

Formulation and Evaluation of an Ion-Activated in-Situ Floating Gel of Ginger (*Zingiber officinale* Roscoe) Extract for Gastroretentive Delivery

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Abstract: The present study explored a liquid-to-gel gastroretentive system containing ethanolic ginger extract. Shade-dried ginger rhizomes were extracted by ethanolic maceration, and the extract was quantified by a UV-Visible spectrophotometric procedure at 237 nm. Eight formulations (F1-F8) were developed using sodium alginate as the principal ion-responsive polymer; hydroxypropyl methylcellulose (HPMC) was included to modify viscosity and release, while calcium carbonate and sodium bicarbonate supported ion-triggered gel formation and buoyancy. The formulations were examined for pH, viscosity, gelation capacity, floating lag time, total floating duration, extract content and in-vitro release. The calibration data gave the regression equation $y = 0.316x - 0.002857$ with $R^2 = 0.993116$ over the reported concentration range. Among the batches, F7 showed pH 6.90, viscosity 710 cP, gelation capacity +++, floating lag time 24 s, floating duration 16 h and extract content 98.7%; the formulation-comparison table reported 98.4% cumulative release at 12 h. For F7, the reported kinetic fitting was highest for the Higuchi model ($R^2 = 0.996431$). On the basis of the combined physicochemical, floating and release characteristics, F7 was identified as the most suitable laboratory formulation. The findings support further investigation of ginger-extract in-situ floating gels as gastroretentive herbal delivery systems; however, botanical authentication, complete batch composition, stability, in-vivo gastric-retention studies and clinical evaluation are necessary before therapeutic or commercial claims are made.

Keywords: Ginger Extract, Gastroretentive Delivery, in-Situ Gel, Floating System, Sodium Alginate, HPMC, Sustained Release and UV-Visible Spectrophotometry.

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I. INTRODUCTION

Oral dosage forms are convenient to administer, but their residence in the stomach is often limited by physiological gastric emptying. This limitation can be important when a formulation is intended to remain in the upper gastrointestinal tract for an extended period. Gastroretentive drug-delivery approaches seek to increase residence time by using mechanisms such as flotation, swelling, adhesion or density modification. In-situ floating gels are particularly attractive because they can be administered as liquids and subsequently transform into a gel under gastric conditions [1-4].

Ion-responsive in-situ gels commonly employ polymers capable of cross-linking in the presence of physiological ions. Sodium alginate is especially useful because calcium ions can promote formation of a calcium-alginate network. In formulations containing a gas-generating component, carbon dioxide may become retained within the newly formed matrix, lowering its apparent density and promoting buoyancy. Polymer concentration, gel strength and gas generation therefore influence floating lag time, floating duration and release behaviour [1,2, 11-17].

Ginger (*Zingiber officinale* Roscoe) is the medicinal rhizome of a plant belonging to the family Zingiberaceae. Its

recognized phytochemical groups include gingerols, shogaols, zingerone and volatile constituents. Ginger has a long history of use in digestive and gastrointestinal preparations, and its biological effects have been investigated in relation to nausea, gastric discomfort, antioxidant activity and gastrointestinal function. These properties provide a rationale for examining ginger as the herbal component of a gastroretentive delivery system.

The present work was designed to prepare eight ion-activated in-situ floating gel formulations containing ginger extract and to compare their physicochemical, floating and in-vitro release characteristics. UV-Visible spectrophotometry was used to establish a working calibration relationship for estimation of extract content. The formulation showing the most balanced performance was selected for further kinetic analysis.

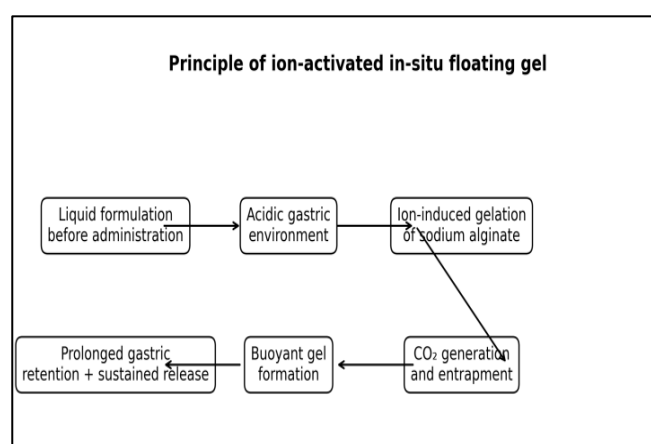


Fig 1 Conceptual Mechanism of the Ion-Activated in-Situ Floating Gel.

The diagram summarizes the intended sequence: liquid administration, ion-mediated gel formation, carbon-dioxide entrapment and development of a buoyant gel matrix.

II. MATERIALS AND METHODS

➤ Materials

Fresh ginger rhizomes were obtained from a local market. Sodium alginate, hydroxypropyl methylcellulose, calcium carbonate, sodium bicarbonate, trisodium citrate, methyl paraben, ethanol and purified water were used for extraction and formulation. The source project states that the chemicals and reagents were of analytical grade.

➤ Preparation of Ginger Extract

Mature, apparently healthy ginger rhizomes were washed first with water and then with distilled water. The material was cut into smaller pieces and shade-dried at room temperature until a constant weight was obtained. The dried rhizomes were powdered mechanically and protected from light and moisture until extraction. Ethanolic maceration was used to prepare the extract. The liquid extract was filtered and concentrated under controlled conditions to obtain a semisolid mass, which was transferred to an amber container and stored under refrigeration until formulation.

The source records indicate that the plant material was collected and subjected to an authentication step; the authentication authority and certificate number, however, were not included in the manuscript data available for this preparation. This information should be inserted from the laboratory record before submission.

➤ UV-Visible Calibration of Ginger Extract

A stock solution nominally containing 100 µg/mL of ginger extract was prepared by dissolving 10 mg of extract in 100 mL distilled water. Aliquots were diluted to obtain the reported working concentrations. Absorbance was measured at 237 nm against distilled water. A calibration plot was generated using concentration on the abscissa and absorbance on the ordinate. The reported observations are listed in Table 1.

Table 1 Reported UV-Visible Calibration Data for Ginger Extract.

Concentration (µg/mL)	Absorbance
0	0.000
1	0.267
2	0.608
3	0.983
4	1.328
5	1.628
6	1.802

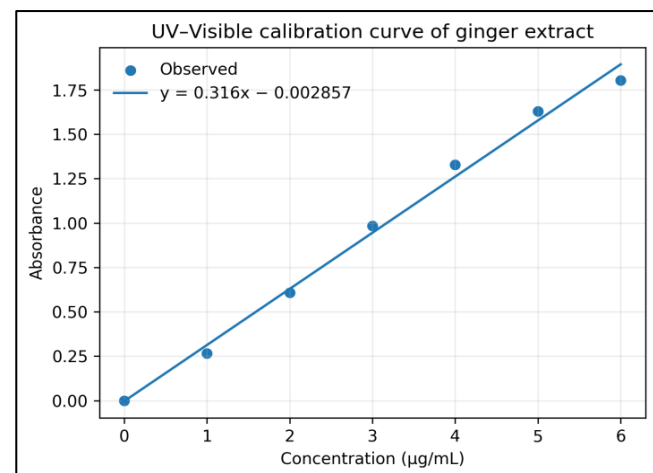


Fig 2 Calibration Plot of Ginger Extract by UV-Visible Spectrophotometry.

The reported regression was $y = 0.316x - 0.002857$ with $R^2 = 0.993116$, demonstrating a strong concentration-response relationship over the investigated range.

➤ Formulation of in-Situ Floating Gel

The formulation strategy combined ion-triggered polymer gelation with gas generation. Sodium alginate was selected as the principal gelling polymer, whereas HPMC was included to modify viscosity and retard matrix diffusion. Calcium carbonate supplied calcium ions for alginate cross-linking and sodium bicarbonate served as the carbon-dioxide-generating component. Trisodium citrate was incorporated to reduce premature gel formation during preparation, and methyl paraben was used as a preservative. Eight batches

(F1–F8) were prepared by changing the sodium alginate level while keeping the other formulation components at their respective study levels. Purified water was heated gently and sodium alginate was dispersed with continuous stirring. HPMC was added gradually and mixed until a uniform polymeric dispersion was obtained. Trisodium citrate and methyl paraben were then incorporated, followed by calcium carbonate and sodium bicarbonate under continuous mixing. The ginger extract was separately dissolved and introduced slowly into the polymeric phase. The final volume was adjusted with purified water, and the preparations were transferred to airtight amber containers for subsequent evaluation. The exact quantitative composition of each F1–F8 batch was not present in the source manuscript supplied for this rewrite. Consequently, no unreported quantities have been introduced into this article. The formulation-composition table from the laboratory record should be inserted before final submission to ensure reproducibility.

➤ Evaluation of Formulations

Physical appearance and homogeneity were assessed visually. The pH was measured using a calibrated pH meter. Viscosity was determined using a suitable viscometer under the study conditions. Gelation was examined after exposure to simulated gastric conditions and graded qualitatively as +, ++ or +++. Floating lag time was recorded as the time required for the formulation to reach the surface, while total floating time represented the duration of buoyancy in 0.1 N hydrochloric acid. Extract content was estimated after

dilution and filtration using the UV–Visible calibration relationship. The source article reports triplicate measurements expressed as mean $\pm$ standard deviation.

In-vitro release was followed at predetermined intervals up to 12 h. The reported release data were evaluated using zero-order, first-order, Higuchi, Korsmeyer–Peppas and Hixson–Crowell models. The coefficient of determination (R^2) was used to compare model fit.

III. RESULTS AND DISCUSSIONS

➤ UV–Visible Calibration

The absorbance increased with increasing extract concentration. The reported calibration relationship was $y = 0.316x - 0.002857$, with $R^2 = 0.993116$. This relationship was used to estimate the extract content of the formulated batches. The calibration plot is shown in Fig. 2.

➤ Physicochemical and Floating Characteristics

The eight formulations showed pH values from 6.20 to 7.00. Across the formulation series, viscosity rose from 380 to 760 cP. Gelation improved from + for F1–F2 to ++ for F3–F4 and +++ for F5–F8. Floating lag time declined from 80 to 22 s, while total floating time increased from 8 to 16 h. The overall trend suggests that increasing the sodium-alginate level strengthened the gel network and improved buoyancy-related performance.

Table 2 Reported Physicochemical, Floating and Release Results for F1–F8.

Batch	pH	Viscosity (cP)	Gelation	Lag time (s)	Floating time (h)	Extract content (%)	Release at 12 h (%)
F1	6.20	380	+	80	8	91.8	82.4
F2	6.35	430	+	70	9	93.1	85.7
F3	6.50	485	++	58	10	94.5	89.3
F4	6.60	540	++	45	12	95.8	92.5
F5	6.70	600	+++	34	14	97.0	95.8
F6	6.80	655	+++	28	15	98.0	97.6
F7	6.90	710	+++	24	16	98.7	98.4
F8	7.00	760	+++	22	16	98.4	97.9

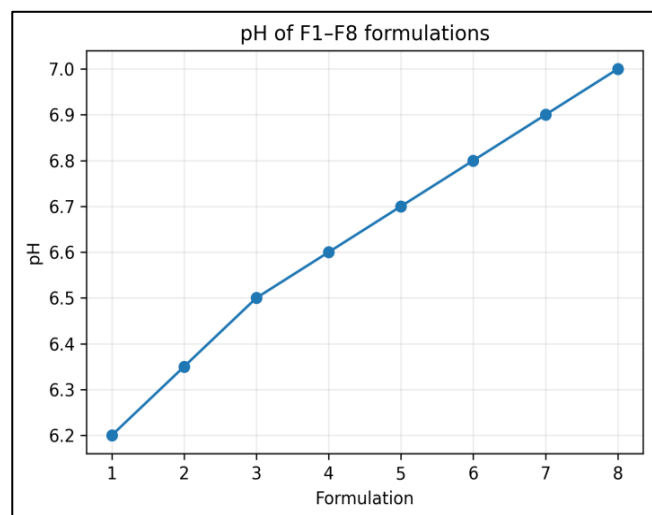


Fig 3 pH Profile of F1–F8.

The reported pH values increased gradually from 6.20 for F1 to 7.00 for F8.

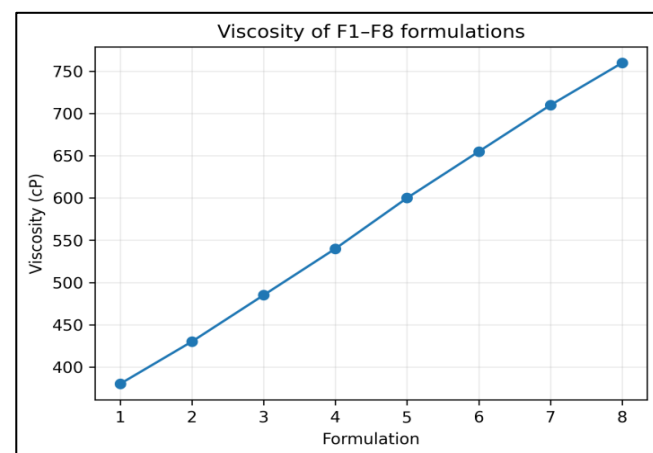


Fig 4 Viscosity Profile of F1–F8.

Viscosity increased from 380 cP to 760 cP across the formulation series

Reported extract content ranged from 91.8% to 98.7%, with F7 showing the highest value.

F7 displayed a pH of 6.90, viscosity of 710 cP, +++ gelation, a 24 s floating lag time, 16 h of buoyancy and 98.7% extract content. F8 floated slightly sooner than F7 (22 s) and also remained buoyant for 16 h, but its reported extract content and 12-h release were lower than those of F7. The source study therefore identified F7 as the preferred batch on the basis of the combined evaluation profile.

➤ In-Vitro Release Behaviour

The formulation-comparison table reported progressive release over 12 h, with F7 reaching 98.4%. The detailed time-course dataset available in the source material contains values that are not fully consistent with the summary table for some batches. To avoid introducing a false value, the present article uses the formulation- comparison result for selection of F7 and reports the detailed F7 time course only where it is internally consistent with the source.

For F7, release increased from 11.8% at 0.5 h to 98.4% at 12 h in the detailed dataset. The gradual release pattern is compatible with diffusion through a hydrated polymeric matrix formed by sodium alginate and HPMC. Nevertheless, a mechanistic conclusion should remain provisional because the available data do not include complete replicate-level statistics or a validated mechanistic study.

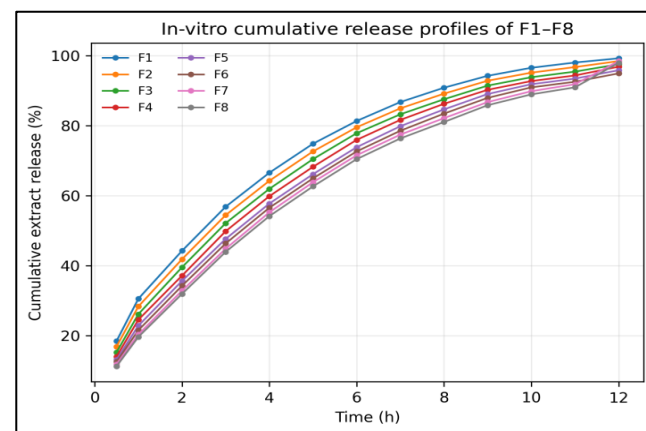


Fig 8 Reported in-Vitro Cumulative Release Profiles of F1–F8.

The plotted curves reproduce the time-course values supplied in the source article. Because the source summary table and detailed release dataset are not completely concordant, the original laboratory records should be used to verify the curves before submission.

➤ Release-Kinetic Analysis of F7

Table 3 Reported Kinetic-Model Fitting for Optimized Formulation F7.

Model	Reported R ²
Zero-order	0.941898
First-order	0.896755
Higuchi	0.996431
Korsmeyer–Peppas	0.665617

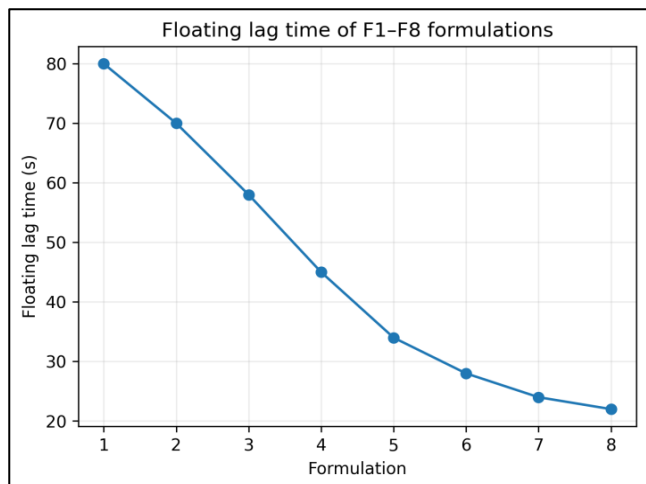


Fig 5 Floating Lag Time of F1–F8.

The time required to achieve buoyancy decreased from 80 s to 22 s.

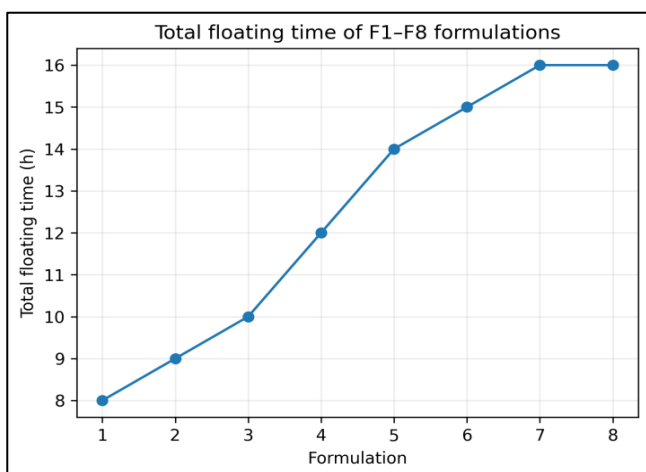


Fig 6 Total Floating Duration of F1–F8.

Floating duration increased from 8 h for F1 to 16 h for F7 and F8

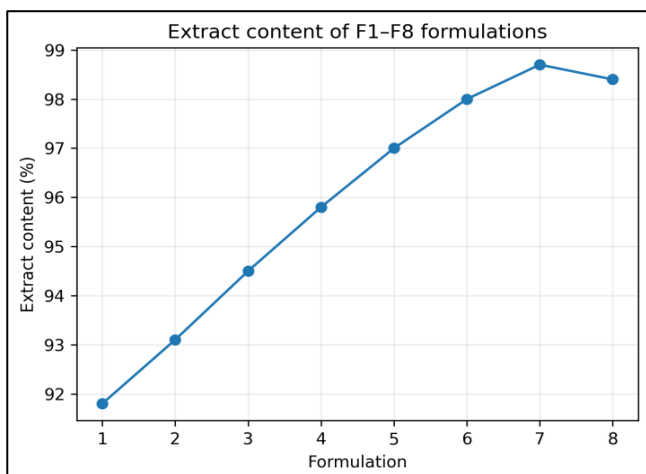


Fig 7 Extract Content of F1–F8.

Among the reported models, the Higuchi equation produced the highest coefficient of determination ($R^2 = 0.996431$). This indicates that the Higuchi model provided the closest mathematical description among the models reported for F7 under the study conditions. It should not, by itself, be interpreted as definitive proof of a single release mechanism.

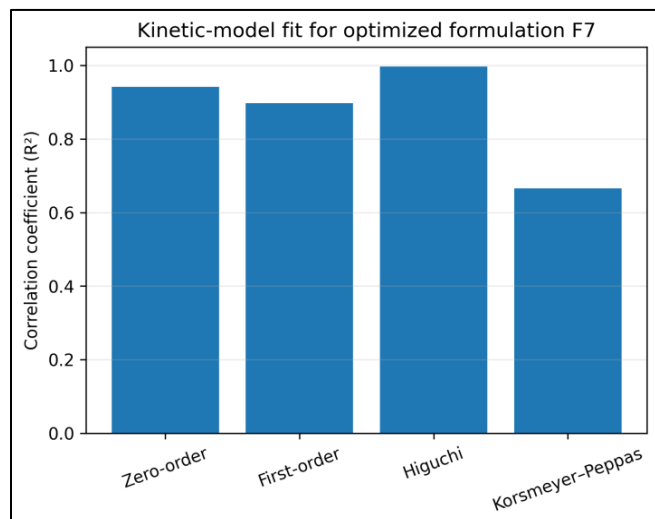


Fig 9 Comparison of Reported Kinetic-Model R^2 Values for F7.

The Higuchi model gave the highest reported fit ($R^2 = 0.996431$), followed by zero-order, first-order and Korsmeyer–Peppas models.

➤ Selection of the Optimized Batch

F7 was selected as the optimized laboratory batch because it provided the most balanced combination of gelation, buoyancy, extract content and reported release. Its principal characteristics were pH 6.90, viscosity 710 cP, +++ gelation, 24 s floating lag time, 16 h floating duration, 98.7% extract content and 98.4% reported cumulative release at 12 h. These results demonstrate formulation feasibility rather than therapeutic efficacy.

IV. CONCLUSION

An ion-activated in-situ floating gel containing ethanolic ginger extract was developed as a laboratory-scale gastroretentive delivery platform. Increasing polymer level across F1–F8 was accompanied by higher viscosity, stronger qualitative gelation, shorter floating lag time and longer buoyancy. F7 produced the most balanced profile and was therefore selected as the optimized batch in the source study. Its reported extract content was 98.7%, while the formulation-comparison table reported 98.4% release at 12 h and the kinetic analysis showed the highest R^2 for the Higuchi model. The findings indicate that ginger extract can be incorporated into an in-situ floating system with prolonged buoyancy. Further work is required to confirm botanical identity, formulation composition, reproducibility, storage stability, gastric retention, safety and pharmacological benefit before any clinical or therapeutic claim is made.

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DECLARATIONS

➤ Conflict of Interest

The authors declare that they have no known conflict of interest related to the work presented in this manuscript.

REFERENCES

- [1]. Gayen, S., Bandyopadhyay, R., Ganguly, R., & Das, S. (2021). A review on floating oral in-situ gelling system. *International Research Journal of Modernization in Engineering Technology and Science*, 3, 1816–1823.
- [2]. Jacob, S., Mathew, A., & Shyma, M. S. (2020). A review on oral in-situ gelling system. *Journal of Pharmaceutical Sciences and Research*, 12, 1056–1061.
- [3]. Aijaz, A., Subhash, V., Rageeb, M., & Kailash, R. (2019). *A textbook of novel drug delivery systems*. PV Publication.
- [4]. Bevyatricks, K. J., & Joshi, A. S. (2020). *Novel drug delivery systems*. Pharmacy Council of India.
- [5]. Arunachalam, A., Karthikeyan, M., & Konam, K. (2011). Floating drug delivery system: A review. *International Journal of Research in Pharmaceutical Sciences*, 2, 76–83.
- [6]. Shashank, C., Prabha, K., Sunil, S., & Kumar, A. V. (2013). Approaches to increase the gastric residence time: Floating drug delivery systems—A review. *Asian Journal of Pharmaceutical and Clinical Research*, 6, 1–9.
- [7]. Jassal, M., Nautiyal, U., Kundlas, J., & Singh, D. (2015). A review: Gastroretentive drug delivery system. *Indian Journal of Pharmaceutical and Biological Research*, 3, 82–92.
- [8]. Parmar, P. D., Pande, S., Shan, S. H., & Sonare, N. (2014). Floating drug delivery system: A novel approach to prolong gastric retention. *World Journal of Pharmaceutical and Pharmaceutical Sciences*, 3, 418–444.
- [9]. Niharika, M. G., Krishnamoorthy, K., & Akkala, M. (2018). Overview on floating drug delivery system. *International Journal of Applied Pharmaceutics*, 10, 65–71.