polymer matrix. From this, it may be concluded that when the microspheres are in contact with mucus layer, they swell rapidly and take up liquid from the mucus layer, Hence, the epithelial cells loose water and shrink which opens the epithelial tight junctions allowing drug to be absorbed.

In vitro Mucoadhesion:

The mucoadhesion of levocetirizine loaded nasal microspheres closely varied between 64.83 ± 0.289

to 78.03 ± 0.451 (Table 2) and was dependent on polymer concentration. Such excellent mucoadhesion of chitosan microspheres were from the electrostatic attraction between chitosan and mucin. Moreover, the linear molecules of chitosan expressed sufficient chain flexibility for interpenetration and entanglement. A good mucoadhesion is the high flexibility of polymer backbone structure and its polar functional groups. Such flexibility of the polymer chain is reduced if the polymer molecules are cross-linked either with each other or with cross-linking agent. The decrease in flexibility imposed upon polymer chain by cross-linking makes it more difficult for cross-linked polymer to penetrate the mucin network. Thus cross-linking effectively limits the polymer chain that can penetrate the mucus layer and could possibly decrease mucoadhesion strength.

In vitro release studies:

The *in vitro* release data of all the formulations were tabulated in Table. The cumulative drug release after 8hrs was found to be 81% , 81.83%, 86.03%, 82.83% respectively for the formulation Lf1 to Lf4 (Table 3). The release studies of Levocetirizine loaded chitosan microspheres are graphically shown in Fig. 2. It was clear that both

the variables (stirring rate & concentration of polymer) had significant impact on drug release. As the concentration of mucoadhesive polymer increased, the drug release also increased proportionally. Stirring rate had more influence on drug release than concentration of mucoadhesive polymer. Drug release increased steeply as the stirring rate was increased from lower to higher level.

This presumably is due to the smaller particle size of microspheres at higher stirring rate which leads to much larger surface area available for release and shorter path length for drug to diffuse through microspheres. The greater drug release from chitosan microspheres may be due to the higher swelling degree of chitosan which forms hydrophilic passage inside the microspheres who help drug diffuse out. The increase hydrophilic pores formed by chitosan facilitated the water penetrating into microspheres, accelerated the erosion of swelling matrix and resulted in a combination of the diffusion and erosion mechanism of drug release from microspheres. From the percent drug release graph, formulations Lf3 were showed best result.

TABLE 3: IN VITRO DRUG RELEASE OF LEVOCETIRIZINE LOADED MICROSPHERES

Time (hrs)	Formulation Code			
	Lf1	Lf2	Lf3	Lf4
0	0	0	0	0
1	14.5±0.500	18.5±0.500	23.16±0.289	22.2±0.721
2	23.7±0.608	23.53±0.500	33.33±0.577	32.5±0.500
3	35.4±0.529	38.83±0.764	43±0.500	42.16±0.764
4	41±0.500	43.33±1.607	51.5±0.500	50.83±1.041
5	51.7±0.265	52.5±0.500	62±0.500	61.4±0.529
6	60.83±0.794	62.83±0.764	68.5±0.500	68.5±0.500
7	68.5±0.500	71±0.500	76±0.500	73±1.000
8	81±0.500	81.83±0.764	86.03±0.451	82.83±0.764

N = mean of 3, SD±= Standard Deviation

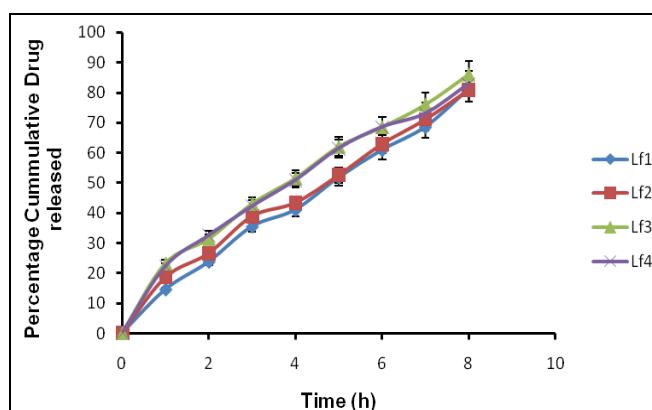


FIG. 3: IN VITRO RELEASE OF LEVOCETIRIZINE LOADED MICROSPHERES

In vitro Drug release kinetics studies:

The *in vitro* drug release data of all the formulations were fit into Zero order, First order, Higuchi Equation and Korsmeyer-Peppas model. The results were shown in Table 4. The ‘R’ values for zero order kinetics of Lf1 to Lf4 were 0.979 to 0.998 and ‘R’ values for first order kinetics of Lf1 to Lf4 were 0.929 to 0.970 respectively. Among the zero order and first order equations, the Zero order Regression co-efficient (R2) value was found to be more than the First order. So all the formulations Lf1 to Lf4 followed Zero order drug release values indicate the drug release follows zero order (Fig. 4). To ascertain the drug release mechanism, the *in-*

vitro data were also subjected to Higuchi diffusion. The ‘R’ values of Higuchi diffusion was 0.945 to 0.965 for formulation Lf1 to Lf4 respectively. So it confirms the drug release by Higuchi diffusion mechanism. Higuchi equation explains the diffusion controlled release mechanism. The diffusion exponent (n) values of Korsmeyer-Peppas model was found to be All the formulations were subjected to Korsmeyer-Peppas plots, ‘n’ value ranges from 0.700 to 0.810 indicating that the drug release was by non-fickian diffusion mechanism (Table 4).

TABLE 4: REGRESSION CO-EFFICIENT (R) VALUES IN THE ANALYSIS OF RELEASE DATA OF MICROSPHERES AS PER VARIOUS KINETICS MODEL AND DIFFUSION EXPONENT (N) VALUE OF PEPPAS EQUATION

Formulation Code	Zero order	First order	Higuchi matrix	Peppas plot		Best fit model
	r ² value	r ² value	r ² value	r ² value	‘n’ value	
Lf1	0.979	0.929	0.945	0.943	0.810	Zero order
Lf2	0.982	0.939	0.960	0.968	0.792	Zero order
Lf3	0.998	0.970	0.965	0.988	0.744	Zero order
Lf4	0.985	0.945	0.941	0.976	0.700	Zero order

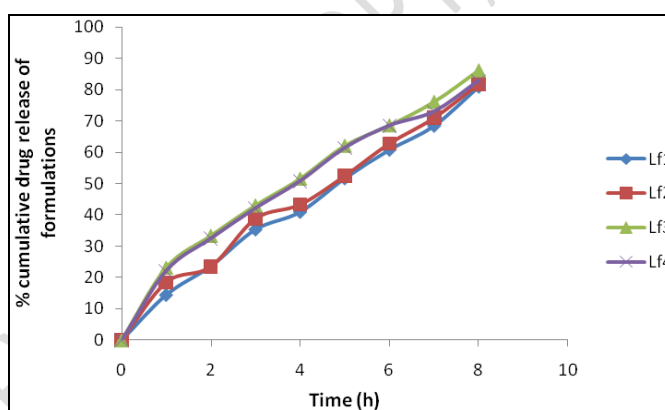


FIG. 4: ZERO ORDER RELEASE KINETICS OF LEVOCETIRIZINE MICROSPHERES FORMULATIONS.

Histological studies:

Nasal mucosa of Goat was obtained from slaughter house in saline phosphate buffer pH 6.4. The mucosa was kept in 10% formalin solution for stabilize the mucosa. Three pieces of nasal mucosa of identical size were cut and mounted on separate glass slide. On one slide was treated with 0.5ml phosphate buffer pH 6.4 (negative control) Second slide treated with 0.5 ml isopropyl alcohol (positive control), in third slide formulation Lf3 (control) and all the slide kept for 6 h. After 6 h slides were subjected to histopathology study for evaluation of nasal toxicity. The specimens were visualized

through Microscope at 100 x magnification. Nasal toxicity study was performed to evaluate any toxic effect of drug and excipients were used in formulation of microspheres on nasal mucosa. In negative control treated with phosphate buffer pH 6.4 nasal mucosa appeared intact with no signs of nasal mucosa damage. While positive control with isopropyl alcohol shows extensive damage of nasal mucosa. After treating with microspheres formulations the nasal mucosa shows no sign of any damage. Hence the developed microspheres formulation can be considered as safe for nasal application (Fig.5).

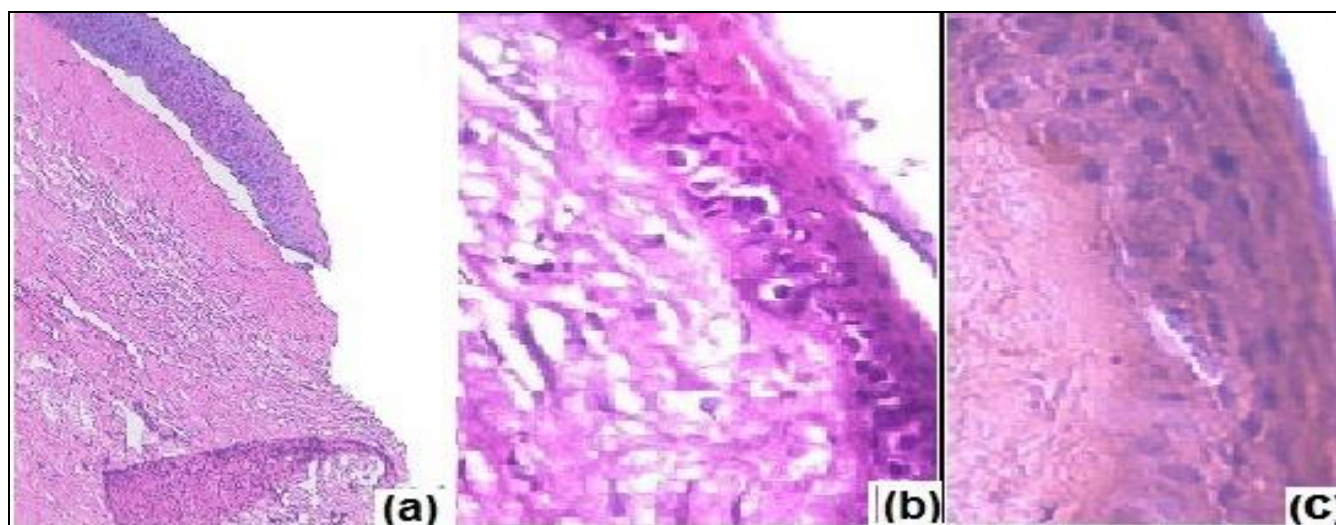


FIG.5: HISTOLOGICAL STUDY (a) NEGATIVE CONTROL, (b) POSITIVE CONTROL AND (c) FORMULATION (LF3)

Stability studies:

Stability studies of the prepared Levocetirizine microspheres were carried out by storing the best formulation Lf3 at 4±1°C, 25±2°C & 60±5°C RH and 37 ± 2°C & 65 ± 5% RH for six month. Parameter namely percentage entrapment efficiency and percentage cumulative drug release was carried out. The result of entrapment efficiency and percentage cumulative drug release after six months of storage were shown in **Table 5**. These studies revealed that, there is a

reduction in entrapment efficiency and percentage cumulative drug release after six months at 4±1°C, 25±2°C & 60±5°C RH and 37±2°C & 65±5% RH. It was also revealed that formulations stored at 25±2°C& 60±5% RH showed maximum entrapment and percentage cumulative drug release followed by the storage at 4±1°C and 37±2°C; 65±5% RH conditions. These results may be attributed to erosion of polymer matrix to some extent during storage (**Table 5**).

TABLE 5: STABILITY STUDIES OF THE OPTIMIZED FORMULATIONS (LF3)

Time in Month	4±1°C		25±2°C & 60±5% RH		37±2°C & 65±5% RH	
	EE (%)	% CDR	EE (%)	% CDR	EE (%)	% CDR
1	87.2	86	87.2	86.03	87.2	86.02
2	87.1	86	87.1	86.02	87	86
3	87	85.9	87.1	86	86.8	85.8
4	86.5	85.8	87.1	86	85.5	85.7
5	86.5	85.7	87	85.9	85	85.7
6	86.2	85.6	87.0	85.9	85.0	85.5

CONCLUSION: In the present studies, it can be concluded that Levocetirizine microspheres based on chitosan prepared by emulsification cross linking method may be considered a promising nasal delivery. Thus, the formulated microsphere seems to be potential candidate as intranasal controlled drug delivery system for the treatment of allergy & rhinitis.

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How to cite this article:

Pandey J and Tripathi PK: Formulation and Evaluation of Levocetirizine Loaded Mucoadhesive Microspheres for Nasal Delivery. *Int J Pharm Sci Res* 2016; 7(5): 2242-51. doi: 10.13040/IJPSR.0975-8232.7(5). 2242-51.

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