Development Of Floating Herbal Beads of Gastric Ulcer Therapy

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Abstract- Gastric ulcer is a gastrointestinal disorder of high prevalence, whose lesions are located in the stomach lining and are the result of an imbalance between the aggressive factors, which include gastric acid, pepsin, and Helicobacter pylori and defensive factors that comprise mucus secretion and mucosal integrity. The growing prevalence of gastric ulcers, and the drawbacks of traditional drug therapy, including frequent dosing, adverse effects and poor adherence to therapy, have seen the development of new drug delivery methods and safer methods of therapy. The use of herbal medicines has attracted much attention in the recent years because of their natural source, safety, and effectiveness in treating diseases. Curcuma longa (turmeric), Piper nigrum (black pepper), and Berberis aristata (daruharidra) are medicinal plants that have been extensively reported to possess anti-ulcer, antioxidant, anti-inflammatory and gastroprotective effects.

Keywords: Gastric ulcer, Helicobacter pylori, Curcuma longa (turmeric), anti-inflammatory and gastroprotective effects.

I. INTRODUCTION

Gastric ulcer is a gastrointestinal disorder of high prevalence, whose lesions are located in the stomach lining and are the result of an imbalance between the aggressive factors, which include gastric acid, pepsin, and Helicobacter pylori and defensive factors that comprise mucus secretion and mucosal integrity. The growing prevalence of gastric ulcers, and the drawbacks of traditional drug therapy, including frequent dosing, adverse effects and poor adherence to therapy, have seen the development of new drug delivery methods and safer methods of therapy.

The use of herbal medicines has attracted much attention in the recent years because of their natural source, safety, and effectiveness in treating diseases. Curcuma longa (turmeric), Piper nigrum (black pepper), and Berberis aristata (daruharidra) are medicinal plants that have been extensively reported to possess anti-ulcer, antioxidant, anti-inflammatory and gastroprotective effects. Curcuma longa is a source of curcumin which has potent antioxidant and mucosal protective properties. Piper nigrum increases bioavailability of drugs and has anti-inflammatory properties because of the availability of piperine. Berberis aristata has a compound, berberine, that possesses anti-microbial and healing powers. The synergistic effect of these herbal drugs is provided in the treatment of gastric ulcers.

The herbal drugs are disadvantaged by their inability to dissolve, insolubility in gastrointestinal fluids, and quick excretion by the stomach despite their therapeutic potential. These difficulties may lessen their bioavailability and treatment outcomes. To address these restrictions, the creation of gastroretentive drug delivery systems (GRDDS) has come into being as a viable solution. The systems are developed to increase the length of stay of drugs in the stomach that leads to the increased absorption of drugs and drug therapy.

Floating drug delivery systems (FDDS) are some of the gastroretentive systems that have become significant. The density of FDDS is supposed to be lower than that of the gastric fluids so that it can be able to stay on the top of the stomach contents long enough. This is due to prolonged gastric retention which provides sustained drug release and enhanced bioavailability specially to drugs that are mainly absorbed in the stomach or have greater solubility in

acidic pH. Floating systems also minimize the dosing frequency and increase patient compliance.

Floating herbal beads are a new and efficient multiparticulate drug delivery system. They are normally prepared in the form of polymers like sodium alginate under ionotropic gelation method where the cross-linking agent like calcium chloride is used to create a stable gel matrix. The desirable properties of the beads include regulated drug delivery, homogenization, enhanced stability and gastric retention. Also, multiparticulate systems have advantages over single-unit dosage form, such as decreased dose dumping and improved uniformity of drug distribution in the gastrointestinal tract.

The current research is aimed at designing and testing floating herbal beads with extracts of Curcuma longa, Piper nigrum and Berberis aristata in the treatment of gastric ulcers. The process involves the collection and authentication of crude drugs, the preparation of herbal extract, preformulation studies, formulation of floating beads, and the determination of other parameters which include particle size, entrapment efficiency, floating behavior, swelling index, in-vitro drug release and stability.

The aim of this study is to establish a stable and working gastroretentive floating drug delivery system utilizing herbal extracts that will be able to furnish sustained drug launch, increased gastric residence period and improved therapeutic performance against gastric ulcers. This is done with an objective to integrate the advantage of the herbal medicine with the modern technology of drug delivery to achieve better patient compliance and treatment outcomes.

II. EXPERIMENTAL WORK

2.1. Collection and Identification of Crude Drugs

Curcuma longa, Piper nigrum and Berberis aristata were purchased in the local herbal market of Buldana, Maharashtra in the form of rhizomes, fruits and roots respectively. The crude drugs were chosen due to their therapeutic application in gastric disorders and reported pharmacological activities. The materials that were gathered were confirmed using their morphological and organoleptic features.

The crude drugs were all looked at keenly so that they were not contaminated by dust and insects, fungi or any other foreign substance. Rhizomes and roots were thoroughly washed with distilled water and dried under a shade at room temperature so as to retain their active phytoconstituent. The dried materials were then crudely ground in a mechanical grinder and sifted through an appropriate sieve to get homogenous particle size. The airtight containers containing the powdered samples were kept under dry conditions until further use.

2.2. Preparation of Herbal Extract.

The crude drugs were then weighed and extracted in appropriate quantities in the form of a powder. Appropriate solvent system (e.g., hydroalcoholic solvent) by maceration or Soxhlet extraction method was used to extract it. This extraction was repeated up to full exhaustion of the drug material.

The extract thus obtained was filtered through muslin cloth then Whatman filter paper to eliminate the insoluble impurities. A rotary evaporator was then used to concentrate the filtrate under reduced pressure and dry it to be left with a semi-solid mass. The dried extract was placed in a desiccator until it was used in formulation.

2.3. Preformulation Studies

2.3.1 Organoleptic Evaluation

The ready herbal extract was analyzed in terms of its organoleptic characteristics such as color, smell and look. The extract was visualized and smelled in small amount to evaluate its characteristic features. Purity was also tested by checking the presence of foreign matter.

2.3.2 Solubility Studies

The solubility of the herbal extract was studied in various media, such as distilled water, 0.1 N hydrochloric acid (pH 1.2), and phosphate buffer.

Each solvent was mixed with a known amount of extract and stirreded at a given time. Solubility behavior was observed visually and noted as either soluble, relatively-soluble or non-soluble.

2.3.3 Phytochemical Screening

The phytochemical screening of the herbal extract was preliminarily conducted in order to determine the presence of different sorts of bioactive constituents including alkaloids, flavonoids, tannins, phenolic compounds, saponins and glycosides. Each category of compounds was also subjected to standard qualitative tests with definite reagents and the findings were documented according to colour changes or the formation of a precipitate.

2.4. Floating Herbal Beads are developed as follows:

Ionotropic gelation method was used to prepare floating herbal beads. Polymer (sodium alginate) was added to a given amount of distilled water to create a homogeneous solution. Herbal extract was next added to the polymer solution and the mixture was stirred to a uniform dispersal.

This was then dropwise extruded through a syringe or a needle into a cross-linking solution containing calcium chloride. When the droplets came into contact with the cross-linking agent, the droplets were ionically gelled into spherical beads. The beads formed were left in the cross-linking solution during a given time to cure fully. The beads were subsequently pooled, rinsed using distilled water to eliminate unnecessary calcium ions and dried under ambient temperature. The dried beads were kept in the airtight containers and were to be evaluated further.

2.5. Evaluation of the Floating Herbal Beads

2.5.1 Physical Appearance

The beads were visually checked in terms of color, shape, texture of the surface, aggregation available and cracks on the surface. The observations were made to measure the general quality and acceptability of the formulation.

2.5.2 Particle Size Analysis

An optical microscope was used to determine the size of the beads. A glass slide with a sample of beads was used and the diameter of randomly chosen beads was measured with a calibrated eyepiece micrometer. The average size of the particles was determined using the measured values.

2.5.3 Entrapment Efficiency

The actual drug content in the beads was measured to determine the trapment efficiency. A given amount of beads was crushed and dissolved in an appropriate solvent. The solution was filtered and analyzed spectrophotometrically to find out the drug content.

The entrapment efficiency was determined by the following formula:

$$\text{Entrapment Efficiency (\%)} = \frac{\text{Actual Drug Content}}{\text{Theoretical Drug Content}} \times 100$$

2.5.4 Floating Lag Time and Floating Duration

The floating of the beads was tested in 0.1 N hydrochloric acid (pH 1.2). The floating lag time was calculated as the time required to make the beads go to the top of the dissolution medium. The total time taken by beads to stay afloat was noted as the floating period.

2.5.5 Swelling Index

The swelling curve of the beads was examined by placing a known mass of the dry beads in 0.1 N hydrochloric acid. At predetermined time intervals, the beads were removed, blotted to remove excess surface water, and weighed.

Swelling index was computed by use of formula:

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

2.5.6 In-Vitro Drug Release Study

The in-vitro drug release study was carried out using a USP Type II (paddle) dissolution apparatus. The medium in which the dissolution took place was 0.1 N hydrochloric acid kept at 37 +/-0.5 o C and stirred at a constant rate.

A fixed amount of beads was added to the dissolution medium and samples were taken at set time intervals. Filtering was done, and the drug content was studied with UV-visible spectrophotometer. The drug release was determined and tabulated as a percentage.

2.5.7 Stability Studies

The stability tests of the optimized formulation were conducted at 40 C + 2 C and 75 percent of relative humidity + 5 percent of relative humidity over three months. The samples were kept in the appropriate containers and assessed after a set time interval regarding the following parameters: physical appearance, particle size, entrapment efficiency, floating behavior, and drug content.

III. RESULTS AND DISCUSSION

3.1. Collection and Authentication of Crude Drugs

The rhizomes of *Curcuma longa*, fruits of *Piper nigrum*, and roots of *Berberis aristata* were collected from the local herbal market of Buldana, Maharashtra, based on their traditional medicinal use and reported efficacy in gastric disorders. The collected crude drugs were carefully examined to ensure they were fresh, mature, and free from contaminants such as soil, insects, fungal growth, or foreign matter. The materials were thoroughly washed with distilled water to remove adhering impurities and subsequently shade-dried at room temperature to preserve thermolabile phytoconstituents. The dried rhizomes and roots were coarsely powdered using a mechanical grinder, passed through a suitable sieve to achieve uniform particle size, and stored in airtight containers under dry conditions for further use in formulation.

3.2. Preformulation Studies

3.2.1. Organoleptic Evaluation

The organoleptic evaluation of the herbal extract revealed a brownish color, characteristic odor, and fine, uniform appearance, with no evidence of foreign matter. These observations indicate good quality, purity, and proper handling during extraction and storage. Consistency in organoleptic properties is essential for ensuring batch-to-batch uniformity and reproducibility in formulation development.

3.2.2. Solubility Studies

Solubility studies demonstrated that the herbal extract exhibited pH-dependent solubility behavior. It was found to be poorly soluble in distilled water, moderately soluble in phosphate buffer, and freely soluble in 0.1 N hydrochloric acid. The enhanced solubility in acidic medium suggests that the extract is suitable for gastroretentive drug delivery systems, as it can readily dissolve in gastric conditions, thereby improving drug availability at the site of action.

3.2.3. Phytochemical Screening

Preliminary phytochemical screening confirmed the presence of important bioactive constituents such as alkaloids, flavonoids, tannins, phenolic compounds, saponins, and glycosides in all three plant extracts. These compounds are known to exhibit antioxidant, anti-inflammatory, and cytoprotective activities. Flavonoids and phenolics help reduce oxidative stress, tannins form a protective layer over the gastric mucosa, and saponins and alkaloids contribute to ulcer healing. The presence of these phytoconstituents supports the therapeutic potential of the formulation in gastric ulcer management.

3.3. Evaluation of Floating Herbal Beads

3.3.1. Physical Appearance

The prepared floating herbal beads were light brown in color, spherical in shape, and exhibited a smooth and uniform surface texture. The absence of aggregation and surface cracks indicates good mechanical strength and integrity of the beads. The spherical shape ensures uniform swelling and predictable drug release, while the smooth surface

contributes to improved floating behavior and stability.

3.3.2. Particle Size Analysis

Particle size analysis revealed that the bead diameter ranged from 820 to 870 µm, with a mean particle size of 847 µm. The narrow size distribution indicates uniform bead formation, which can be attributed to controlled extrusion and consistent cross-linking conditions during ionotropic gelation. Uniform particle size is important for achieving consistent buoyancy, drug entrapment, and release characteristics.

3.3.3. Entrapment Efficiency

The entrapment efficiency of the floating herbal beads was found to be 90.5 ± 1.8%, indicating efficient incorporation of the herbal extract within the polymeric matrix. The high entrapment efficiency may be due to the formation of a dense polymer network that effectively traps the drug and minimizes its loss during preparation. The low standard deviation suggests good reproducibility and uniform distribution of the drug within the beads.

3.3.4. Floating Lag Time and Floating Duration

The floating behavior study showed that the beads exhibited a floating lag time of 32 seconds and remained buoyant for approximately 4 hours. The short lag time indicates rapid onset of buoyancy, while the prolonged floating duration ensures extended gastric residence time. This property is essential for gastroretentive drug delivery systems as it enhances drug retention in the stomach and improves therapeutic efficacy.

3.3.5. Swelling Index

The swelling study demonstrated that the beads exhibited a gradual increase in swelling index over time, reaching up to 130% at 8 hours. This indicates significant water uptake and hydration of the polymer matrix. Controlled swelling behavior is desirable as it maintains bead integrity, supports sustained drug release, and contributes to prolonged gastric retention without rapid erosion.

3.3.6. In-Vitro Drug Release Study

The in-vitro drug release study showed a sustained release pattern over 12 hours. An initial release of 10.5% was observed within the first 30 minutes, likely due to the presence of drug on the surface of the beads. This was followed by a gradual increase in drug release, reaching 94.6% at 12 hours. The sustained release profile indicates effective control of drug diffusion by the polymeric matrix, which helps in reducing dosing frequency and improving patient compliance.

3.3.7. Stability Studies

Stability studies conducted under accelerated conditions (40°C ± 2°C / 75% RH ± 5% RH) for three months indicated that the formulation remained stable throughout the study period. There were no significant changes in physical appearance, particle size, entrapment efficiency, floating behavior, or drug content. Minor variations observed were within acceptable limits, suggesting good physical and chemical stability and indicating that the formulation has satisfactory shelf-life potential.

IV. CONCLUSION

Overall, the results demonstrate that the developed floating herbal beads possess desirable physicochemical properties, high entrapment efficiency, effective buoyancy, controlled swelling behavior, and sustained drug release characteristics. The formulation remained stable under accelerated conditions, confirming its robustness and suitability for long-term storage. These findings support the potential of the developed system as an effective gastroretentive drug delivery approach for the management of gastric ulcers.

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