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Design and characterization of matrix tablets with sustained release of Salbutamol Sulphate based on natural polymers

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Abstract
When it comes to creating a sustained-release formulation for oral consumption, hydrophilic matrices are an interesting option to consider. They can be used for controlled release of both water-soluble and water-insoluble drugs. Linseed mucilage (LM) and Tamarind seed polysaccharide (TSP) are investigated as excipients in drug delivery systems in this study. The main aim of proposed work is to focus on the possibilities of using these polysaccharide in industries with particular reference to its physical properties, chemical properties for the formation of new drug delivery systems. During the course of this study, the objective was to develop a sustained release matrix tablet formulation of Salbutamol Sulphate for treating asthma in patients. The matrix tablets of Salbutamol Sulphate prepared by wet granulation method and evaluated for its drug release characteristics. In the presence of increased concentrations of LM, TSP, the drug release was decreased. Drug release kinetics was explained by Higuchi's equation. Testing of the optimized formulation for stability revealed that the drug degradation was not appreciable. The results suggest that the LM and TSP can be used in the formulation of Sustained release tablets.

Keywords: Salbutamol sulphate, hydrophilic matrix, linseed mucilage, tamarind seed polysaccharide, sustained-release formulation, treatment of asthma

Introduction
Hydrophilic matrices are an interesting option when developing an oral sustained release formulation. The drug release from such matrices can be controlled through their physical properties. Since Polysaccharides are nontoxic and acceptable by the regulating authorities they are the preferred hydrophilic polymers [1].
Gums and Mucilages are polysaccharide complexes formed from sugar and uronic acid units. They can absorb large quantity of water and swell [2].
Synthetic hydrophilic polymers are used more often than natural polymers[2]. Today the whole world is interested in natural drugs and excipients. As a non-toxic, cheaper and readily available alternative to synthetic materials, natural material has many advantages over synthetic ones. Furthermore, they can be modified to obtain tailor made materials for drug delivery system allowing them to compete with the synthetic product that are commercially available. Many kinds of natural gum and mucilages are used in the food industry and are regarded as a safe for human consumption [3].
In recent times, increasing attention has been given to the application of gums and mucilages of various sources as pharmaceutical excipients. They possess a variety of pharmaceutical properties, which include binding, disintegrating, suspending, emulsifying, gelling, and sustaining properties [4-12].
Present work reports extraction of gum/mucilage of *Linum usitatissimum* and *Tamarindus indica* using water and precipitation by acetone. Mucilage yield is dependent on the temperature. Physicochemical characteristics of gum/mucilage such as solubility, swelling index, loss on drying, pH were studied. Salbutamol Sulphate was as a model drug in the evaluation of mucilage's release retarding properties in tablets.

Materials and Methods

The linseeds and tamarind seeds were collected from local area of Buldhana, Maharashtra, India and authenticated by Shri Shivaji Science and Arts College, Chikhali, dist. Buldana. Salbutamol sulphate was obtained as a gift sample from Leben Lab Akola. Lactose Monohydrate (IP grade), Talc (AR grade), Starch and Acetone (AR grade) were obtained from Loba Chemie Pvt. Ltd, Mumbai (India).

Isolation of mucilage

Linseed

Seeds of *Linum usitatissimum* were taken and soaked for 12 h in distilled water, then this mixture was boiled at 70-80 °C for around 30 min, heating increases rate of mucilage extraction and inactivates enzymes. After 2-3 hour maximum amount of mucilage was extracted in water, which results in formation of thick glue like mass. To reduce viscosity this thick glue like mass was diluted with water, then passed through the several folds of muslin cloth. Around three times volume of acetone was added to the thick glue to carry out precipitation of dissolved mucilage from glue. Precipitated mucilage was separated. Mucilage was dried at 50 °C in hot air oven and gave a yield of 45 g-50 g mucilage/Kg linseed, stored in desiccator for further use.

Tamarind seed

The seeds of *Tamarindus indica* were washed thoroughly with water to remove the adhering materials. Then, the reddish testa of the seeds was removed by heating seeds in sand. The testa was removed. The crushed seeds of *Tamarindus indica* were soaked in water separately for 24 h and then boiled for 1 h and kept aside for 2-3 h for the release of mucilage into water. The soaked seeds were taken and passed through the sieve to remove marc from the filtrate. Then, around three times volume of acetone was added to precipitate the mucilage. The separated mucilage was dried at 50 °C in hot air oven and gave a yield of 35 g-40 g mucilage/Kg tamarind seed, stored in desiccator for further use.

Chemical Test for Mucilages [13, 14, 15]

Extracted mucilages were analyzed for various chemical tests, Molisch's test developed violet green color at the junction of the two layers showed presence of carbohydrate in it. The absence of starch was confirmed by iodine test, showed no color change on addition of iodine solution. The presence of mucilage further substantiated by Ruthenium solution which showed development of pink color.

Physiochemical, Derived and Microbiological Properties of Mucilages [16-18]

Separated mucilages was evaluated for various physiochemical properties such as solubility, swelling index, water retention capacity, loss on drying, pH, melting point, microbial load, particle size distribution as well as for various derived properties such as bulk density, tapped density, compressibility index, Housner ratio and angle of repose.

Microbial Load [19-21]

The test is designed for the estimation of the number of viable aerobic micro-organisms present in pharmaceutical substances. Total viable aerobic microbial count was determine by plate count method.

Pour - Plate Method

Casein soya bean digest agar such as medium 2 was added in each petri dish and allowed to solidify. Then pre treated sample preparation was spread on the solidified medium in a petri dish and it was incubate at 37^{o} for 72 hour. Result was examined after 24 hour.

Particle Size Distribution [22]

Few particles of Linseed mucilage and Tamarind seed polysaccharide powder were taken separately on a glass slide, uniformly spread by a brush, such that individual particle can be seen and particle size distribution was measured by Microscope Image Analyzing System (Vision plus-5000).

Rheology Study [19, 20, 23]

Rheological measurements were carried out using a rotational viscometer (Brookfield R/S plus rheometer) equipped with C25 measuring spindles and for each test, approximately 0.2-0.5 ml sample was transferred to sample compartment (Cone and plate).

A) Determination of Viscosity at Different Concentration of Mucilage

The viscosity was measured for linseed mucilage and Tamarind seed polysaccharide solutions with concentration of 1%, 2% and 3% (which were prepared in distilled water) at shear rate 30 1 / s and the graph was plotted between by taking concentration on X- axis and viscosity on Y- axis.

B) Determination of Viscosity at Different pH

The viscosity was measured for 1%, 2% and 3% linseed and Tamarind seed polysaccharide solutions with pH ranging from 2.0 to 10.0 (adjusted using 0.1N NaOH and 0.1N HCl) at different shear rates and at room temperature.

Drug-Excipient Interactions

It is important to check any kind of interaction between drug and mucilage. It was done by using Fourier transformed infrared spectroscopy and Differential Scanning Calorimetry.

Fourier Transform Infrared Spectroscopy

IR spectra of pure Salbutamol Sulphate and mucilage were taken separately and physical mixture of drug and mucilage were kept for a month at room temperature and then their FTIR were taken to know any possible interaction between drug and mucilage.

Differential Scanning Calorimetry

A differential scanning calorimeter was used for thermal analysis of drug, excipient and their physical mixture. The drug and excipients were passed through sieve no. 60. Drug alone and its mixture with excipient was weighed directly in the pierced DSC aluminium pan (Aluminium Standard 40µl) and scanned from temperature range of 200^{0} to 300 °C and at heating rate of 10 °C/min in nitrogen atmosphere at flow rate 50 ml/min. the thermogram obtained were observed for any interaction.

Experimental Methods

Preparation of Granules and Tablet

Drug and excipients were weighed accurately as per composition given in Table No 7 and powdered to obtained uniform particle size using mortar and pestle. In order to ensure uniform mixing of dug and excipients, the powder was thoroughly mixed. To form damp mass required amount of starch paste was added to the above mixture. Then prepared damp mass was passed through sieve no # 16/22. The granules which passed through sieve no #16 and retained on sieve no. #22 were used. The prepared granules were kept for drying in hot air oven at 50-60°. Then dried granules were collected, separated from fines by sieving. Separated granules were weighed and analyzed for bulk density, true density, angle of repose, and Carr's index. Weighed amount of prepared granules were taken, lubricants and fines were added to it and uniformly mixed. Compression was performed on the prepared mixture.

Evaluation of Tablets

Prepared tablet was evaluated for weight variation, hardness, friability, thickness and diameter, drug content [24].

Determination of Swelling and Erosion Behavior of Sustained Release Matrix Tablet: The extent of swelling was measured in terms of % weight gain by the tablet. The swelling behavior of all formulation was studied. One tablet from each formulation was kept in a petri dish containing pH 1.2 for 2 h and pH 6.8 phosphate buffer for 6 h. At the end of 0.5 h and 1 h, the tablet was withdrawn, soaked with tissue paper, and weighed. Then after every 1 h, weights of the tablet were noted, and the process was continued till the end of 8 h. To determine matrix erosion, tablet was introduced into the dissolution apparatus under the standard set of conditions as specified for determination of *in vitro* drug release. The tablets were removed using a small basket at hourly intervals and swollen tablets were placed in a oven at 40 °C and after 48 h tablets were removed and weighed. The same tablet was subjected for erosion study up to 12 h. Swelling (%) and erosion (%) was calculated according to the following formula [19, 20, 24].

$$\% \text{ Swelling} = (W_t - W_0) / W_0 \times 100$$

$$\% \text{ Erosion} = (W_0 - W_r) / W_0 \times 100$$

Where,
W_t = the weight of the matrix after swelling
W_0 = the initial weight of the matrix
W_r = the weight of the eroded matrix

Dissolution Studies

The *in vitro* release of Salbutamol Sulphate from formulated tablets was carried out in acid buffer pH 1.2 for 2 h and then phosphate buffer pH 6.8 for remaining 10 h. The studies were performed in USP dissolution apparatus II, at 37±0.5° C and 50 rpm speed. Samples were taken at 1 hour interval and analyzed for Salbutamol Sulphate content at 276 nm by using UV–visible spectrophotometer [25].

Stability Study

The optimized batches FL_1 was kept for stability study, results shows insignificant difference for drug release and other evaluation parameter for the period of 6 months at 40 °C/75% RH.

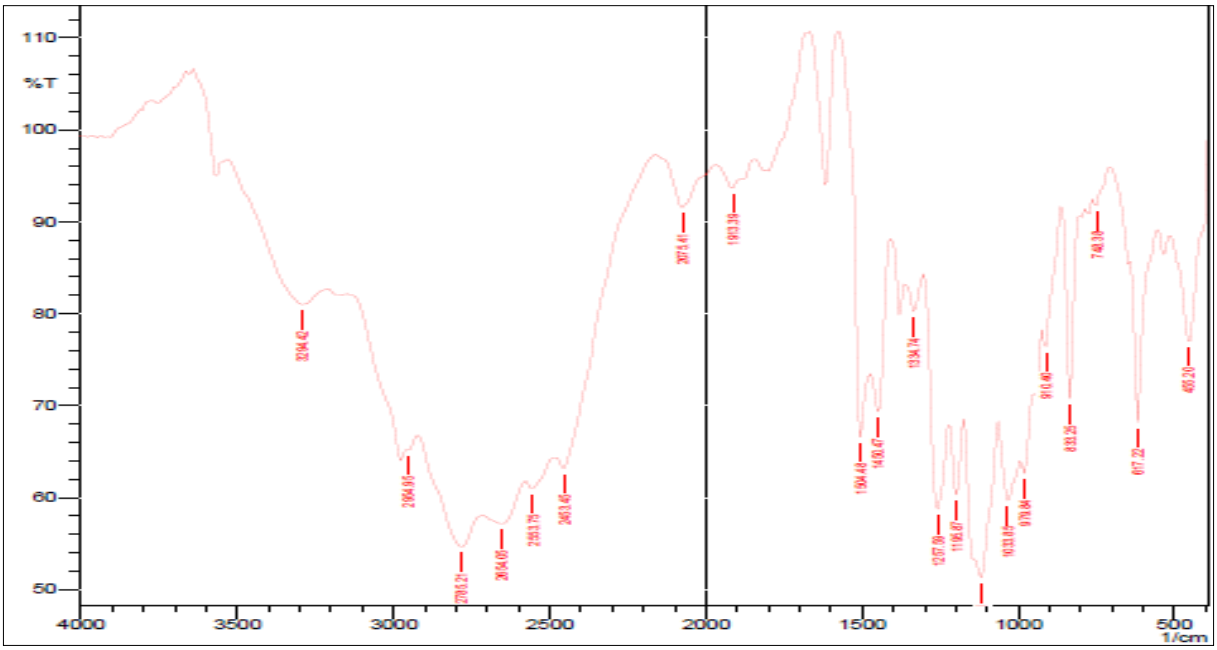

Fig 1: FTIR Spectra of Salbutamol Sulphate

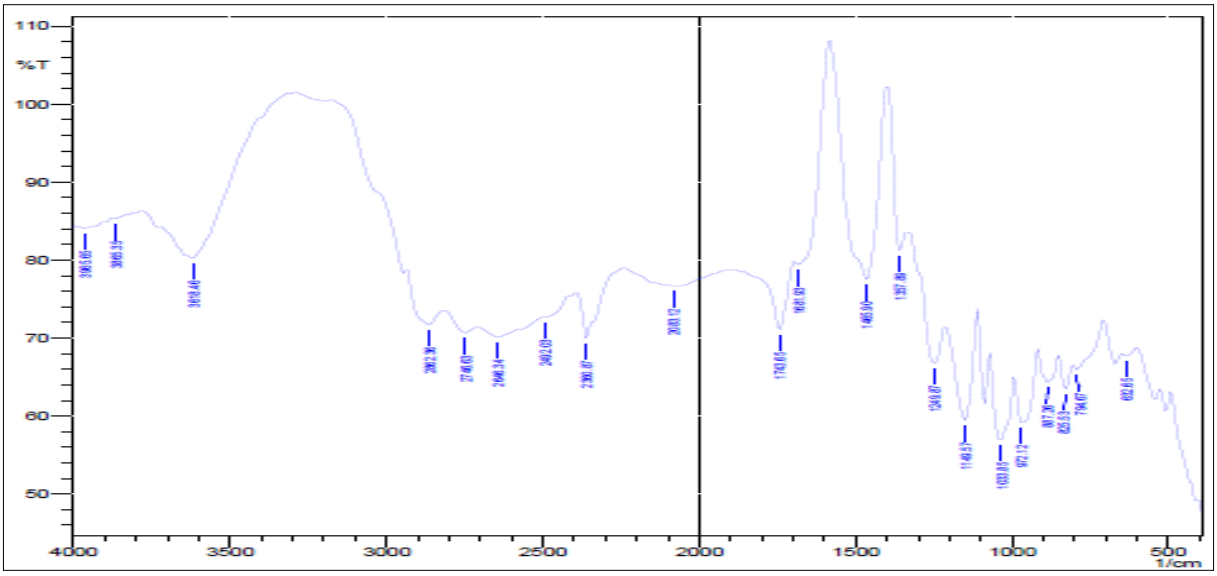

Fig 2: FTIR Spectra of Linseed Mucilage

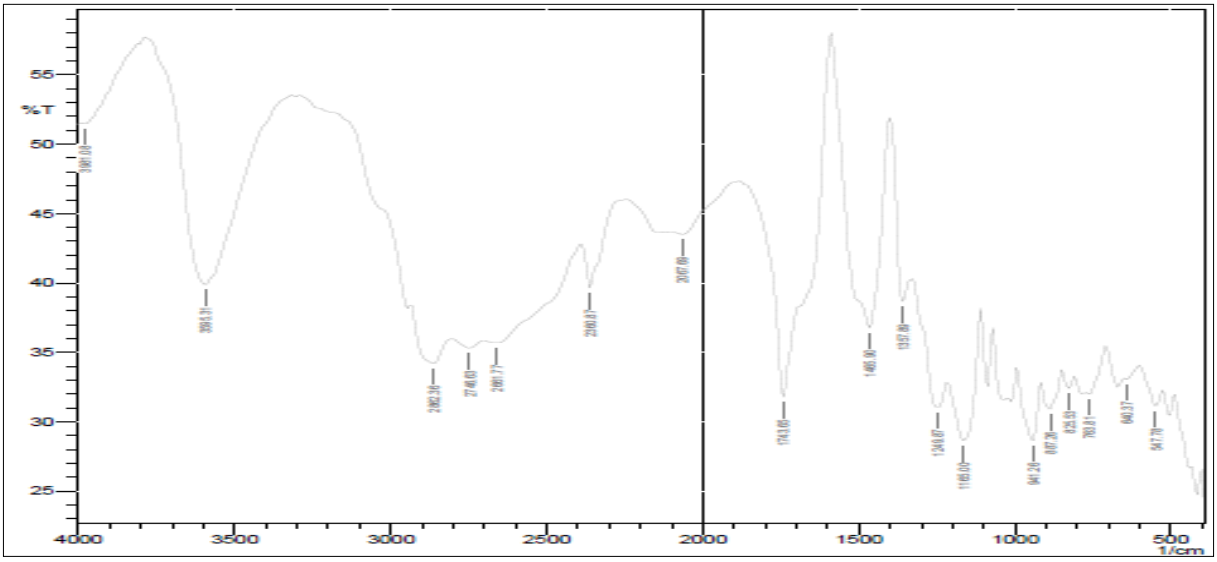

Fig 3: FTIR Spectra of Tamarind Seed Polysaccharide

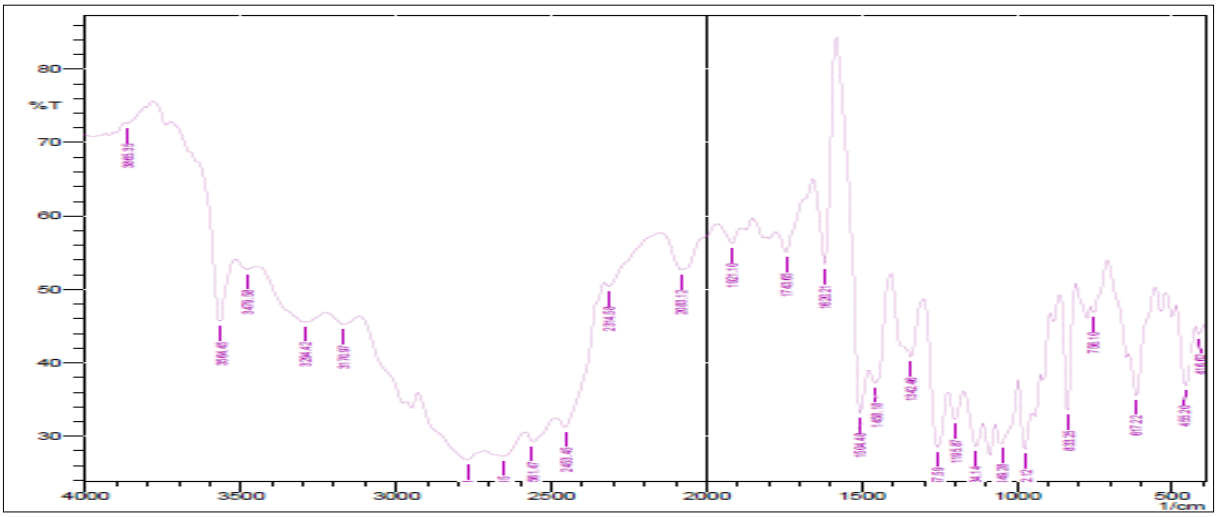

Fig 4: FTIR Spectra of Physical Mixture of Salbutamol Sulphate and Linseed Mucilage

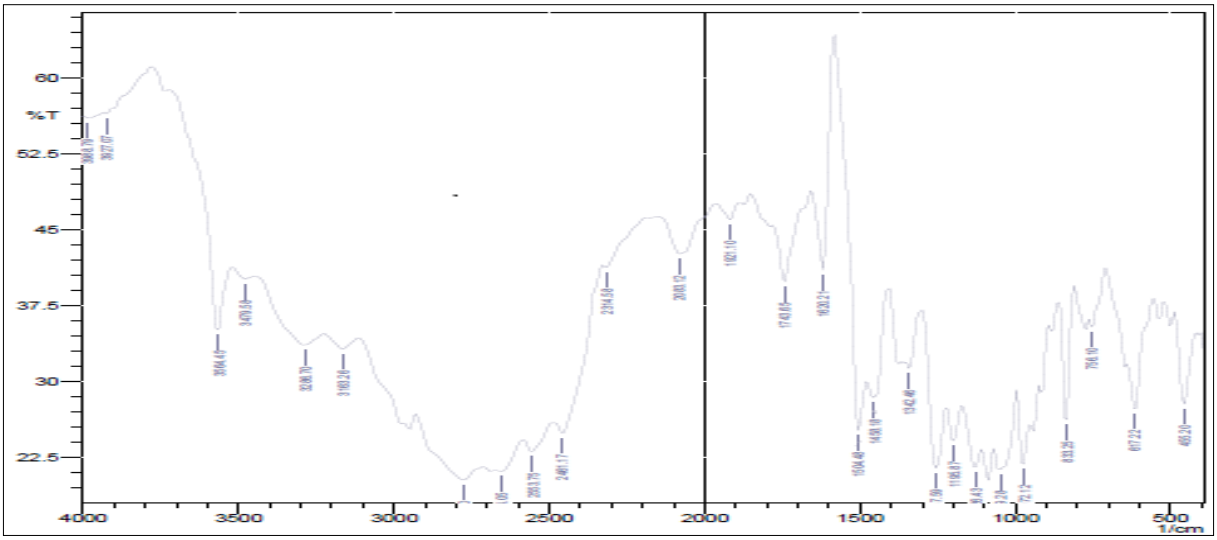

Fig 5: FTIR Spectra of Physical Mixture of Salbutamol Sulphate and Tamarind Seed Polysaccharide

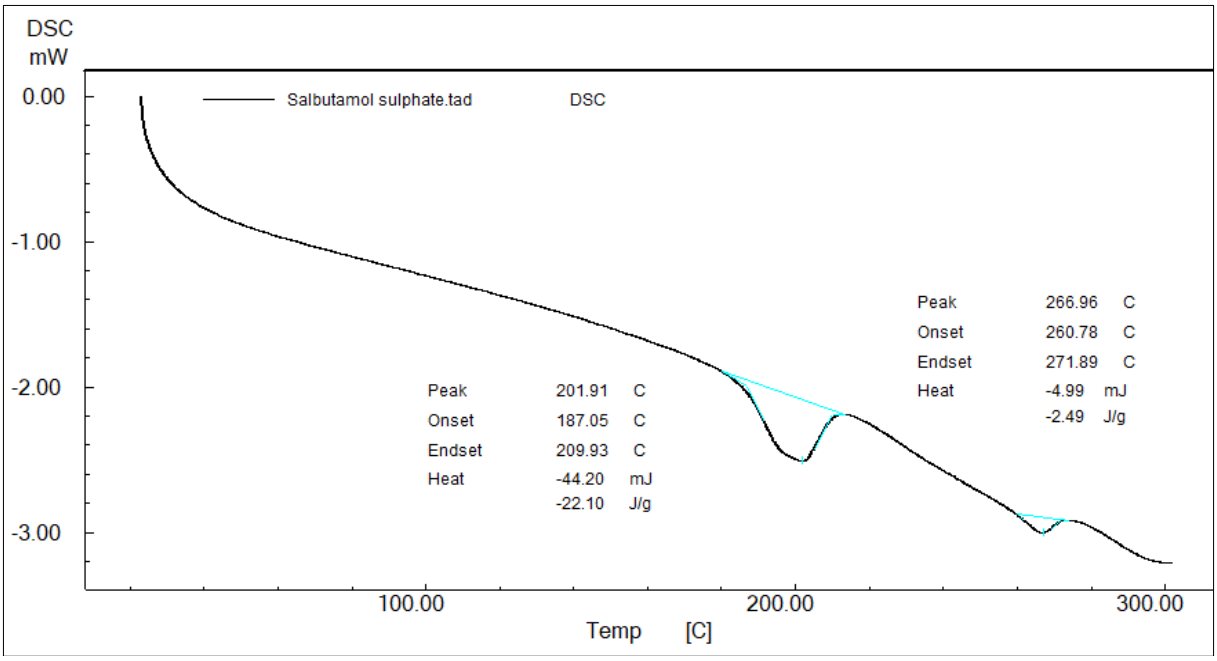

Fig 6: DSC Thermograph of Salbutamol Sulphate

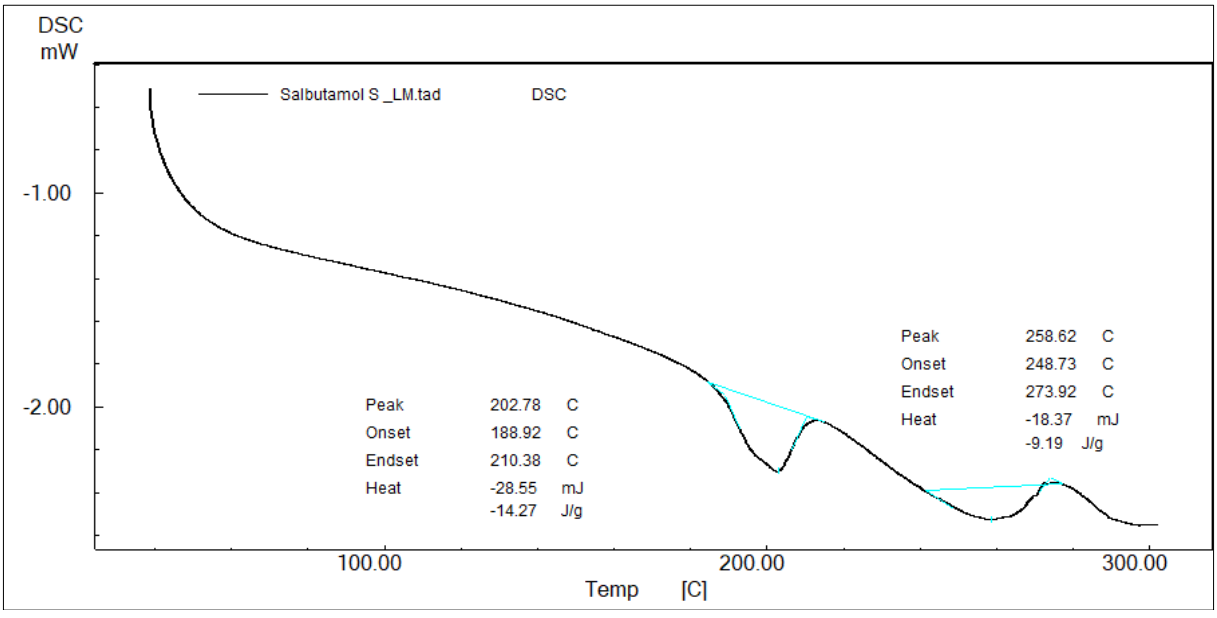

Fig 7: DSC Thermograph of Salbutamol Sulphate and Linseed mucilage

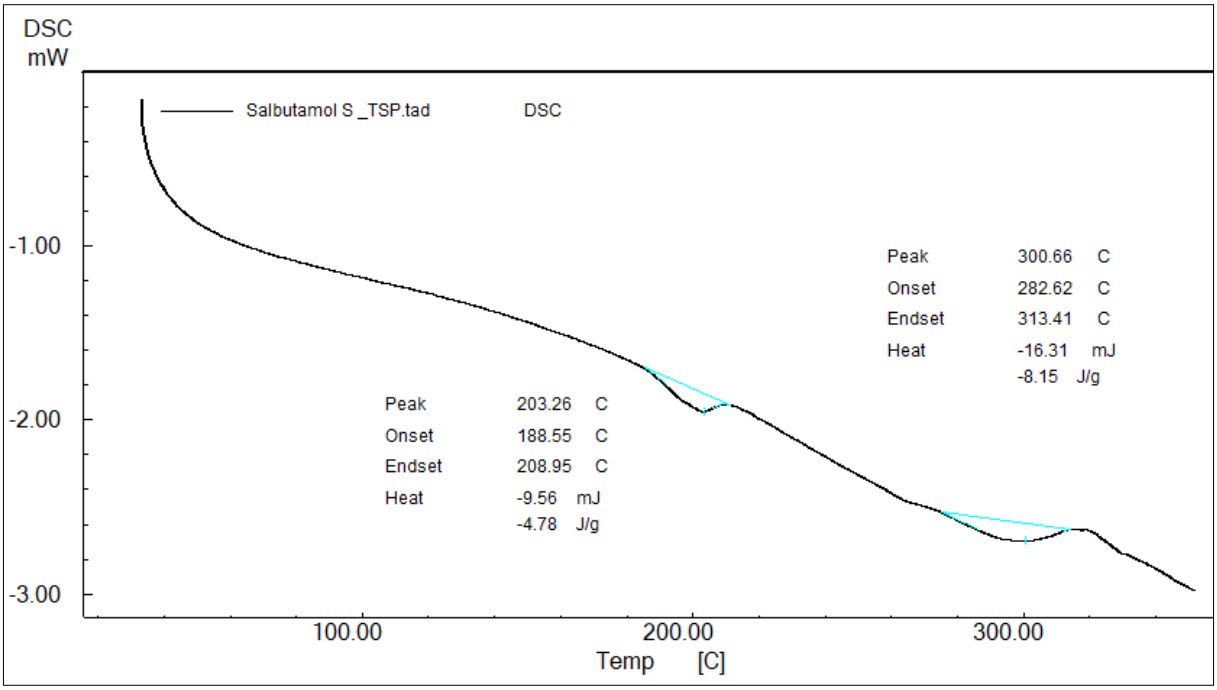

Fig 8: DSC Thermograph of Salbutamol Sulphate and Tamarind Seed polysaccharide

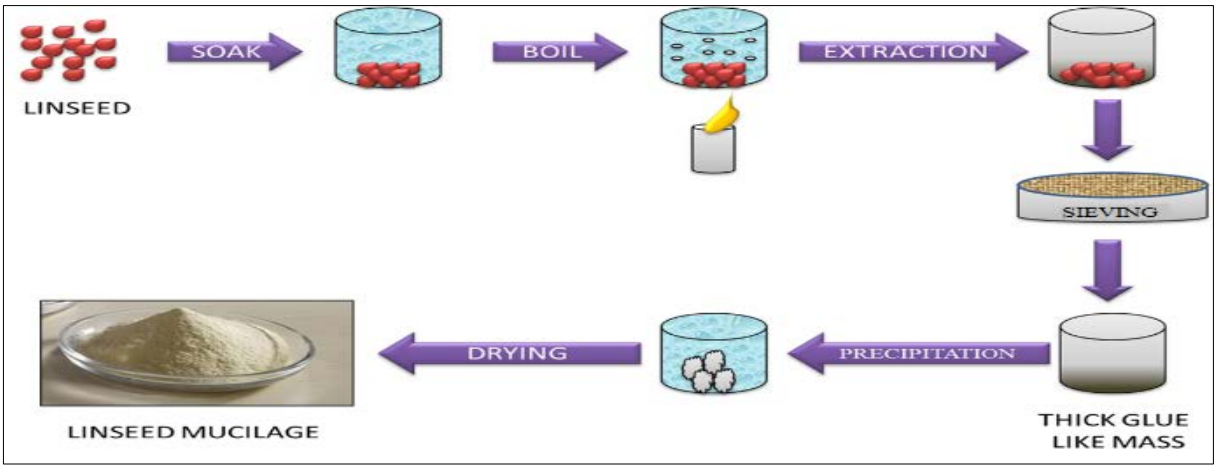

Fig 9: Separation of Linseed Mucilage

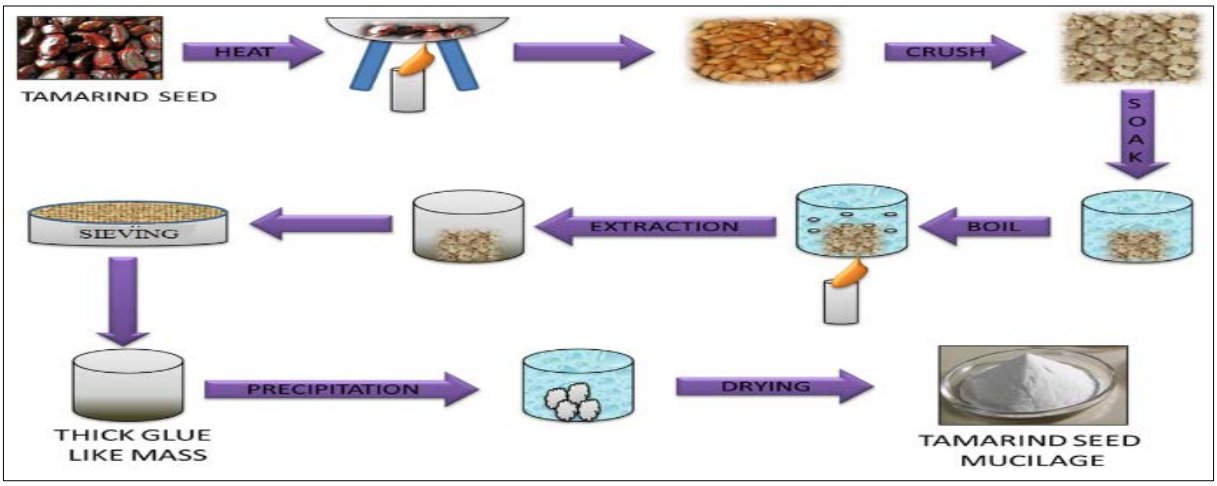

Fig 10: Separation of Tamarind Seed Polysaccharide

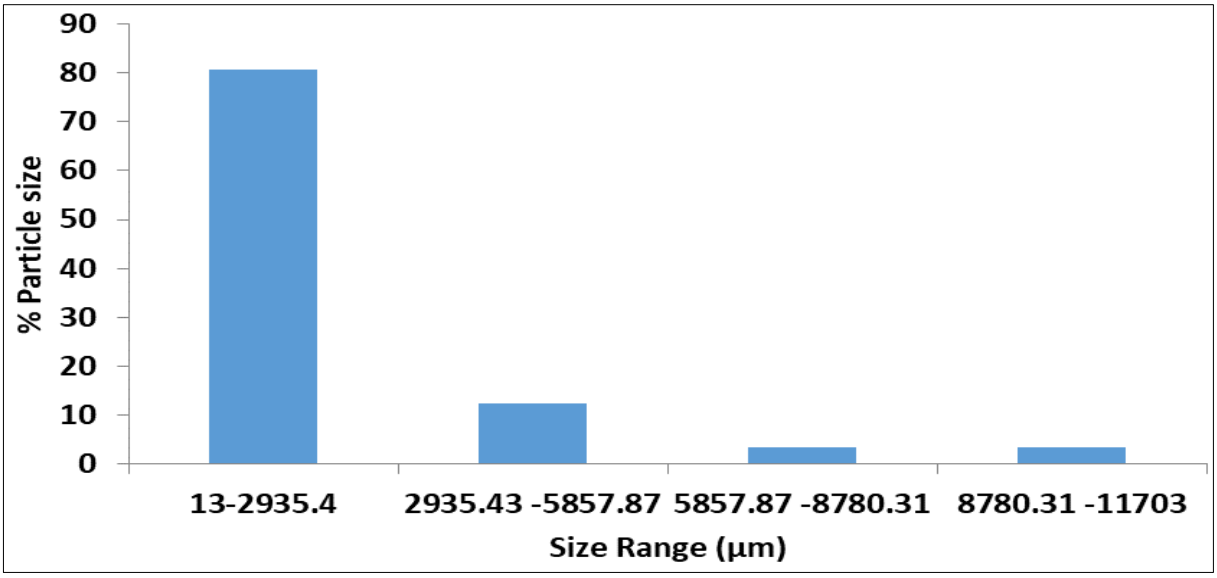

Fig 11: Particle Size Distribution for Linseed Mucilage

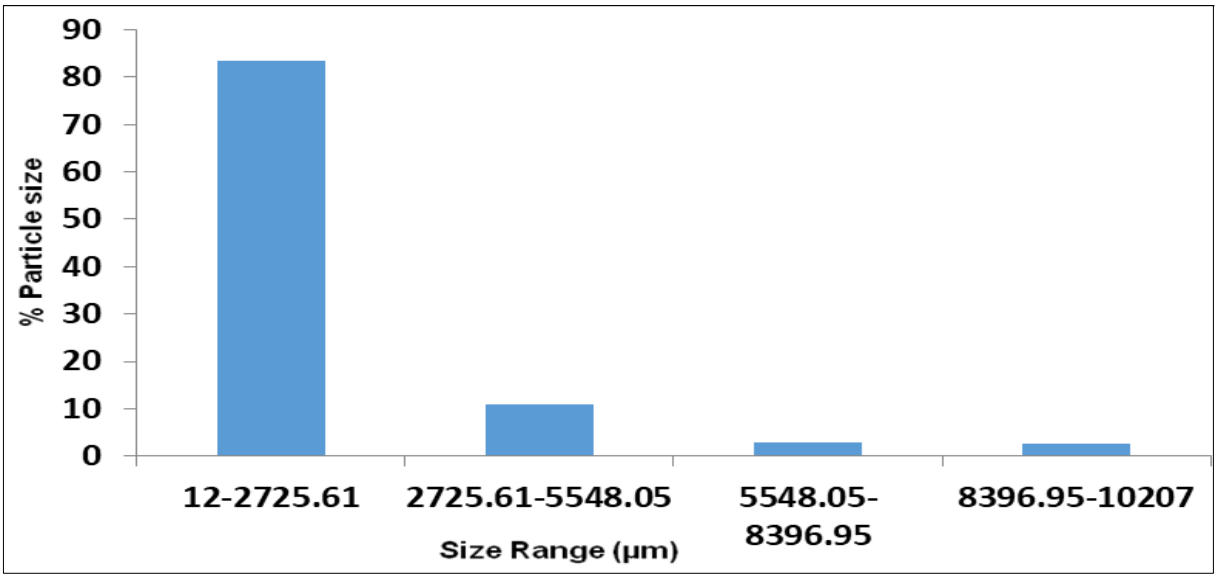

Fig 12: Particle Size Distribution for Tamarind Seed Polysaccharide

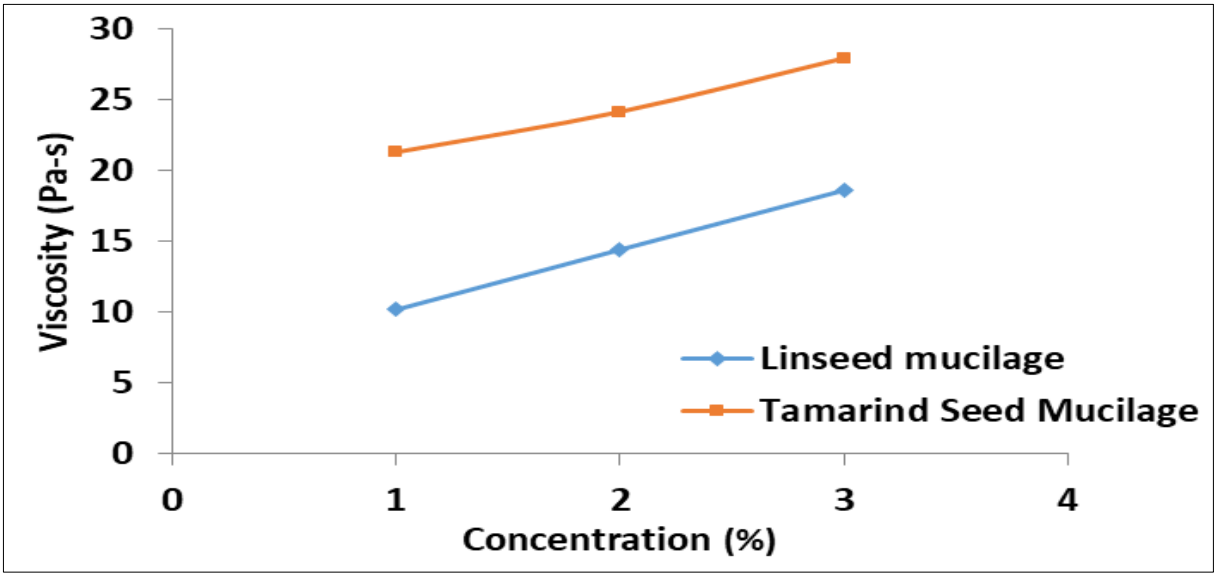

Fig 13: Effect of Concentration on Viscosity of Linseed mucilage and Tamarind seed Polysaccharidde

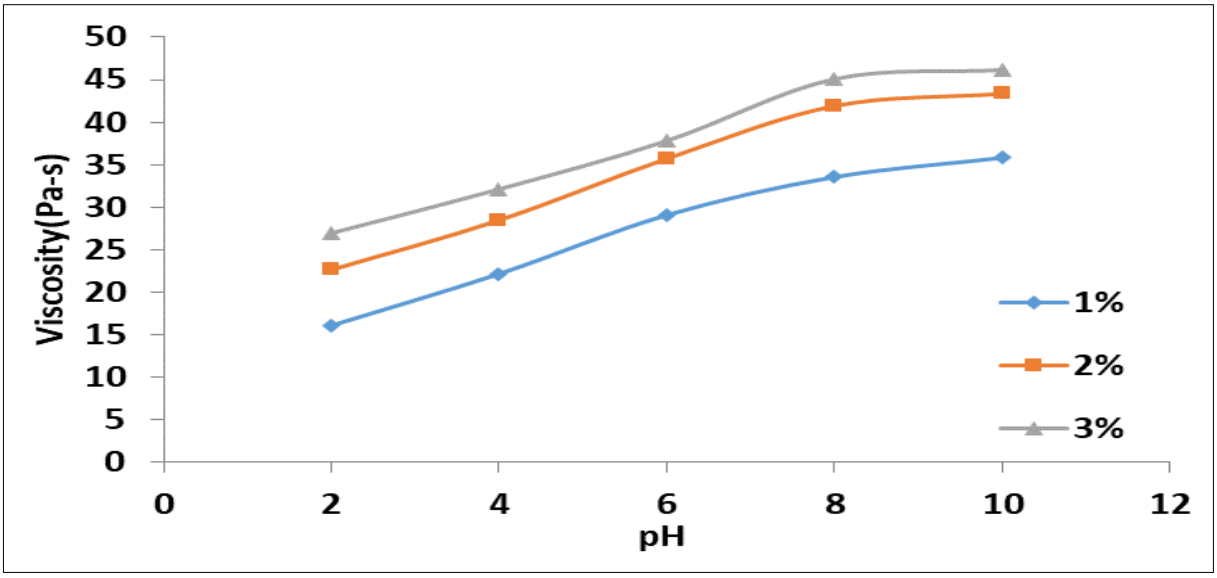

Fig 14: Effect of PH on viscosity of Linseed Mucilage

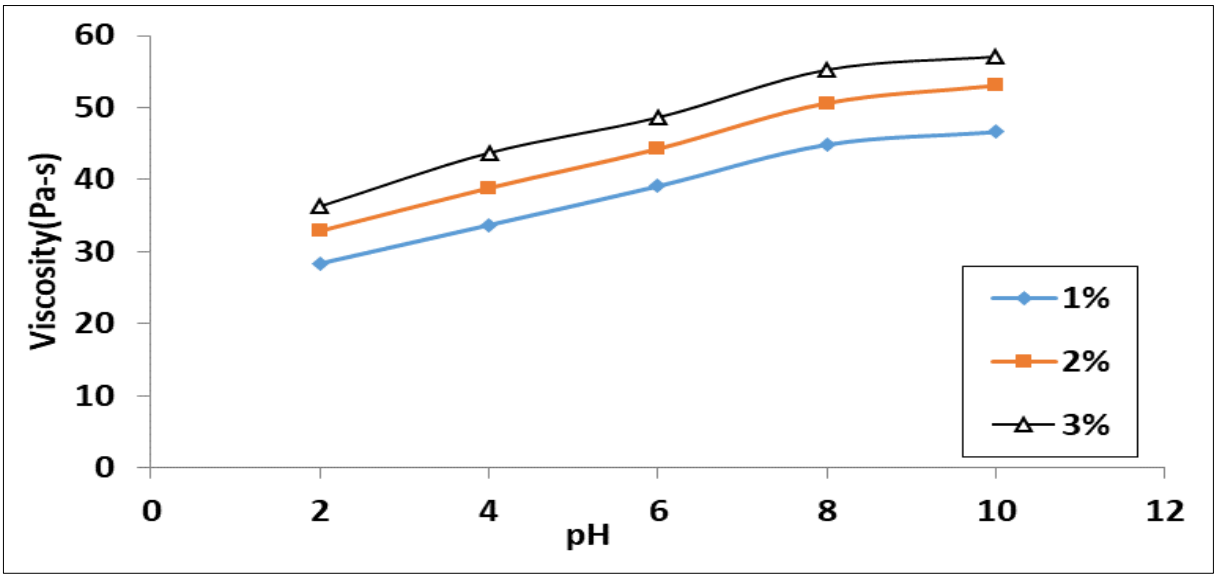

Fig 15: Effect of PH on viscosity of Tamarind seed Polysaccharide

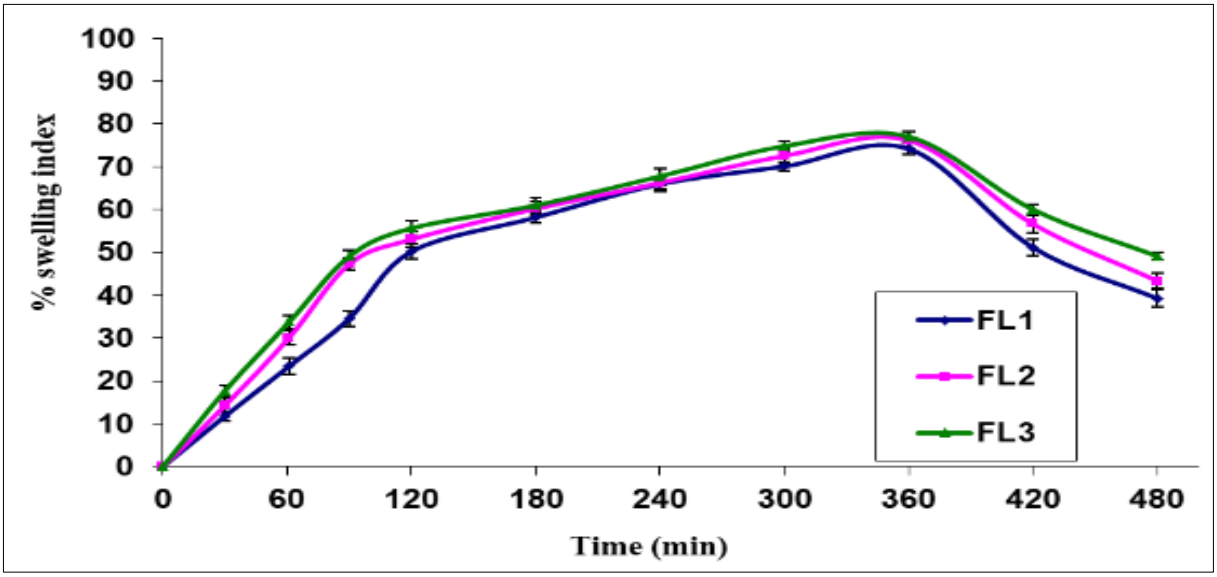

Fig 16: Percentage Swelling Indices of Formulations FL_1 – FL_3

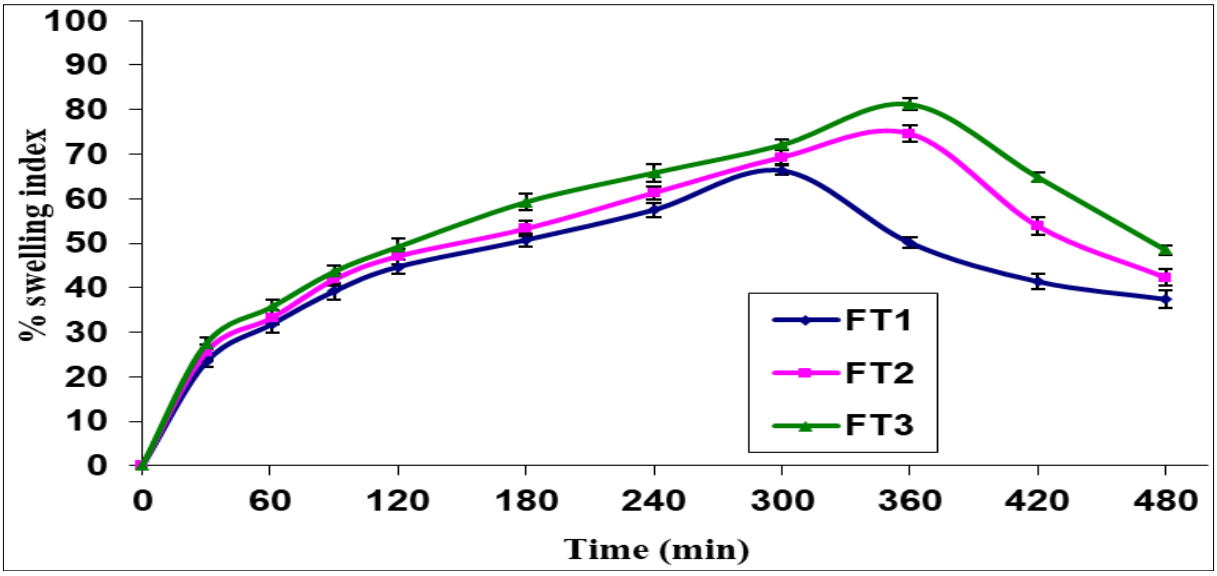

Fig 17: Percentage Swelling Indices of Formulations $FT_1 – FT_3$

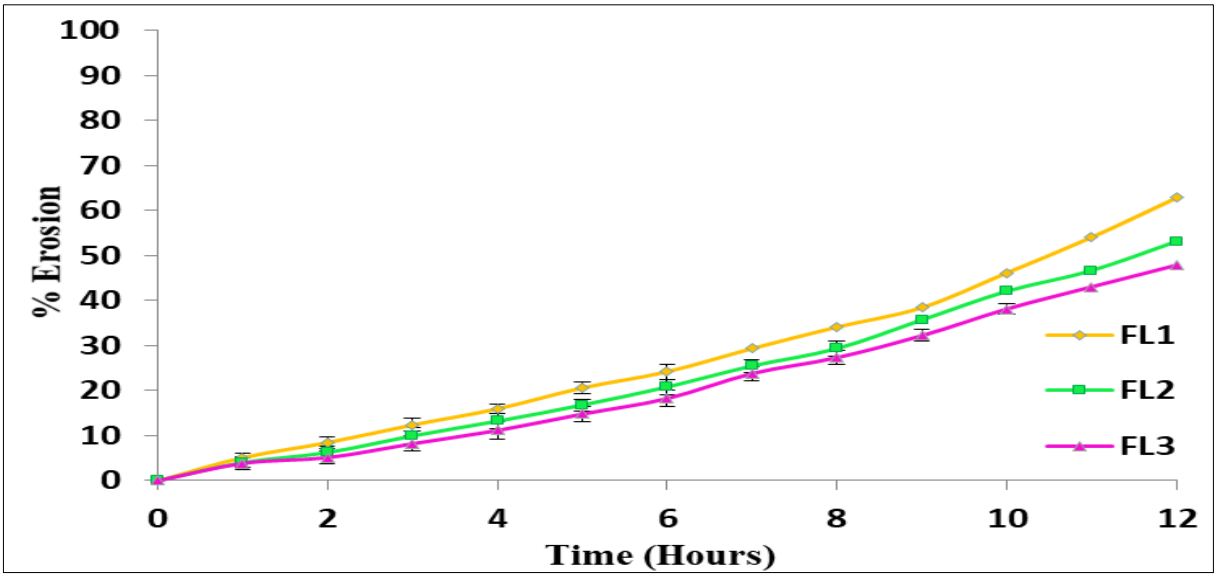

Fig 18: Percentage Erosion of Formulations $FL_1 – FL_3$

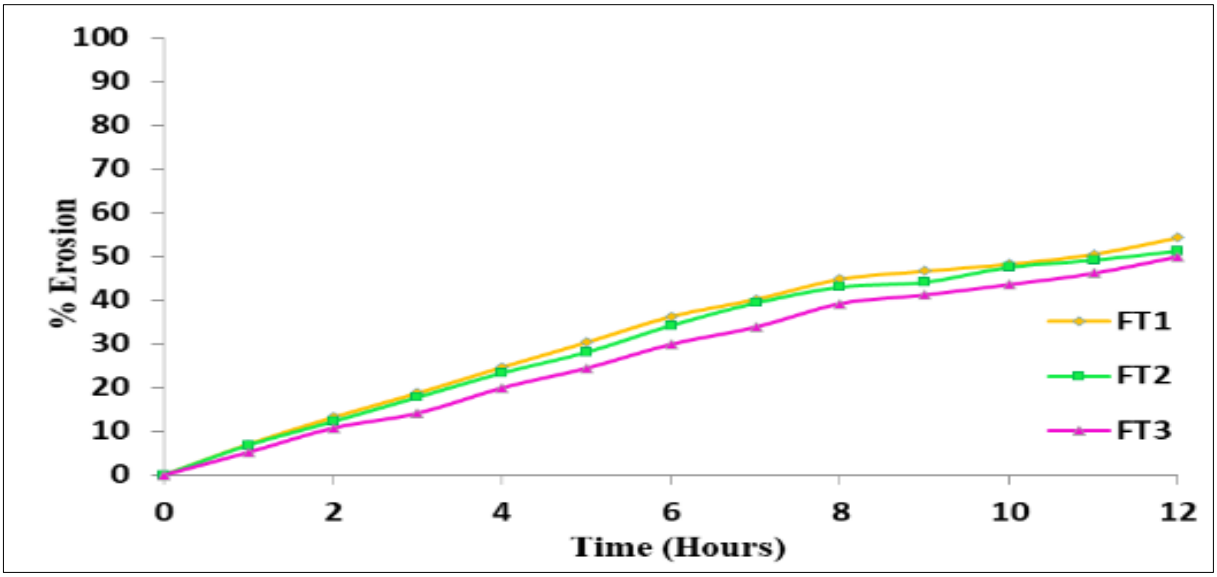

Fig 19: Percentage Erosion of Formulations FT_1-FT_3

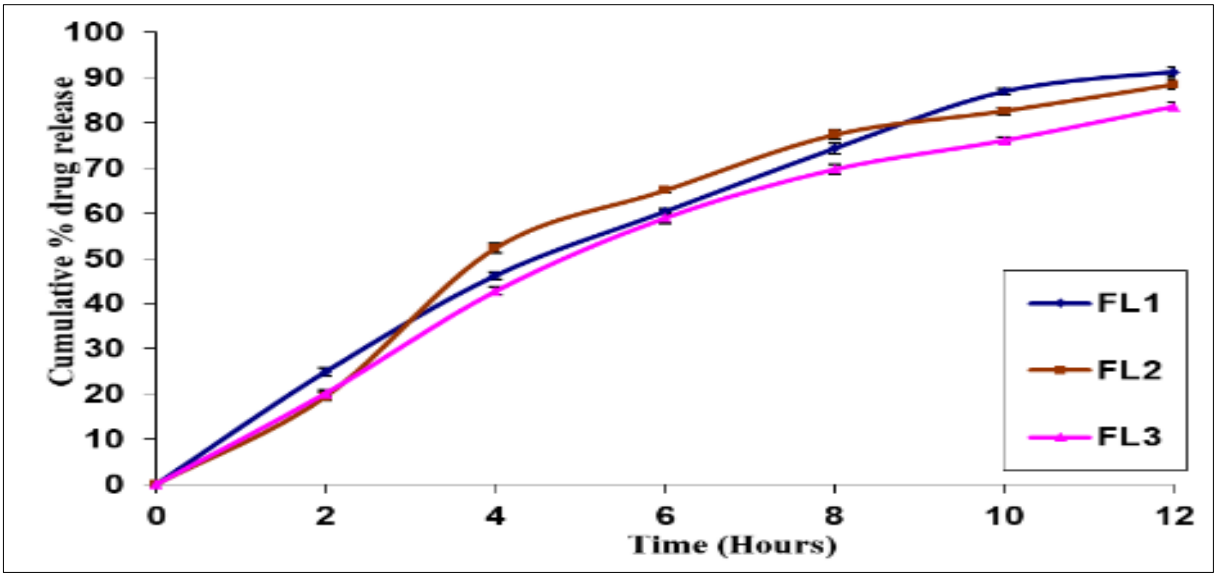

Fig 20: *In vitro* Drug Release Profiles of Formulations FL_1–FL_3 for 12 h

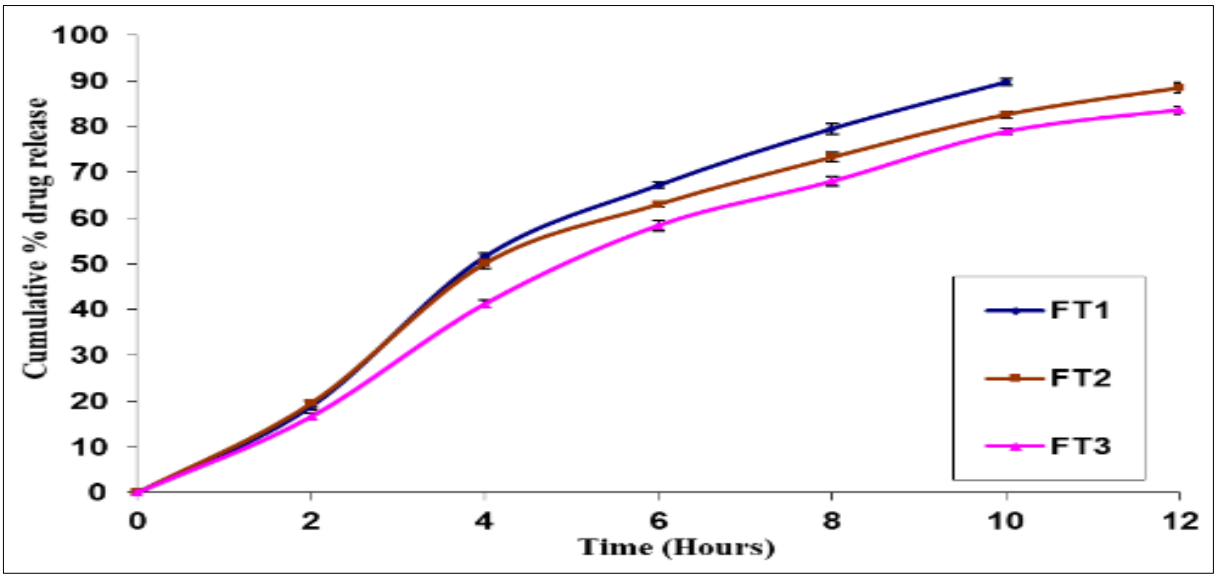

Fig 21: *In vitro* Drug Release Profiles of Formulations FT_1–FT_3 for 12 h

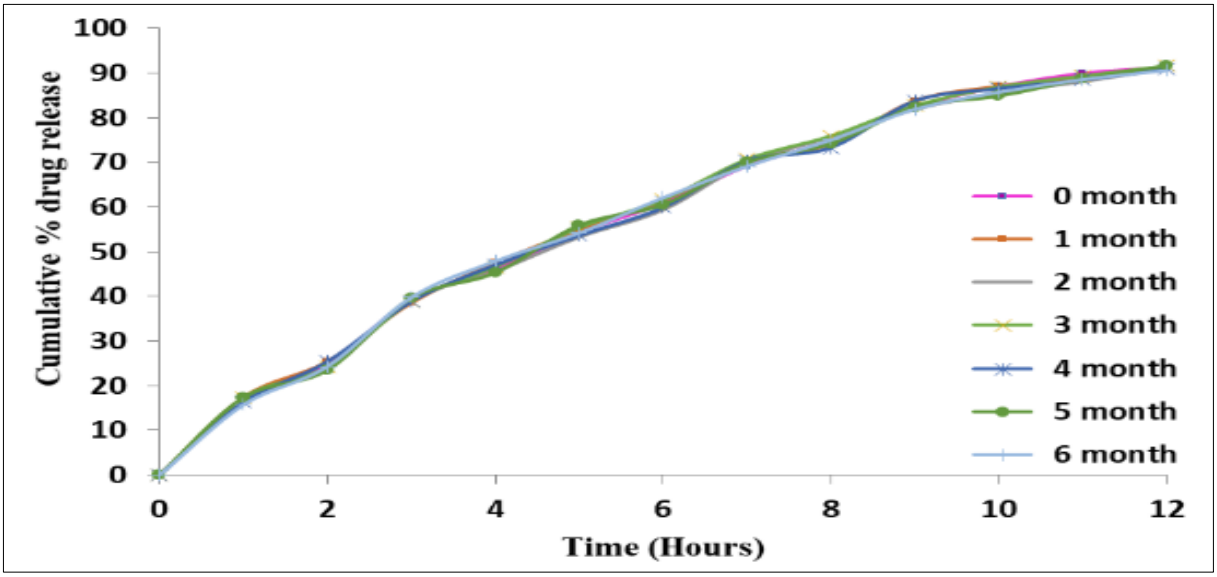

Fig 22: *In vitro* Drug Release Study of Formulation FL_1 kept for Stability at 40^0C±/75% RH

Results and Discussion

The mucilages were isolated from the seeds of *Linum usitatissimum* and *Tamarindus indica* using aqueous extraction followed by precipitation using acetone as non-solvent (Fig. 9 and 10). The yield of the mucilage was calculated with respect to the weight of dried seeds and was found to be 45 g-50 g and 35 g-40 g respectively. Extracted mucilages were analyzed for various chemical tests, Molisch's test developed violet green color at the junction of the two layers showed presence of carbohydrate in it. The absence of starch was confirmed by iodine test, showed no color change on addition of iodine solution. The presence of mucilage further substantiated by Ruthenium solution which showed development of pink color. In the microbial load testing, the polysaccharide showed 6000 and 8000 colony forming unit per gram of bacteria for linseed mucilage and Tamarind seed polysaccharide respectively which was in acceptable limits for the natural products (table 2). The above results indicated that the selected polysaccharide can be used as an excipient in dosage forms. The viscosity of 1% w/v solution of the Linseed mucilage and Tamarind seed polysaccharide was found to be 10.20 Pa.s. and 21.33 Pa.s respectively. The effect of concentration and pH on the viscosity is given for Linseed mucilage and Tamarind seed polysaccharide in table 5 and 6 respectively. Viscosity and pH are important physical properties, which can contribute significantly to the understanding of the granule and tablet properties of various substrates. The pH of the isolated mucilage was found to be 6.32±0.19 and 6.85±0.23 respectively. The compatibility between the drug and the isolated mucilages were found to be good by the FTIR and DSC studies (Fig.1, 2, 3, 4, 5, 6, 7 and 8). The matrix tablets of Salbutamol sulphate using linseed mucilage and Tamarind seed polysaccharide were prepared by wet granulation method. Table 8 shows the data obtained from the evaluation of tablets. The hardness of the tablets was found to be in the range of 10.00 – 12.00 kg/cm$^{2.}$ The tablets showed 95.90- 98.52% of the labeled amount of drug, indicating uniformity in drug content. The individual weight variation was found to be within±7.5% of the average tablet weight and the friability values were found to be in the range of 0.24 - 0.51% for all the formulations. The swelling index increased with the increase in concentration of mucilage wherein Tamarind seed polysaccharide have more swelling than Linseed mucilage and the matrices underwent both water uptake and erosion simultaneously immediately after placement in the dissolution medium. The drug release decreased as the concentration of mucilage in the matrix increased. The *in vitro* drug release profile of Salbutamol Sulphate from all the formulations is shown in Table 11 and Fig. 20, 21. The results indicated retardant release of drug from all the formulations with increase in the polymer concentration. The Formulation FL_1 showed a slow and complete drug release of 91.30±0.91 over a period of 12 hr. The 'n' value of formulation FL_1 from korsmeyer-peppas equation was found to be 0.829 indicating that the release mechanism was non-Fickian or anamolous release ($0.5 < n < 1$). It showed that the release was dependent on both drug diffusion and polymer erosion. R^2 value (i.e., 0.978) was maximum for Higuchi plot. Therefore release kinetics fits Higuchi plot.

Table 1: Characterization of Mucilages.

Property of mucilage	Result	
	Linseed mucilage	Tamarind seed Mucilage
Bulk density (g/cc)	0.488±0.02	0.551±0.03
Tapped density (g/cc)	0.541±0.04	0.683±0.02
Compressibility Index (%)	18.85±0.05	23.95±0.04
Housner Ratio	1.18±0.06	1.22±0.08
Angle of repose (^{0})	$35^0$20'±0.12	$42^0$10'±0.14
Swelling Index (%)	1000±0.32	1900±0.58
Water Retention (%)	8.00±1.02	14.00±1.21
Loss on drying (%)	5.2±0.16	7.4±0.89
PH	6.32±0.19	6.85±0.23
Melting point (^{0}C)	260^0 - 280^0	240^0 - 260^0
Practical yield (g/Kg)	45g-50g	35g-40g

*Each value represent the mean ± standard deviation (n=3)

Table 2: Results of Pathogenic Microbial Load

Mucilage	No. CFU/ml	Microbial load (No. of CFU /gm mucilage)
Linseed mucilage	60	6000
Tamarind seed Polysaccharide	80	8000

Table 3: Particle Size Distribution for Linseed Mucilage

Sr. No.	Particle size range (µm)	Percentage
1	13 to 2935.43	80.7
2	2935.43 to 5857.87	12.28
3	5857.87 to 8780.31	3.51
4	8780.31 to 11703	3.51

Table 4: Particle Size Distribution for Tamarind seed Polysaccharide

Sr. No.	Particle size range (µm)	Percentage
1	12 to 2725.61	83.48
2	2725.61 to 5548.05	10.97
3	5548.05 to 8396.95	3.01
4	8396.95 to 10207	2.54

Table 5: Effect of Concentration on Viscosity of Linseed mucilage and Tamarind seed Polysaccharide

Sr. No.	Concentration (%)	Viscosity (Pa.s)	
		Linseed mucilage	Tamarind seed Mucilage
1	1	10.20	21.33
2	2	14.44	24.18
3	3	18.63	27.96

Table 6: Effect of pH on Viscosity Linseed Mucilage and Tamarind seed Polysaccharide

pH	Viscosity of Linseed Mucilage (Pa.s)			Viscosity of Tamarind seed Polysaccharide (Pa.s)		
	1%	2%	3%	1%	2%	3%
2	16.11	22.66	26.96	28.37	32.88	36.30
4	22.18	28.48	32.13	33.71	38.84	43.71
6	29.09	35.72	37.81	39.09	44.27	48.63
8	33.56	41.92	45.08	44.85	50.62	55.24
10	35.82	43.35	46.15	46.60	53.05	57.08

Table 7: Composition of Salbutamol Sulphate Tablets

Ingredients (mg)	FL_1	FL_2	FL_3	FT_1	FT_2	FT_3
Salbutamol sulphate	4.8	4.8	4.8	4.8	4.8	4.8
Lactose monohydrate	120.7	110.7	100.7	80.7	70.7	60.7
Linseed mucilage	20	30	40	-	-	-
Tamarind seed Polysaccharide	-	-	-	60	70	80
Magnesium stearate	3	3	3	3	3	3
Talc	1.5	1.5	1.5	1.5	1.5	1.5

*Weights are given for one tablet
Tablets with Linseed mucilage: FL_1, FL_2, FL_3
Tablets with Tamarind seed Polysaccharide: FT_1, FT_2, FT_3

Table 8: Post Compression Parameter of Salbutamol Sulphate Tablets:

Formulations	Hardness* (kg/cm^2)	Friability* (%w/w)	Thickness* (mm)	Diameter* (mm)	%Drug Content*
FL_1	11.45±0.09	0.37±0.05	3.13±0.044	6.03±0.08	97.95±0.29
FL_2	11.13±0.05	0.24±0.04	3.19±0.035	6.02±0.06	95.90±0.30
FL_3	10.31±0.03	0.31±0.07	3.11±0.036	6.03±0.09	98.52±0.53
FT_1	10.66±0.01	0.29±0.06	3.11±0.033	6.02±0.02	96.78±043
FT_2	11.32±0.08	0.32±0.02	3.17±0.051	6.02±0.04	96.91±0.51
FT_3	11.03±0.02	0.51±0.09	3.12±0.037	6.03±0.07	97.25±0.66

*Each value represent the mean ± standard deviation (n=3).

Table 9: Percentage Swelling Indices of Formulations containing Linseed Mucilage and Tamarind seed Polysaccharide

Time(min)	% Swelling Index*					
	FL_1	FL_2	FL_3	FT_1	FT_2	FT_3
0	0±0	0±0	0±0	0±0	0±0	0±0
30	11.82±1.80	14.27±1.27	17.72±1.49	23.37±1.63	25.60±1.45	27.43±1.22
60	23.47±1.79	30.15±1.56	33.80±1.28	31.86±1.26	33.28±1.71	35.74±1.61
90	34.58±1.73	47.28±1.61	49.08±1.67	39.21±1.16	41.82±1.52	43.60±1.53
120	50.23±1.76	53.07±1.30	55.63±1.35	44.71±1.67	47.09±1.48	49.18±1.44
180	58.17±1.29	60.19±1.76	60.98±1.77	50.76±1.59	53.27±1.79	59.23±1.76
240	65.92±1.72	66.22±1.43	67.77±1.29	57.50±1.33	61.33±1.81	65.80±1.89
300	70.08±1.80	72.54±1.05	74.82±1.91	66.32±1.08	69.31±1.33	72.08±1.43
360	74.18±1.61	76.15±1.59	77.01±1.57	50.09±1.46	74.63±1.04	81.20±1.67
420	51.15±1.23	56.63±2.01	60.02±1.83	41.39±1.72	53.84±1.01	64.82±1.32
480	39.27±1.92	43.37±1.35	49.13±0.78	37.42±1.63	42.26±1.90	48.44±2.03

*Each value represent the mean ± standard deviation (n=3)

Table 10: Percentage erosion of formulations containing Linseed Mucilage and Tamarind seed Polysaccharide

Time (h)	% Erosion*					
	FL_1	FL_2	FL_3	FT_1	FT_2	FT_3
0	0±0	0±0	0±0	0±0	0±0	0±0
1	5.13±1.67	4.03±1.56	3.87±1.36	7.06±1.07	6.84±1.27	5.20±1.49
2	8.48±1.75	6.28±1.60	5.15±1.08	13.18±1.54	12.21±1.59	10.74±1.02
3	12.40±1.37	9.97±1.39	8.23±1.09	18.72±1.77	17.78±1.35	14.12±1.74
4	15.98±1.89	13.24±1.71	11.17±1.61	24.65±1.61	23.34±1.91	19.94±1.39
5	20.63±1.90	16.82±1.03	14.81±1.79	30.32±1.49	28.07±1.77	24.43±1.61
6	24.22±1.52	20.84±1.24	18.26±1.82	36.24±1.53	34.20±1.47	29.91±1.46
7	29.37±1.09	25.50±1.80	23.82±1.17	40.16±1.78	39.33±1.02	33.82±1.09
8	34.14±1.25	29.36±1.45	27.35±1.42	44.78±1.89	42.97±1.69	39.20±1.21
9	38.46±1.13	35.72±1.71	32.23±1.50	46.61±1.23	44.08±1.58	41.18±1.69
10	46.17±1.61	42.10±1.38	38.15±1.24	48.20±1.47	47.52±1.45	43.56±1.32
11	54.08±1.38	46.69±1.83	43.07±1.72	50.47±1.81	49.12±1.81	46.13±1.50
12	62.84±1.71	53.18±1.29	47.89±1.91	54.27±1.90	51.25±1.77	49.97±1.73

*Each value represent the mean ± standard deviation (n=3)

Table 11: *In vitro* dissolution profiles of Salbutamol Sulphate tablets

Time (hr)	Cumulative % drug release					
	FL_1	FL_2	FL_3	FT_1	FT_2	FT_3
0	0	0	0	0	0	0
1	17.07±0.53	12.21±0.98	13.46±0.63	14.34±0.34	13.20±0.27	10.59±0.35
2	24.95±0.61	19.46±1.07	20.16±0.76	18.88±0.47	19.51±0.67	16.62±0.01
3	39.44±0.76	43.84±0.53	32.67±0.81	43.17±0.09	44.92±0.44	35.71±1.04
4	46.18±0.50	52.24±0.84	42.71±0.59	51.56±0.77	50.08±0.81	41.25±0.85
5	54.32±0.84	58.06±0.68	54.40±0.28	58.81±0.59	58.18±0.01	50.87±0.15
6	60.37±0.72	65.04±0.37	58.93±0.64	67.20±0.15	63.02±0.49	58.42±0.91

7	69.20±0.63	71.68±0.42	63.33±0.39	74.23±0.37	68.71±0.42	64.11±0.37
8	74.34±0.97	77.36±0.67	69.70±0.71	79.56±0.22	73.31±0.21	68.07±0.88
9	82.50±1.05	80.05±0.51	73.61±0.03	85.07±1.81	77.29±0.59	72.71±0.36
10	86.96±0.82	82.64±0.82	76.12±0.72	89.71±0.69	82.62±0.33	78.92±0.18
11	89.94±0.74	86.37±1.21	79.93±0.59	-	85.15±1.46	80.03±0.52
12	91.30±0.91	88.49±0.93	83.62±0.27	-	88.49±0.38	83.67±0.82

*Each value represent the mean ± standard deviation (n=3)

Table 12: Evaluation of Tablet Containing Linseed Mucilage as Release Retardant FL_1 kept for Stability at 40 °C /75% RH

Parameter	0 month	1 month	2 month	3 month	4 month	5 month	6 month
Appearance	Cream	Cream	Cream	Cream	Cream	Cream	Cream
Thickness (mm)	3.15	3.13	3.14	3.13	3.13	3.14	3.14
Hardness (Kg/cm^2)	11.44	11.39	11.47	11.49	11.43	11.58	11.54
Friability (%)	0.36	0.34	0.35	0.35	0.36	0.34	0.35
Drug content (%)	97.65±0.53	98.13±0.84	97.91±0.95	98.24±0.69	97.76±0.22	97.92±0.15	98.03±0.26

Table 13: *In vitro* Drug Release Study of Formulation FL_1 kept for Stability at 40 °C±/75% RH

Time (hr)	Cumulative % drug release*						
	0 month	1 month	2 month	3 month	4 month	5 month	6 month
0	0±0	0±0	0±0	0±0	0±0	0±0	0±0
1	17.07±0.21	17.42±0.28	16.89±1.19	17.35±0.72	16.28±0.74	17.33±0.52	15.74±0.41
2	24.83±0.36	25.43±0.83	23.86±0.98	24.28±0.61	25.39±0.53	23.52±0.19	24.28±0.68
3	39.25±0.19	38.55±0.74	39.08±0.71	38.95±0.93	38.86±0.46	39.61±0.45	39.76±0.29
4	46.09±0.02	47.46±0.62	45.61±0.86	46.59±0.75	47.01±1.21	45.29±0.18	47.88±0.82
5	54.32±0.93	54.90±1.97	53.29±0.79	55.40±0.59	53.66±0.01	55.96±0.10	54.18±1.68
6	60.89±0.90	61.51±0.08	59.39±0.62	61.62±0.85	59.92±0.54	60.55±0.01	62.07±0.74
7	69.20±0.27	70.41±1.13	69.91±0.81	70.69±0.92	70.29±0.38	69.99±0.63	69.13±0.02
8	74.95±0.21	74.09±1.08	75.71±0.57	75.93±0.69	73.31±0.21	74.20±0.86	75.02±0.57
9	82.44±0.74	83.79±0.87	81.90±0.53	82.74±0.47	83.75±0.59	82.36±0.15	81.90±0.09
10	86.96±1.82	87.05±0.62	85.50±0.89	86.88±0.64	86.52±0.82	84.85±0.50	85.72±1.36
11	89.94±0.88	89.04±1.52	88.12±0.94	89.37±0.83	88.48±0.47	88.71±0.72	88.57±0.53
12	91.30±1.46	91.48±0.41	91.01±0.03	91.62±0.77	90.92±0.06	91.62±0.91	90.59±0.59

*Each value represent the mean ± standard deviation (n=3)

Conclusion

The use of natural gum for pharmaceutical application is attractive because they are economical, readily available, non-toxic, capable of chemical modification, and potentially biodegradable. The sustained release matrix tablet (FL_1) prepared from linseed mucilage showed good control in drug release pattern for 12hrs in very small concentration, having good practical yield and hence more economic. From the present work it can be concluded that Linseed mucilage and Tamarind seed polysaccharide can be a better substitute to the expensive synthetic sustained released additives.

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