WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 8.453
Volume 14, Issue 10, 411-422. Review Article ISSN 2277–7105

FORMULATION AND EVALUATION OF BIODEGRADABLE CURCUMIN MICROBEADS INCORPORATED FACE SCRUB

M. Ramya*[1], B. Swarupa[1], Yuvaraj Kumar Sah[2], Manish Kumar[3], Dinesh Kumar Yadav[2], Nand Kishor Bharti[4] and S. Arshiya[5]

[1]Assistant Professor, [2,3,4,5,6]Student,

Dept. of Pharmacy, Sri Venkateswara College of Pharmacy, Andhra Pradesh.

Article Received on
28 March 2025,

Revised on 18 April 2025,
Accepted on 08 May 2025

DOI: 10.20959/wjpr202510-36717

***Corresponding Author**
Dr. M. Ramya
Assistant Professor, Dept. of Pharmacy, Sri Venkateswara College of Pharmacy, Andhra Pradesh.

ABSTRACT

The present study focuses on the formulation and evaluation of a biodegradable face scrub incorporating curcumin-loaded microbeads, aimed at providing a natural, effective, and eco-friendly alternative to synthetic exfoliants. Curcumin, known for its antioxidant and anti-inflammatory properties, was encapsulated in sodium alginate microbeads using the ionic gelation technique with calcium chloride as the crosslinking agent. The prepared microbeads were incorporated into a gel-based scrub containing natural ingredients such as aloe vera, glycerin, and walnut shell powder. The microbeads were characterized for morphology, particle size, and encapsulation efficiency. The final scrub formulation was evaluated for pH, viscosity, spreadability, grittiness, and stability under various storage conditions. A patch test was also conducted to assess skin irritation potential. The microbeads were spherical, uniform in size, and showed high encapsulation efficiency (over 80%). The face scrub had an acceptable pH (5.8–6.2), good viscosity, and desirable spreadability. Stability studies indicated no significant changes in physical appearance or performance over four weeks. The patch test confirmed that the formulation was safe and non-irritant to the skin. Overall, the study successfully developed a skin-safe, biodegradable, and effective exfoliating face scrub that offers a sustainable alternative to conventional microplastic-based products.

KEYWORDS: Face scrub, Curcumin microbeads and Controlled medication administration.

INTRODUCTION

When developing delayed-release pharmaceutical delivery systems, the primary objective is to reduce the frequency of medication administration or increase the medication's efficacy by focusing on the areas where it is most needed.[1,2] This method can provide a consistent drug distribution or help reduce the overall quantity of medication needed. These systems, which are designed to deliver a long-lasting therapeutic impact by releasing the medication gradually over a longer period of time after just one dose, are referred to by terms such as sustained-release, sustained action, prolonged action, and extended action. Developing efficient drug delivery methods has recently been essential to the creation of novel pharmaceuticals.

As a result, research is constantly looking for methods to administer medications with a well-controlled release profile over a long period of time. The development of synthetic styles for the production of bio-comparable attractive globules has gained popularity recently. These microbeads are nearly spherical and range in size from 0.5 to 1000µm. We can use a variety of active medications to treat the enabling a variety of release characteristics, such as a prolonged release with few adverse effects or a rapid release. These free-flowing particles have the ability to transport powdered or crystalline medication patches. These microbeads continue to function well even under physiological settings. Additionally, they can be customized to include particular components and transport them precisely where they are required, guaranteeing that the appropriate dosage of medication reaches the intended location while minimizing systemic exposure to minimize any unintended side effects. To make microbeads, we're combining a variety of polymers. This comprises binding agents like gelatin, chondroitin sulphate, and avidin, as well as cationic polymers like chitosan and anionic ones like sodium alginate, all in a particular ratio.

MATERIALS AND METHOD

Curcumin, the key polyphenol in turmeric (Curcuma longa), is typically extracted using solvents due to its health benefits and distinctive yellow color.

Drug-Excipient compatibility: Excipients were carefully selected and mixed with the API in a fixed ratio to ensure stability and efficacy. FTIR analysis was used to assess potential drug–excipient interactions.

Preparation of micro beads

Curcumin was accurately weighed and added to 100 mL of alginate solution with continuous stirring. Various concentrations of HPMC, CMC, and chitosan were then incorporated to produce modified alginate microspheres. For CMC-based formulations, the polymer was mixed with alginate before drug addition.

Each 20 mL dispersion was dropped via a 16G syringe into 100 mL of gently stirred 1.5% (w/v) calcium chloride solution. Microspheres were washed with distilled water, soaked in 1% (w/v) isopropyl alcohol for 10 minutes, and air-dried at room temperature for 24 hours. A table lists the ingredients and their proportions.

Table 1: Formulation of microbeads.

Formulation	F1	F2	F3	F4
Curcumin(mg)	1.5	1.5	1.5	1.5
Sodium alginate(g)	2	2	2	2
HPMC K 100(g)	2	-	-	-
HPMC K 4 M(g)	-	2	-	-
CMC(g)	-	-	2	-
Chitosan(g)	-	-	-	2
Cacl2(w/v)	1.5%	1.5%	1.5%	1.5%
Isopropyl alcohol(ml)	10	10	10	10
Distilled water(ml)	50	50	50	50

Preparation of face scrub

After measuring and dissolving sodium lauryl sulphate in water, potato starch—which serves as a gelling agent—was added to the mixture. After that, the prepared extract was added, and for roughly five minutes, everything was mixed together. Lastly, the mixture was mixed with microbeads, which gave the gel a pleasant grainy texture.

Evaluation for face scrub

Physical appearance: The formulation's physical appearance was observed visually. During this test, color, consistency, character, and scent were all noted.

Homogeneity: A thorough examination of the formulation's homogeneity was conducted. To Using a digital pH meter, the pH of the scrub component was measured.

Extrudability: The length of time necessary for the sample to completely extrude from the container or the sample amount/time required was used to measure extrudability.

Determination of spreadability of scrub: The gel was lightly dusted with the scrub. A 20g wooden weight was placed on top of it. Both the area covered and the time it took for the brush to spread were measured.

Irritability: A small amount of scrub was put on the skin's surface and allowed to sit there for a short while.

Washability is determined by applying a tiny quantity of the sample scrub to the skin, then washing it off with water.

Grittiness: Grittiness was examined by the author.

Foam ability: A tiny quantity of scrub was agitated in a measuring cylinder, and the amount of foam that resulted was quantified.

Evaluation of microbeads

Particle size analysis: Using a microscopic technique, we were able to determine the microbeads' size distribution. We were able to determine the average particle sizes with the aid of the data we collected, which improved our comprehension of the microbeads' homogeneity.

Drug content determination: One gram of microbeads was dissolved in ten milliliters of ethanol, sonicated for ten minutes, filtered, and then diluted with ten milliliters of ethanol. Dilute 5 ml of the aforementioned solution with 10 ml of ethanol. Measure absorbance using UV-visible spectroscopy at 426 nm.

Efficiency of drug Loading and Entrapment

We began by carefully weighing a sample of beads (about 100 mg) and crushing it in a mortar. The crushed material was then dissolved in 75 milliliters of 0.1N HCl, increasing the volume to 100 milliliters. Then, we filtered the mixture and analyzed it using a UV spectrophotometer at a wavelength of 234 nm, using 0.1N HCl as our blank. You can calculate the drug loading and entrapment efficiency percentage using the equations provided.

Drug content % $= \frac{Actual drug content}{Weight of beads} x100$

Entrapment efficiency % $= \frac{Actual drug content}{Theoretical drug content} x100$

In-vitro dissolution studies

Using USP type II equipment, in-vitro dissolution tests were conducted for each formulation. We put some carefully measured floating curcumin beads into 900 milliliters of a pH 1.2 0.1 N HCl buffer. While stirring at 50 rpm, we maintained the temperature at 37 ± 0.5 °C. To maintain the sink state, we removed 5 ml of the sample and added 5 ml of new dissolving media at predetermined intervals. With the 0.1 N HCl buffer (pH 1.2) acting as our blank, we used a UV spectrophotometer to evaluate the collected samples at 234.8 nm after filtering them if necessary. To learn more about the release kinetics and how the medication is released, We used a variety of kinetic equations, including zero-order and first-order, to assess the in-vitro dissolution data.

Antimicrobial activity: To test our formulations' antibacterial efficacy, we employed the agar diffusion method. We used regular Petri dishes that were filled with medium down to a depth of roughly 0.5 cm for this. Before adding our formulations, we equally distributed 0.5 mL of the inoculum over the agar surface and allowed the plates to dry at 35°C for 15 minutes. Next, we made 0.5 cm diameter bores and put 100 mg of the formulations into them. Following a 24-hour incubation period at 35°C, hours, we measured the zone of inhibition around the bores.

Findings and Conversation preformulation research

Curcumin absorption maxima: A UV-visible spectrophotometer was used to evaluate the absorption maxima for a pure sample of curcumin at 425 nm.

Table 2: Absorbance values of curcumin.

Concentration µg/ml	Absorbance
1	0.274
2	0.419
3	0.582
4	0.800
5	0.938
6	1.163

Construction of calibration curve of curcumin: With an R2 value of 0.9953, the standard graph for curcumin data has shown remarkable linearity over a concentration range of 1 to 6 µg/ml. The curcumin samples were estimated using the equation y= 0.1777x + 0.074 that was obtained from this graph.

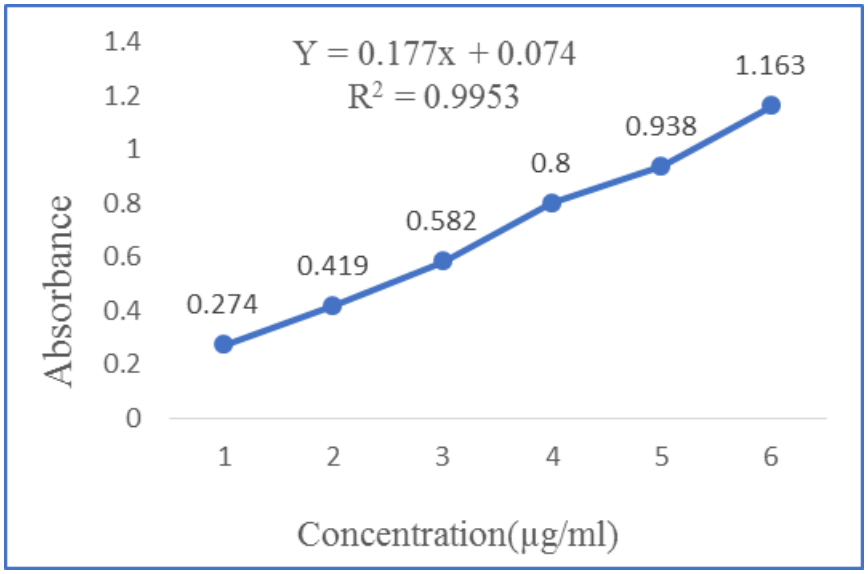


Fig. 1: Standard calibration curve of curcumin.

Drug excipient compatibility

FTIR spectroscopy

The FT-IR spectrophotometric study's results indicates that the physical mixture of pharmaceuticals and excipients exhibits negligible alterations in their spectra. The spectra of pure curcumin were measured at 3491 cm-1 for the O-H bond and 1759.41 cm-1 for the C=O bond. The measured value for Tretinoin was 1685.87 cm-1. With readings of 1758.23 cm-1 and 1672.24 cm-1 for the C=O stretching and 3517.78 cm-1 and 2933.87 cm-1 for the O-H stretching, the FT-IR spectroscopy of these medications shows spectra that are fairly comparable to those of the pure components (see Figure 3). For the O-H stretching, the spectrograph of the physical mixture of the pharmaceuticals and excipients displays peaks at 3517.78 cm-1, 2933.87 cm-1, and 3346.43 cm-1group. Curcumin and Tretinoin exhibit distinct peaks on the C=O stretching spectrograph at 1758.23 cm-1 and 1672.24 cm-1, respectively. Furthermore, there are distinct peaks in the C-H stretching group for HPMC and CMC at 2868.55 cm-1 and 2909.12 cm-1, respectively. which suggests that they are not interfering with one another. The peaks of ketone (C=O), hydroxyl (O-H), and methyl (C-H) did not significantly alter, and the measured levels of curcumin and retinoin were unaffected. The results indicated that there was little change in the primary peaks of pure curcumin. This implies that there was no discernible change in the valsartan frequencies, suggesting that the formulations are not undergoing any chemical interactions. The purity of the medicine and its compatibility with the excipients are further supported by this.

Table 3: Principle IR Peaks of Curcumin.

Drug	Drug + polymers	Functional group
1759	2868	C=O
3491	3517	O-H
1685	1758	Aromatic C=O

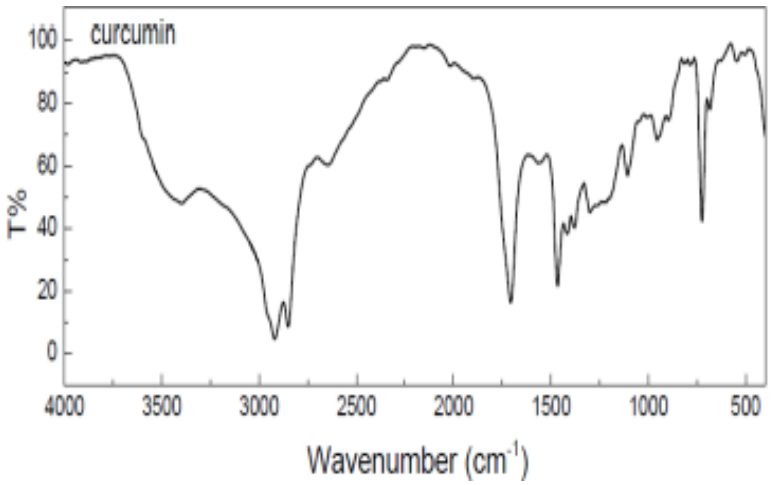


Fig. 2: FTIR of pure curcumin.

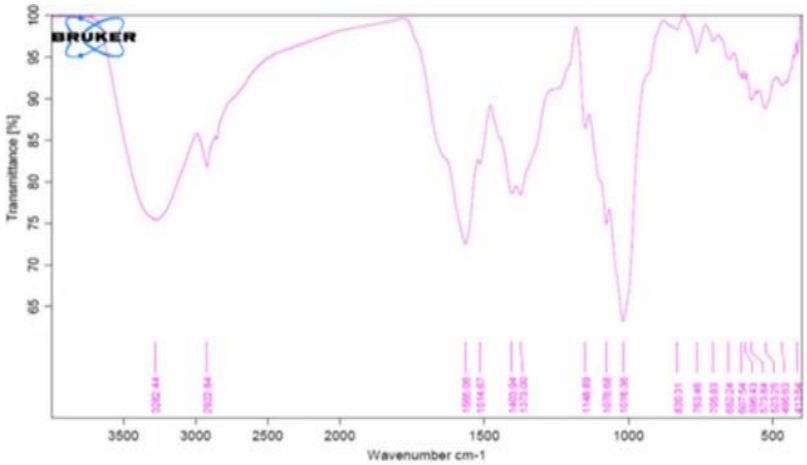


Fig. 3: FTIR of curcumin with polymers.

Physical appearance

Curcumin's physical characteristics relate to IP. It was discovered that curcumin was an amorphous, vivid yellow-orange powder.

Determination of melting point

Curcumin's melting point was found to be between 180 and 183 ˚C, which is in line with the Indian pharmacopoeia's requirements. This demonstrates that the sample that we bought is, in fact, curcumin.

Percentage yield: From F1 to F4, the percentage yield for each of the microbead formulations varied from 85.3% w/w to 94.5% w/w.

Particle size: From F1 to F4, the average particle size of the various microbead formulations was determined to be between 1.33 ± 0.06 mm and 1.45 ± 0.03 mm. Increasing the amount of coating polymer caused the microbeads' diameter to increase from F1 to F4, while maintaining a consistent concentration of curcumin microbeads and calcium chlorid.

Table 4: Determination of flow properties.

Formulation	Bulk density (g/ml)	Tapped density(g/ml)	Angle of repose(°)	Compressibility index	Hausner's ratio
F1	0.6±0.154	0.75±1.125	26.46±3.389	20±1.30	1.25±0.186
F2	0.625±2.15	0.714±1.84	26.83±0.341	12.46±2.10	1.14±0.21
F3	0.7±1.267	0.8±2.54	24.61±1.45	12.5±1.11	1.14±0.96
F4	0.627±0.145	0.718±0.115	28.82±1.27	12.47±1.85	1.15±0.13

Drug content of curcumin micro beads

The drug content in the prepared microbeads used for the face scrub was found to be between 95% and 98%. This suggests that the method we used for creating these microbeads results in a high level of content uniformity.

Formula	Drug/ polymer (w/w)	Assay
F1	Curcumin/HPMC K 100/Sodium alginate	96±0.92
F2	Curcumin /HPMC K 4 M /sodium alginate	95±0.23
F3	Curcumin /CMC/sodium alginate	95±0.36
F4	Curcumin /chitosan / sodium alginate	98±1.48

Drug Loading and Entrapment efficiency

As the percentage of coated polymers with different viscosity grades increased, we saw a consistent rise in drug entrapment efficiency in formulations F1 through F4, ranging from 71.93 %w/v to 83.02 %w/v. The table contains the specific results.

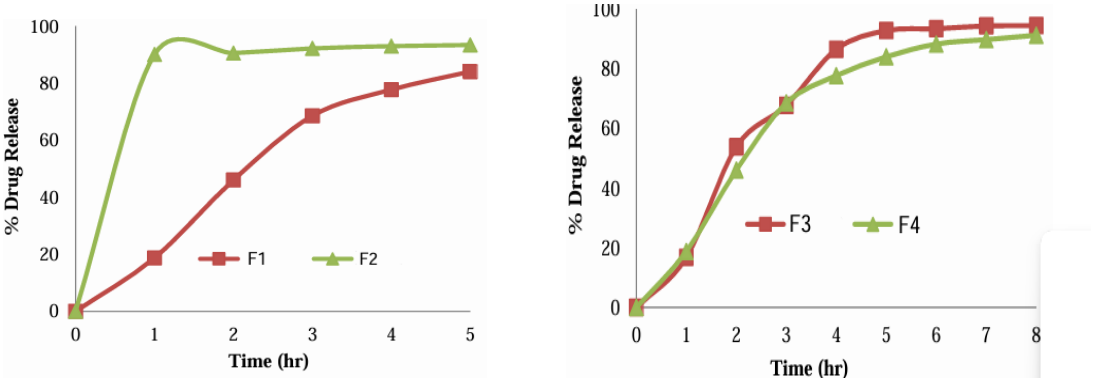
S. No	Drug formulation	Drug entrapment efficiency % (w/w)	Drug encapsulation efficiency
1	F1	75.93±0.03	12.19±0.02
2	F2	74.50±0.05	11.52±0.04
3	F3	73.72±0.04	12.19±0.03
4	F4	82.77±0.05	14.13±0.05

In-vitro drug release study

Table 5 displays the cumulative proportion of medication release from various formulations. Figure 3 makes it evident that the polymer HPMC K100M (F3) efficiently maintains the drug release, with the curcumin microbeads achieving 99.75% at the 12-hour point. However, the formulations that used CMC and HPMC K4M were unable to sustain the drug release for the required amount of time.

Table 5: Cumulative % of drug release.

Time in hrs	F1	F2	F3	F4
0.5	20.62±0.84	15.84±0.61	21.03±1.07	25.32±1.30
1	33.71±0.26	23.62±0.97	32.16±0.97	48.91±1.24
2	44.52±1.25	34.52±1.20	42.33±1.24	65.23±0.87
3	50.84±1.63	46.35±0.78	49.53±0.95	73.54±0.67
4	68.51±1.42	55.62±1.25	58.62±1.36	88.35±1.11
5	84.88±0.96	60.32±1.86	69.65±1.45	93.58±1.20
6	91.48±1.24	66.84±0.56	78.95±0.96	99.72±1.01



% Drug release of F1 and F2 % Drug release of F3 and F4

Fig. 4: Cumulative drug release of F1-F4 formulations.

Antimicrobial activity: Gram-positive S. aureus and gram-negative E. coli were used to investigate the antibacterial efficacy of many formulations. We saw distinct areas where growth was suppressed. The table provides specifics on the outcomes, including the zones of inhibition for every formulation. Our research revealed that when curcumin was applied topically as a scrub, it retained its antibacterial qualities against both of these microbes.

Table 6: Zone of Inhibition of prepared face scrub.

Microorganisms	Zone of Inhibition (mm)						
	Standard (Pure Drug)	F1	F2	F3	F4	F5	F6
S. aureus	29	28	28	27.5	25.5	28.5	26
E. coli.	30	27.5	28.5	29.5	27.5	28	27.5

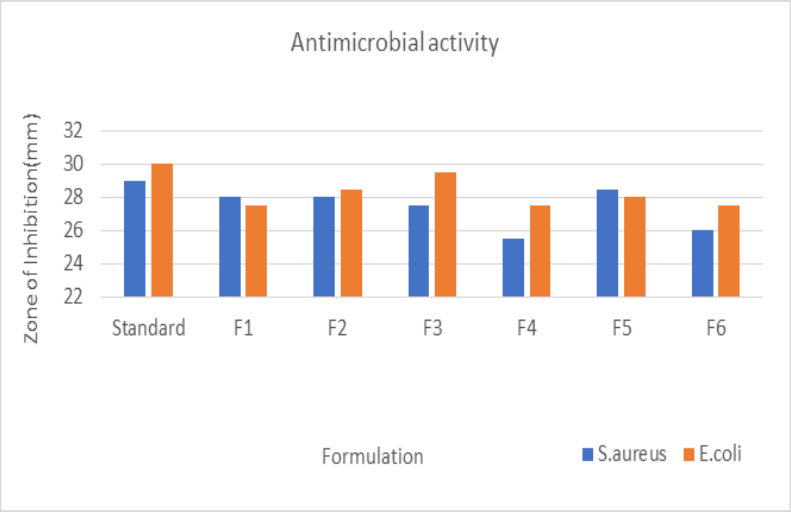


Fig. 5: Zone of inhibition prepared face scrub.

CONCLUSION

We used a combination of polymers, HPMC K100, chitosan, and sodium alginate, both separately and together, to make curcumin-loaded microbeads for a face scrub. The formulations containing 0.5% of HPMC K100 and chitosan each produced a consistent release of the medicine for roughly six hours, according to our comparison of the drug release rates of all the various formulations. With a release that lasts for a full six hours, it appears that this combination is the greatest choice for our curcumin-loaded microbead face scrub.

REFERENCES

1. Mullaicharam Bhupathyraaj, Alka Ahuja, Jayasekher and Sushama Pole, formulation of micro beads: a review, International Journal of Pharmaceutical Sciences and Research, 2021; 12(1): 95-103.
2. Ruo-Chi Hsu1, Ming-Yang Lin1, Kang-Yi Lien2, Lein-Yu Hung1, Fong-Yu Cheng 3, Chih-Chia Huang3, Chen-Sheng Yeh3, Huan-Yao Lei4 and Gwo-Bin Lee1,2, Tunable Magnetic Alginate Microbeads by Using a Spotting-based Alginate Microbead Generator and Its Applications for Immunoassay-based Diagnosis Proceedings of the 2011 6th IEEE International Conference on Nano/Micro Engineered and Molecular Systems February, 2011; 20-23, 117-120.
3. Bhupathyraaj M, Ahuja A, Pole JS. Formulation of Micro Beads: A Review. International Journal of Pharmaceutical Sciences and Research, 2021; 12(1): 95-103.
4. Kota RK, Gande S. Development and characterization of alginate microspheres containing Olmesartan by ionotropic gelation method. International Journal of Pharmaceutical Sciences and Drug Research, 2018; 10(4): 335-41.

5. S.P.Vyas and R.K.Khar, Targeted and Controlled drug delivery, 07: 418.
6. Lachman L, Liberman H, Kanig J. The Theory and Practice of Industrial Pharmacy. Mumbai: Varghese Publishing House, 1986; 3: 430.
7. Gibaldi M, Parrier D. Biopharmaceutics and clinical Pharmacokinetics. Philadelphia: Lea and Febiger, 1984; 3, 15: 64-82.
8. Belyaeva E, Valle D.D., Neufeld R.J. Ponceleta D. New approach to the formulation of hydrogel beads by emulsification/thermal gelation using a static mixer. Chem Eng Sci, 2004; 59(2): 2913–20.
9. Badarinath A.V. Reddy J.R. Mallikarjuna R. K. Alagusundaram M, Gnanaprakash K., Chetty M.S. Formulation and Characterization of Alginate Microbeads of Flurbiprofen by Ionotropic Gelation Techniques. Int J Chem Tech Res, 2010; 2(1): 361-367.
10. Prasanth V.V; Chakraborthy M. A.; Mathew S. T.; Mathapan R.; "Microspheres - An Overview"; International Journal of Research in Pharmaceutical and Biomedical Sciences, 2011; 2(2): 332-338.
11. Da SP, Diniz MM and De Jong G: Chitosan-alginate beads as encapsulating agents for Yarrowialipolytica lipase: Morphological, physico-chemical and kinetic characteristics. Int J of Bio Macro, 2019; 139: 621-30.
12. Kota RK and Gande S: Development and characterization of alginate microspheres containing Olmesartan by ionotropic gelation method. International Journal of Pharmaceutical Sciences and Drug Research, 2018; 10(4): 335-41.
13. Bilal M, Rasheed T, Iqbal HMN, Li C, Hu H and Zhang X: Development of silver nanoparticles loaded chitosan alginate constructs with biomedical potentialities. International Journal of Biological Macromolecules, 2017; 105(1): 393-400.
14. K. Rajini Naidu, B. Jasper Wilson, Md. Sana Safreen Siddiqua Banu, K. Ganga Bhavani, C Madhavi Latha, & Sreenivasulu M. Review of anaemia in pregnancy. Future Journal of Pharmaceuticals and Health Sciences, 2023; 3(2): 147–156.
15. Intakhab Alam M., Amit Kumar Nayak., Saquib Hasanain M., Sarawar Beg, "Mucoadhesive beads of Gliclazide: design, development and evaluation" Science Asia, 2010; 36: 319-325.
16. P. Balakrishnan, B.-J. Lee, D. H. Oh et al., "Enhanced oral bioavailability of dexibuprofen by a novel solid Self-emulsifying drug delivery system (SEDDS)," European Journal of Pharmaceutics and Biopharmaceutics, 2009; 72, 3: 539–545.

17. Unagolla JM, Jayasuriya AC. Drug transport mechanisms and in-vitro release kinetics of vancomycin encapsulated chitosan-alginate polyelectrolyte microparticles as a controlled drug delivery system. EJPS, 2018; 114: 199-09.
18. Das B, Devi JR. Microparticulate drug delivery system- a review. World Journal of Pharmaceutical and life sciences, 2016; 2(6): 243-58.
19. Badron V, Gurikov P. A continousapproch to the emulsion gelation method for the production of aerogel microparticle. CSPEA, 2019; 566: 58-69.
20. Varalaxmi A, Madhuri Reddy M, Deepika G, Simon M, Bharat P, Golam Sofiullah SK. Formulation and Evaluation of Nitrofurantoin Microspheres Loaded in Hard Gelatin Capsule. International Journal of Experimental and Biomedical Research, 2022; 1(1): 23-29.
21. Kataria S., Middha A., Sandhu P., Ajay B. and Bhawana K.; "Microsphere: A Review" International Journal of Research in Pharmacy and Chemistry, 2011; 1(4): 125-145.
22. Khan S.; Tiwari T.; Rao N.; Joshi A.; Dubey B.K.; "Microspheres: A Review"; World journal of pharmacy and pharmaceutical sciences, 2012; 1(1): 125- 145.
23. Pandya K.; Prajapati G.; Patel M.R.; Patel K.R.; Patel N.M.; "A Review on Microspheres"; Internationalepharmaceuticasciencia, 2012; 2(2): 53-57.
24. Alagusundaram M, Chetty MS, Umashankari K, Badarinath AV, Lavanya C, Ramkanth S. Microspheres as a novel drug delivery system: A review. Int J Chem Tech Res, 2009; 1(3): 526 534.
25. VN Deshmukh, JK Jadhav, VJ Masirkar, and DM Sakarkar. Formulation, Optimization and Evaluation of Controlled Release Alginate Microspheres Using Synergy Gum Blends. Available from: URL: http://www.rjptonline.org/ volumes and issue/ 2009/ vol-2- issue-3
26. Jakir Ahmed Chowdhury, Sheikh Tasnim Jahan, Md. Masud Morshed, Jewel Mallick, Aninda Kumar Nath, Md Zia Uddin. Development and Evaluation of Diclofenac Sodium Loaded Alginate Cross-Linking Beads. Bangladesh Pharmaceutical Journal, 2011; 14(1): 41-48.