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Original Article

PREPARATION AND EVALUATION OF GELLAN GUM-LINSEED GUM BLEND MICROBEADS FOR SUSTAINED RELEASE OF ACECLOFENAC

SITANGSU MAITY[1*], SANTOSH KUMAR MAHAPATRA[2]

[1]Department of Pharmaceutics, Seemanta Institute of Pharmaceutical Sciences, Jharpokharia, Mayurbhanj 757086, Odisha, India, [2]Department of Pharmaceutics, Institute of Pharmacy and Technology, Salipur, Cuttack 754202, Odisha
Email: sitangsu02@gmail.com

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ABSTRACT

Objective: The objective of the current investigation was to design aceclofenac encapsulated microbeads using gellan gum and linseed gum blends following ionotropic gelation by trivalent Al^{3+}-ions as cross-linking agent.

Methods: Various formulation parameters like polymer-polymer blend (gellan gum and linseed gum), proportion and concentration of aluminium chloride (*i.e.,* cross-linker) were considered for preparation of different formulations. *In vitro* aceclofenac release from these microbeads was performed in 0.1 N HCl (pH 1.2) for a preliminary 2 h, and after this period, it was continued in phosphate buffer (pH 7.4) for the next 6 h (a total of 8 h).

Results: These gellan gum-linseed gum microbeads of aceclofenac exhibited drug encapsulation efficiency of 27.70 ± 0.42 to 74.27±2.57 % and average sizes of gellan gum-linseed gum microbeads were ranged 739.57 ± 22.70 to 968.07 ± 42.24 µm. The release of drug (*in vitro*) from these gellan gum-linseed gum microbeads of aceclofenac demonstrated a sustained pattern of drug-releasing (over 8 h).

Conclusion: These gellan gum-linseed gum microbeads can be used as an effectual option of polymeric carrier matrices for sustained release.

Keywords: Linseed gum, Gellan gum, Aceclofenac, Microbeads, Sustained release

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INTRODUCTION

During past few decades, extensive researches have been done on the successful exploitations of natural gums in drug delivery as natural gums are readily accessible from natural origins, sustainable production, biodegradability and biocompatibility [1-3]. Natural gums are extracted from (i) plant, (ii) marine and (iii) microbial resources [4-24]. Since long, natural gums are being used as excipients for various dosage forms [27-29]. Gellan gum is extracted as a fermentation product of *Psedomonus eloda* and used as a biopolymer due to its hydrophilicity, gelation capability, biocompatibility, biodegradability, *etc* [30-32]. It is used in nanoparticles, microparticles, beads, hydrogels, films, *etc* [26, 33]. The gellan gum structure entails the tetrasaccharide of glucose, glucuronic acid and rhamnose (2:1:1) [34]. Deacetylated gellan gum experiences ionotropic gelation by Ca^{2+}, Al^{3+}, *etc*., which is used to develop polymeric beads [34, 35]. The ionotropically gelled gellan gum beads have been reported to exhibit rapid drug-releasing due to low mechanical strength in the intestinal pH (alkaline) [35, 36]. To counter such a problem, the blending of other biopolymers with deacetylated gellan gum to prepare ionotropically gelled beads has been researched [34, 35]. The present work was an attempt to design and evaluate the ionotropically gelled microbeads of deacetylated gellan gum and linseed gum blends for sustained drug releasing.

Linseed gum is extracted from linseeds (*Linum usitatisimum*; family: Linaceae) [37, 38]. On acid-catalyzed hydrolysis, linseed gum yields D-xylose, L-arabinose, L-galactose, L-rhamnose, D-galacturonic acid and D-glucose [22]. It is reported as neutraceutical and antidiabetic [39, 40]. It has also been investigated as tabletting excipients, matrix former, gel former and mucoadhesive [22, 38-42]. Considering the sustained drug releasing property of it, in the present research, the efficacy of linseed gum as release retardant blends with anionic natured deacetylated gellan gum to design ionotropically gelled gellan gum-linseed gum microbeads for sustained release was studied. Previously, any research work on gellan gum-linseed gum microbeads has not been performed till date. Hence, the designing of Al^{3+}ion-induced gellan gum-linseed gum microbeads can be an option for sustained delivery of drugs over a prolonged period. Aceclofenac was investigated as model drug. Its plasma elimination half-life is about 4 h and the recommended dose of aceclofenac is given as 200 mg/daily in divided dosing [11, 43]. Therefore, the current research was aimed to design and evaluate Al^{3+}ion-induced ionotropically gelled gellan gum-linseed gum microbeads for controlled releasing of aceclofenac.

MATERIALS AND METHODS

Materials

Aceclofenac (Drakt Pharmaceutical Pvt. Ltd., India), aluminum chloride (Merck Ltd., India), deacetylated gellan gum (SRL India Ltd., India) and acetone (Merck Ltd., India) were employed. Linseed gum was extracted from linseeds (*Linnum usitatisimum*), which were purchased from Jharpokharia local market (Dist: Mayurbhanj, Odisha, India) in November 2019. All other chemicals and reagents used in the current research were of analytical grade and commercially available.

Extraction of linseed gum

In the present work, linseed gum was extracted using the method which was previously reported by Hasnain *et al.* (2018) [22]. Demineralised water (1 L) and linseeds (250 g) were soaked for overnight at room temperature and, afterward, warmed using a water bath until the formation of slurry. After cooling of the formed slurry, it was placed inside a laboratory refrigerator for overnight for the settlement of materials present as undissolved. The supernatant portion of the solution was carefully decanted and then concentrated using a water bath at 45±2 °C to 1/3rd of the initial volume. At room temperature, the concentrated solution was cooled and then taken in a beaker containing thrice the volume of acetone. The formed precipitated material was washed employing acetone. After that, it was repeatedly washed using demineralized water. The finally washed gum precipitated material was dried in a tray dryer for 12 h at a temperature of 45±2 °C. The extracted dried gum was crushed and grinded to a fine powder. Fine gum powder was also passed across an 80 mesh screen and finally, the obtained linseed gum was stored in air-tight desiccators for further study.

Preparation of Al^{3+}-ion induced ionotropically gelled gellan gum-linseed gum microbeads of aceclofenac

Briefly, aqueous solutions of extracted linseed gum (at a temperature of 45±2 °C) and aqueous gellan gum solutions (at a temperature of 60±2 °C) were prepared using a tabletop magnetic stirrer at 400 rpm for 30 min. Both the gum solutions were mixed together with stirring at 500 rpm for 30 min to prepare gellan gum-linseed gum solution mixtures. The polymer concentration of 2 % w/v was maintained in all the solution mixtures. Then, aceclofenac (required amount maintaining the aceclofenac to polymer ratio-1: 2) was added into prepared gellan gum-linseed gum solution mixtures and all the gellan gum-linseed gum mixtures containing aceclofenac were separately homogenized using a homogenizer (Remi Motors, India) at 600 rpm for 30 min. The gellan gum-linseed gum-aceclofenac dispersions were extruded drop-wise in the aluminum chloride (ionotropic crosslinker) aqueous solutions through 18-G extruder needle and the extruded droplets were retained for 10 min to produce w*et al.*$^{3+}$-ion induced gellan gum-linseed gum microbeads of aceclofenac. The wet beads were collected by decanting the solution and thoroughly washed for 2 times by demineralised water. After that, washed microbeads were dried using tray dryer at 45±2 °C for overnight. The dried Al^{3+}-ion induced ionotropically gelled gellan gum-linseed gum microbeads of aceclofenac were stored in air-tight desiccators for further study. Formulation.

Determination of drug encapsulation efficiency (DEE)

Microbeads of aceclofenac were sampled and powdered employing clean pestle-mortar. For each formulation, microbeads powders (10 mg) were taken and placed in a volumetric flask containing 500 ml phosphate buffer (pH 7.4). After overnight stay at 37±2 °C, the solution mixtures were stirred, separately, using table top magnetic stirrer at 500 rpm for 30 min. The solutions were filtered by means of Whatman® filter paper (No. 40). The aceclofenac contents in the solution were estimated using a Double-beam UV-VIS spectrophotometer (Shimadzu, Japan) at 274.5 nm wavelength against the appropriate blank solution. DEE (%) of gellan gum-linseed gum microbeads containing aceclofenac was estimated by the formula [19]:

$$\text{DEE (\%)} = \frac{\text{Actual content of aceclofenac in gellan gum–linseed gum microbeads}}{\text{Theoretical content of aceclofenac in gellan gum–linseed gum microbeads}} \times 100$$

Particle size measurement

Average particle sizing of 100 dried gellan gum-linseed gum microbeads of aceclofenac was measured by an optical microscope (Olympus) with a micrometer, which was previously calibrated using a stage micrometer [19].

Scanning electron microscopy (SEM) analyses

The samples of gellan gum-linseed gum microbeads of aceclofenac were coated by gold sputter and SEM photographs were taken using a scanning electron microscope (JEOL Ltd., Japan) operated at the acceleration voltage of 20 kV.

Fourier transform-infrared (FTIR) spectroscopy

Using a set of clean pestle and mortar, various samples were powdered, separately and these were analyzed using a FTIR spectroscope (Shimadzu, Japan) as the pellets made of potassium bromide and samples (99: 1). These pellets were separately placed one by one in the sample holder and the spectral scanning was operated within the wavelength range 4000-400 $cm^{-1}$and 1 cm/sec scan speed.

Differential scanning calorimetry (DSC)

The moisture free samples (approximately 7 mg) were taken and placed inthe pan made of platinum crucible-aluminium in hermetically sealed condition and ∞-alumina powders as reference substance was employed. DSC thermograms for each tested samples were taken and analyzed in a differential scanning calorimeter (Perkin Elmer®, Japan)atthe heating rate of 10 °C/min under the constant flow of nitrogen gas(flow rate of 150 ml/min).

***In vitro* aceclofenac release study**

In vitro aceclofenac releasing from various gellan gum-linseed gum microbeads of aceclofenac was performed employing the basket type dissolution rate test apparatus (Campbell Electronics, India). The basket of the dissolution apparatus was covered by the nylon cloth of 100 mesh. The temperature of the dissolution system was 37±0.5 °C under and the speed of basket shaft was 50 rpm. Gellan gum-linseed gum microbeads of aceclofenac equivalent to aceclofenac of 100 mg were placed with the basket and immerged in 900 ml 0.1 N HCl (pH 1.2). *In vitro* aceclofenac release from these microbeads was performed in 0.1 N HCl (pH 1.2) for a preliminary 2 h, and after this period, it was continued in phosphate buffer (pH 7.4) for the next 6 h (a total of 8 h). At the regular time, aliquots (5 ml) were sampled from the dissolution vessel and instantly, the same volume of fresh dissolution medium was replaced to maintain the sink condition. The sampled aliquots were filtered and for aceclofenac contents estimated by a UV-VIS spectrophotometer (Shimadzu, Japan) at 274.5 nm wavelength against the appropriate blank solution.

Analyses of *in vitro* aceclofenac release kinetics and release mechanism

The data of aceclofenac releasing (*in vitro*) from gellan gum-linseed gum microbeads of aceclofenac were analyzed by important kinetic mathematical modelling and their squared correlation coefficient (R^2) was compared to analyze the accuracy [44-45].

Zero-order equation: $M = M_0 - K_0 t$

First-order equation: $M = M_0 e^{-kt}$

Higuchi equation: $M = K_h t^{0.5}$

Korsmeyer-Peppas equation: $M = K_{k-p} t^n$

Where M is the cumulative content of aceclofenac released in time t,

M_0 is the start value of M,

k_0, k_1, k_h and $K_{k\text{-}p}$ are the aceclofenac releasing rate constants for zero-order, first-order, Higuchi and Koresmeyer-Peppas equations, respectively. The aceclofenac release exponent (as an indicative of drug-releasing mechanism) was designated as 'n'. For the spherical matrices, n ≤ 0.43is the indicative of Fickian mechanism (as indicative of diffusion control mechanism). The n value within the range 0.43-0.85 is designated as the non-Fickian mechanism (as indicative of anomalous transport-based release mechanism); whereas n ≥ 0.85 is the indicative of case-II transport mechanism (as indicative of relaxation controlled mechanism) [46, 47].

Statistical analysis

All other data were estimated and analyzed by performing simple statistical analyses using MedCalc software, version 11.6.1.0 (trial version).

RESULTS AND DISCUSSION

DEE

The DEE (%) of Al^{3+}-ion-induced gellan gum-linseed gum microbeads containing aceclofenac was found in-between the range, 27.70 ± 0.42 to 74.27±2.57% (table 1). From the result, it has been noticed that DEE (%) of these gellan gum-linseed gum microbeads (encapsulated with aceclofenac) was significantly controlled by the investigated formulation parameters: crosslinker (here aluminium chloride) concentration in the crosslinking solutions, polymer-blend (gellan gum-linseed gum) contents and ratio (p<0.05). The encapsulations of aceclofenac in the gellan gum-linseed gum microbeads was found to be enhanced with the increments of polymer contents used (*i.e.,* gellan gum and linseed gum) in the polymer-blends and decreasing crosslinker concentration in the crosslinking solutions. The augmentation of DEE in these gellan gum-linseed gum microbeads could be due to viscosity increment of gellan gum-linseed gum blend solutions by increasing polymer contents, which might have been obstruct the aceclofenac leaching from microbeads to the crosslinking solutions [30, 31]. The decreasing encapsulation of aceclofenac with the increment of crosslinker concentration in the crosslinking solutions can be authorized by the reality that the aqueous content might be expelled out from the gellan gum-linseed gum based ionotropically gelled matrices as the ionotropic gelation proceeds [19]. The higher degrees of cross-linking might also cause the convective loss of aceclofenac amounts in these ionotropically gelled biopolymeric microbeads during preparation.

Table 1: Formulation parameters of different Al^{3+}-ion induced ionotropically gelled gellan gum-linseed gum microbeads of aceclofenac with DEE (%) and sizes of microbeads (average diameter, µm)

Code	Formulation parameters				Average diameter (µm)[c]
	Polymers		$AlCl_3$ (%)	DEE (%)[a,b]	
	Gellan gum (mg)	Linseed gum (mg)	in crosslinking solution		
B-1	280	50	5	36.75 ± 1.12	911.47 ± 32.12
B-2	280	50	3	51.29 ± 1.44	927.42 ± 34.87
B-3	280	0	5	29.25 ± 0.57	780.16 ± 23.47
B-4	280	0	3	37.01 ± 1.05	826.34 ± 30.22
B-5	250	50	5	30.60 ± 0.48	832.57 ± 28.48
B-6	250	50	3	45.74 ± 1.36	881.08 ± 30.17
B-7	250	0	5	27.70 ± 0.42	739.57 ± 22.70
B-8	250	0	3	39.54 ± 0.98	812.50 ± 27.84
B-O	280	100	2	74.27±2.57	968.07 ± 42.24

[a]DEE (%) = drug encapsulation efficiency (%), [b](Mean ± SD; n = 3), [c]Mean± SD; n = 100.

Particle size

The average particle sizing of formulated gellan gum-linseed gum microbeads of aceclofenac was in-between739.57 ± 22.70 to 968.07 ± 42.24 µm (table 1). Bigger sizing was noticed when polymers (gellan gum and linseed gum) were increasingly used and crosslinker concentration was decreased in the crosslinking solutions. This result could be attributed by the conception of hydrodynamic viscosity [34, 35]. During preparation, when polymers (gellan gum and linseed gum) were increasingly used, larger droplets of gellan gum-linseed gum blend solutions could pass via the needle mouth to the crosslinking solutions. The higher degrees of crosslinking by higher concentrations of crosslinker (aluminium chloride) in the crosslinking solutions produced the smaller-sized microbeads, which could be explained by the fact of contraction of gelled gellan gum-linseed gum matrices by the higher concentrations of crosslinker *via* availing more concentrated Al^{3+}ions. The obtained results of the current study are in agreement with some of the published reports [19, 30, 31, 34, 35].

SEM analyses

SEM photograph of ionotropically gelled gellan gum-linseed gum microbeads of aceclofenac (B-O) is shown in fig. 1. SEM photograph indicating surface morphology of gellan gum-linseed gum microbeads at the 200 x magnification demonstrated irregular shaped non-agglomerated microbeads having a rough and corrugated surface. In addition, some traces of polymeric debrises were also observed on the microbead surface, which might be caused by means of instantaneous preparation of formation of ionotropically gelled gellan gum-linseed gum microbead matrices.

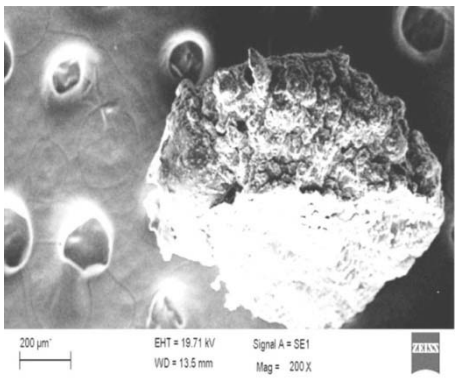

Fig. 1: SEM photograph of ionotropically gelled gellan gum-linseed gum microbeads of aceclofenac (B-O)

FTIR spectroscopy analyses

FTIR spectra of gellan gum, linseed gum, gellan gum-linseed gum microbeads without aceclofenac, gellan gum-linseed gum microbeads of aceclofenac (B-O) and aceclofenac (pure) are shown in fig. 2. The FTIR spectrum of gellan gum presented different characteristic peak at3630.8 cm^{-1}(due to stretching of–OH groups), band at 2920–3300 cm^{-1}(due to C-H stretch), peak at 1663.5 cm^{-1}(due to C=O stretch), peak at 1403.6 cm^{-1}(due to methyl–C-H bond)and peak at 889.7 cm^{-1}(due to-C-O stretch of alkyl ether group) (fig. 2a). The FTIR spectrum of DG showed the characteristic peaks at 3622.8 cm^{-1}because of–OH stretch, peak at 1735.2 $cm^{-1}$for cyclic ketones and peaks at 1514.1 $cm^{-1}$for aromatic–NO_2 (fig. 2b). The FTIR spectrum of gellan gum-linseed gum microbeads without aceclofenac presented majority of the characteristic peaks and bands of both the polymers (linseed gum and gellan gum) present in the polymer-blends employed lacking any significant changes (fig. 2c). The FTIR spectra of pure ACE showed characteristic peaks and bands, such as band at 3317.6 cm^{-1}(because of secondary N-H rocking vibrations), peaks at 3029.6 cm^{-1}(because of aromatic-C-H stretch vibration) and at 2939.8 cm^{-1}(due to aliphatic-C-H stretch vibrations), a sharp band at 1770.7 cm^{-1}(due to C=O stretching of carboxylate), a band at 1717 cm^{-1}(due to C=O stretching vibration) and a sharp peak at 717.5 cm^{-1}(due to stretching vibration of 1, 2 di-substituted C-Cl) (fig. 2d). The FTIR spectra of the ionotropically-gelled gellan gum-linseed gum microbeads of ACE (B-O), various characteristic bands and peaks, which were already appeared in the individual spectra of linseed gum, gellan gum and pure aceclofenac without any significant changes and shifting (fig. 2e). From the obtained results of the FTIR spectroscopy analyses this result clearly demonstrates that no chemical/physical interaction was occurred in-between the polymer-blend (gellan gum and linseed gum) used and aceclofenac. Therefore, it is evident that Al^{3+}-ion induced ionotropically gelled gellan gum-linseed gum microbeads of aceclofenac (B-O) had maintained the significant properties of pure aceclofenac, even after the encapsulation within the gellan gum-linseed gum microbeads.

DSC analysis

DSC thermograms of aceclofenac (pure) and gellan gum-linseed gum microbeads of aceclofenac (B-O) are shown in fig. 3. These DSC thermograms indicated the physical states of pure aceclofenac and aceclofenac encapsulated within ionotropically-gelled gellan gum-linseed gum microbeads of aceclofenac (B-O). The DSC thermogram of aceclofenac (pure) demonstrated a comparative sharp typical endothermic peak at 153.53 °C (fig. 3, a), indicating the transition melting point temperature of aceclofenac. In contrast, the DSC thermogram of gellan gum-linseed gum microbeads of aceclofenac (B-O) (fig. 3, b) demonstrated a weaker endothermic peak at 143.57 °C, which indicated that the comparatively amorphous dispersion of aceclofenac within the gellan gum-linseed gum microbeads in comparison to that of pure aceclofenac. The shifting of sharp endothermic peak (noticed in the DSC thermogram of pure aceclofenac) to the broader endothermic peak at the low temperature. This fact can be attributed to the transfer of comparatively amorphous state of aceclofenac after the encapsulation of aceclofenac by gellan gum-linseed gum microbeads formulated *via* ionotropic gelation induced by Al^{3+}-ions.

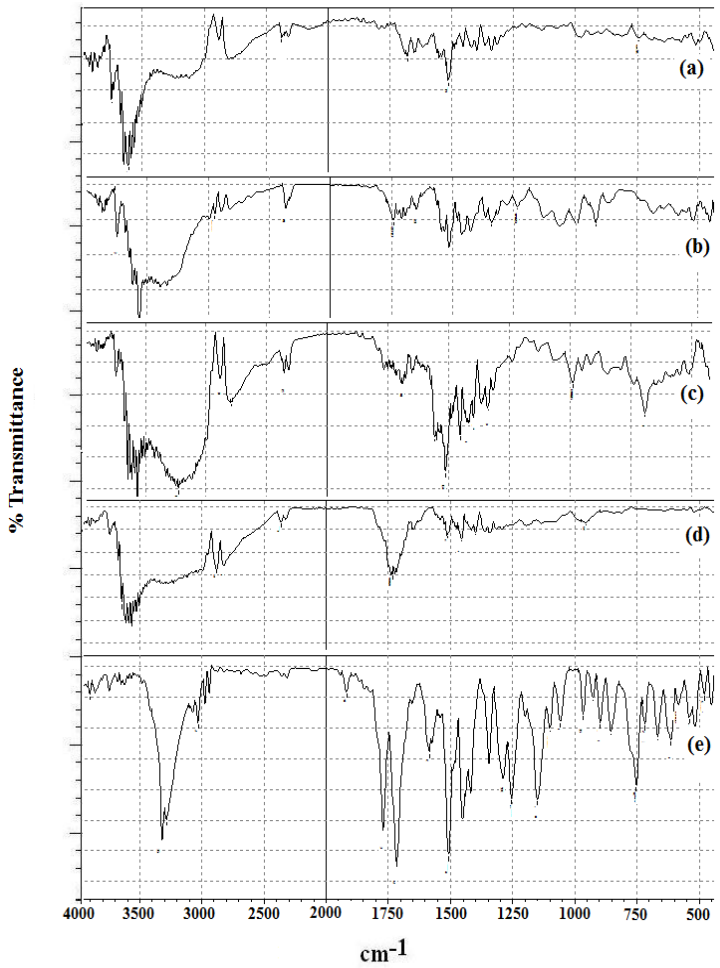

Fig. 2: FTIR spectra of: (a) gellan gum, (b) linseed gum, (c) gellan gum-linseed gum microbeads without aceclofenac, (d) gellan gum-linseed gum microbeads of aceclofenac (B-O) and (e) aceclofenac (pure)

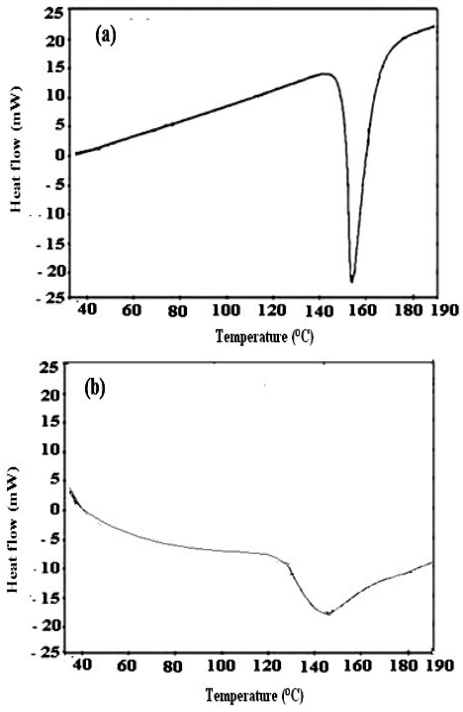

Fig. 3: DSC thermograms of (a) aceclofenac (pure) and (b) gellan gum-linseed gum microbeads of aceclofenac (B-O)

In vitro aceclofenac release

Different Al^{3+}-ion-induced gellan gum-linseed gum microbeads of aceclofenac (B-1 to B-8, and B-O) demonstrated *in vitro* sustained aceclofenac releasing over a prolonged period (8 h) (fig. 4). The *in vitro* release of aceclofenac from gellan gum-linseed gum microbeads was found to be relatively slower in 0.1 N HCl (pH 1.2) and next, a speedy releasing of aceclofenac was estimated in phosphate buffer (pH 7.4). This fact could be because of rapid swelling of ionotropically gelled gellan gum-based microbeads in higher (alkaline) pH in comparison with that of the lower (acidic) pH and this occurrence might led to a relatively rise in the aceclofenac release, *in vitro*, in the alkaline pH. The trivalent Al^{3+}ions, which were participated in the inotropic gelation of gellan gum-based microbeads, could not only be displaced by monovalent Na^{+}ions but also be sequestered by phosphate (PO_4^{2-}) ions contained in phosphate buffer (pH 7.4). This fact might produce the loose and soluble gelled structure of gellan gum-based microbeads when these might be exposed to in the alkaline medium (pH 7.4) [19]. At the preliminary phase of the study, the utmost content of aceclofenac released from gellan gum-linseed gum microbeads of aceclofenac could probably be because of the crystals of aceclofenac, which were adhered onto the microbead surface. Retardation of aceclofenac releasing, *in vitro*, by this ionotropically gelled gellan gum-linseed gum microbeads was noticed with increasing contents of gellan gum and linseed gum as this might increase the hydrophilic characteristics of the gellan gum-linseed gum blends in these microbeads, which might generate the viscous natured polymeric gels on the surface of these gellan gum-linseed gum microbeads to produce blockade the surface pores onto the microbeads of aceclofenac to facilitate the aceclofenac releasing in a sustained pattern over a prolonged time. Furthermore, the retardation of *in*

vitro aceclofenac releasing from the gellan gum-linseed gum microbeads of aceclofenac formulated with higher aluminium chloride concentration could be attributable to the fact that free volume of ionotropically gelled gellan gum-linseed gum matrices might be decreased and the hindering movements of solute through the gellan gum-linseed gum matrices at the higher degree of ionotropic crosslinking, when increased content of crosslinker was used [19].

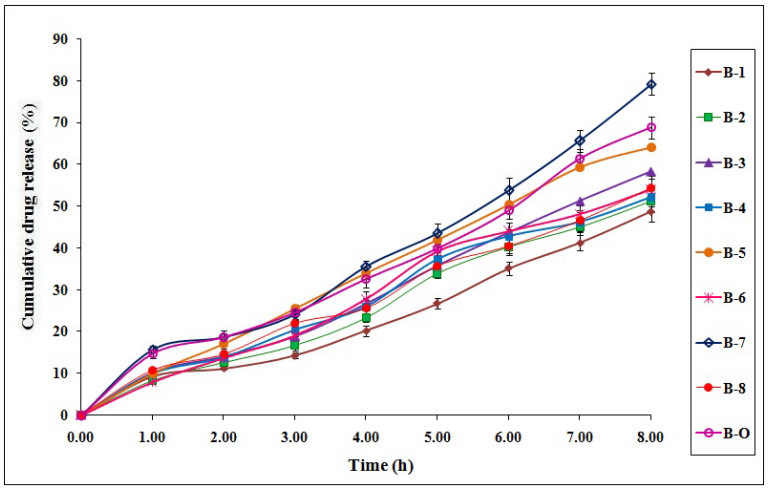

Fig. 4: *In vitro* release of aceclofenac from gellan gum-linseed gum microbeads (B-1 to B-8 and B-O) (mean±SD; n = 3)

In vitro aceclofenac releasing results of gellan gum-linseed gum microbeads of aceclofenac (B-1 to B-8, and B-O) were tested for curve-fitting by kinetic mathematical modelling (table 2). When the respective R^2values were compared, zero-order model was found to be best-fit for the microbeads B-2 (R^2 = 0.9875), B-3 (R^2 = 0.9893), B-4 (R^2 = 0.9861), B-5 (R^2 = 0.9975), B-6 (R^2 = 0.9846), B-8 (R^2 = 0.9929) and B-O (R^2 = 0.9911). Furthermore, Korsmeyer-Peppas model was found to be closer as the best-fitto zero-order model for the microbeads B-2 (R^2 = 0.9605), B-3 (R^2 = 0.9773), B-4 (R^2 = 0.9502), B-8 (R^2 = 0.9654) and B-O (R^2 = 0.9627). On the other hand, the first-order model was followed by gellan gum-linseed gum microbeads B-1 (R^2 = 0.9869) and B-7 (R^2 = 0.9879) as best-fitting. However, zero-order model was found to be closer as the best-fit to the Korsmeyer-Peppas model for the microbeads B-1 (R^2 = 0.9727), and B-7 (R^2 = 0.9740). The values of release exponent (n) estimated from the aceclofenac releasing results (*in vitro*) of gellan gum-linseed gum microbeads of aceclofenac (B-1 to B-8, and B-O) and these ranged from 0.8075 to 0.9727. Gellan gum-linseed gum microbeads B-2, B-3, B-5, B-6, and B-O presented the 'n' values range in-between0.8825 to 0.9727 indicating that the aceclofenac releasing was occurred by the super case-II transport mechanism; whereas, 'n' values for microbeads B-1 and B-4 were near about 0.85 (0.8470 and 0.8461, respectively). This result might be attributed to the dissolution, enlargement and/or relaxation of the ionotropically gelled gellan gum-linseed gum matrices. On the other hand, gellan gum-linseed gum microbeads B-7 and B-8 microbeads exhibited 'n' values range less than 0.85 (0.8115 and 0.8075, respectively) indicating the non-Fickian releasing mechanism (anomalous transport). This result might be attributed to the diffusion and swelling controlled releasing of the aceclofenac from these gellan gum-linseed gum microbeads [19, 31].

Table 2: Results of curve fitting of the *in vitro* aceclofenac release data from Al^{3+}-ion-induced ionotropically gelled gellan gum-linseed gum microbeads of aceclofenac

Models		Formulation code								
		B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8	B-O
Zero order	R^2	0.9727	0.9875	0.9893	0.9861	0.9975	0.9846	0.9740	0.9929	0.9911
First order	R^2	0.9869	0.9605	0.9773	0.9502	0.9322	0.9255	0.9879	0.9654	0.9627
Higuchi	R^2	0.6554	0.6767	0.6861	0.7501	0.7236	0.6879	0.6865	0.7657	0.7403
Korsmeyer- Peppas	R^2	0.9233	0.9746	0.9640	0.9752	0.9974	0.9885	0.9280	0.9767	0.9507
	n	0.8470	0.9254	0.8825	0.8461	0.9282	0.9691	0.8115	0.8075	0.9727

R^2 = squared correlation coefficients; n = diffusional exponent

CONCLUSION

In the current communication, gellan gum-linseed gum microbeads of aceclofenac were formulated *via* ionotropic gelation induced by Al^{3+}-ions. These gellan gum-linseed gum microbeads of aceclofenac exhibited aceclofenac encapsulation efficiency of 27.70 ± 0.42 to 74.27±2.57 % and average sizes of gellan gum-linseed gum microbeads were ranged 739.57 ± 22.70 to 968.07 ± 42.24 µm. The gellan gum-linseed gum microbeads of aceclofenac demonstrated *in vitro* sustained release of aceclofenac over 8 h and this result could probably be important in terms of the potential medication advantages of favorable patient compliances and reduced dosing intervals. For this reason, these gellan gum-linseed gum microbeads of aceclofenac can be used as novel kinds of the potential option of polymeric microbeads carrier-matrices for sustained release of aceclofenac. The presented work showed an easy, economic and feasible approach to develop gellan gum-linseed gum microbeads for sustained release of aceclofenac *via* ionotropic gelation induced by Al^{3+}-ions.

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AUTHORS CONTRIBUTIONS

All the authors have contributed equally.

CONFLICTS OF INTERESTS

The authors declare no conflict of interest.

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