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FORMULATION AND EVALUATION OF FLOATING TABLETS WITH *GLYCYRRIZHA GLABRA*

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ABSTRACT

Herbal products are valued for their natural properties, lack of side effects, and affordability, making them beneficial for people across various countries. Considering these advantages, herbal plants were selected for this study. Licorice, a traditional medicinal herb, is widely used for treating ulcers. This study aimed to develop and evaluate herbal floating tablets containing Licorice extract (Glycyrrhiza glabra). The extract was prepared using maceration, in which Licorice was soaked in a 30:70 ethanol-water mixture for seven days. Afterward, the mixture was filtered, and the extract was dried in an oven before being stored in an airtight container for future use. The tablets were developed using a direct compaction technique, using Licorice extract along with polymers such as xanthan gum, sodium alginate, guar gum, and HPMC K15, as well as excipients like magnesium stearate, talc, and microcrystalline cellulose. The formulations were tested for properties including width, solidity, mass consistency, friability, suspension time, and dissolving rate. Optimization of the formulations focused on floating time and laboratory drug release. The tablet thickness ranged from 5 to 5.4 mm, while hardness varied between 6 and 6.4 kg/cm². All preparations met the USP standards for the tendency to break and weight uniformity. All tablets achieved a buoyancy time of under 5 minute and remained afloat for this entire study duration. This optimized formulation, FS3, demonstrated a drug release of 71.2% over 8 hours in vitro, with an initial buoyancy time of just 20 seconds. Each tablet formulation was successfully prepared.

KEYWORDS: Floating tablets, Licorice extract, different polymers, antiulcer activity.

INTRODUCTION

The major challenge in the development of an oral sustained release drug delivery system is not just to sustain the release of drug but also to prolong the presence of the dosage form within the gastrointestinal tract (GIT) until all the drug is completely released at the desired period of time.[1] Gastro-retentive drug delivery systems have gained significant interest in the past few decades. Most of the conventional oral delivery systems have shown some limitations related to fast gastric-emptying time.[2] Garg and Gupta[3] classified the gastro-retentive dosage forms into four main classes: (A) floating systems[4], (B) expandable systems[5], (C) bioadhesive systems[6] and (D) high density systems.[7] Floating systems are of two types: (i) effervescent systems, depending on the generation of carbon dioxide gas upon contact with gastric fluids, and (ii) non-effervescent systems. The latter systems can be further divided into four sub-types, including hydrodynamically balanced systems[8], microporous compartment systems[9], alginate beads[10] and hollow microspheres or microballons.[11] In addition, super-porous hydrogels[12] and magnetic systems.[13] In floating dosage forms (FDs), the dosage form remains buoyant on the gastric fluid when the stomach is full. However, as the stomach empties and the tablet reaches the pylorus, the buoyancy of the dosage form may be reduced. It may be due to passage of the dosage form through the pylorus into the small intestine. Thus, the buoyancy of floating dosage form in the stomach may be limited to only 3–4 h. Furthermore, FDs do not always release the drug at the intended site. In a bioadhesive drug delivery system, the mucous secreted by the mucosa lining of stomach wall may detach the drug from stomach wall due to high mucous turnover. Then the detached tablet may emptyed from the stomach along with its contents.[14] A floating-bioadhesive drug delivery system (FBDDS) would overcome these drawbacks of floating and bioadhesive systems and would have a significant effect on improving the therapeutic effect of the drug involved.[15]

Licorice is a plant with a sweet root used for centuries in traditional medicine. The root contains natural compounds that can help with sore throats, digestive problems, and inflammation. Licorice is often used to soothe the stomach, reduce coughing, and treat ulcers.

Licorice has several therapeutic properties that make it useful in medicine. The main active compound, glycyrrhizin, helps reduce inflammation and is widely used for treating ulcers and soothe the gut. Flavonoids in licorice have antioxidant properties, protecting cells from damage and supporting heart health.

The plant also has antimicrobial properties, which help fight infections and support respiratory health by reducing coughs. Licorice's antiviral activity makes it useful against some viral infections, while its anti-inflammatory effects make it beneficial for soothing skin conditions and reducing swelling.

The main aim of this project Formulation and evaluation of floating tablets with Glycyrrizha Glabra.

PREPARATION OF LICORICE EXTRACT

Preparation of Licorice extract by Maceration method

Licorice powder was procured from the Balu herbal store in Hyderabad. 100 of licorice powder was weighed accurately and transferred into the conical flask. Ethanol and water (70:30) were taken as solvents and kept for 6-7 days for maceration at room temperature. After 7 days filter the extraction with the help of filter paper. The extract solution is placed in a hot air incubator at a temperature of 50 °C and housed in an airtight vessel in a cool, dark location.

Fig 1: Image of licorice extract.

After 7 days use filter paper to filter the extract. The extract solution is subsequently subjected to heat in a hot air oven at 50°C and preserved in a tightly sealed container in a cool, dark location.

Formulation table of herbal tablets

Formulation table of herbal using different polymers

Xanthan gum (X1, X2, X3)

Table 1: formulation of herbal tablets with Xanthan gum.

Ingredients(mg)	FX1(75mg)	FX2(60mg)	FX3(50mg)
Licorice	250	250	250
Xanthan gum	75	60	50
Sodium bicarbonate	100	100	100
Magnesium stearate	10	10	10
Talc	20	20	20
Microcrystalline cellulose	45	60	70
Total weight	500	500	500

Physical characters of the extract

Color of extract: Brown

Total weight of extract: 8.8gm

Preparation of standard graph of Licorice (Glycyrrhetinic acid)

A UV spectrophotometric method has been established for analyzing the drug.

Formulating 0.1 N HCl solution

8.5 milliliters of hydrochloric acid (HCl) was measured and added for a volumetric flask, then diluted with distilled water added to achieve a resultant volume of 1000 milliliters.

Preparation of Stock Solution 1 in 0.1 Normal hydrochloric acid

A 100-milligram quantity of myrrh extract was weighed and placed into a 100 mL calibrated flask. The extract was dissolved in 70% ethanol, and the capacity was adjusted until 100 mL using the prepared 0.1 Normal hydrochloric acid buffer mixture, which is labeled as 1000 µg/ml.

Preparation of Stock Solution 2 in 0.1 N HCl of Licorice Extract

1 ml from the initial stock solution was dispatched into a 10 mL calibrated flask, subsequently diluted with 0.1 N HCl to a final volume of 10 milliliters. The resulting solution exhibits a concentration of 100 µg/milliliters and is labeled as Stock Solution 2.

Determination of absorption maxima in 0.1N HCL of the Licorice extract

During the procedure, 1 ml of Stock Solution 2 (100 µg/milliliters) was injected into a 10 milliliters volumetric flask along then brought up to 10 ml with 0.1 Normal hydrochloric acid. The resulting solution had a concentration of 10 µg/ml and was labeled as the test solution. Subsequently, the solution was analyzed employing a dual-beam UV-visible spectrophotometer to identify these absorption maxima of the drug within the wavelength interval of 200 nm to 400 nm. The drug demonstrated absorption maxima in 250 nm.

FX1: tablet with xanthan gum (75mg), **FX2:** tablet with xanthan gum (50mg), **FX3:** tablet with xanthan gum (60mg).

Sodium alginate (S1, S2, S3)

Table 2: formulation of herbal tablets with Sodium alginate.

Ingredients(mg)	FS1(75mg)	FS2(60mg)	FS3(50mg)
Licorice	250	250	250
Sodium Alginate	75	60	50
Sodium bicarbonate	100	100	100
Magnesium stearate	10	10	10
Talc	20	20	20
Microcrystalline cellulose	45	60	70
Total weight	500	500	500

FS1: tablet with Sodium alginate (75mg), FS2: tablet with Sodium alginate (50mg), FS3: tablet with Sodium alginate (60mg).

Guar gum (G1, G2, G3)

Table 3: Formulation of herbal tablets with Guar gum.

Ingredients(mg)	FG1(75mg)	FG2(60mg)	FG3(50mg)
Licorice	250	250	250
Guar gum	75	60	50
Sodium bicarbonate	100	100	100
Magnesium stearate	10	10	10
Talc	20	20	20
Microcrystalline cellulose	45	60	70
Total weight	500	500	500

FG1: tablet with Guar gum (75mg), FG2: tablet with Guar gum (50mg), FG3: tablet with Guar gum (60mg).

HPMC K15 (H1, H2, H3)

Table 4: Formulation of herbal tablets with HPMC K15.

Ingredients(mg)	FH1(75mg)	FH2(60mg)	FH3(50mg)
Licorice	250	250	250
HPMC K15	75	60	50
Sodium bicarbonate	100	100	100
Magnesium stearate	10	10	10
Talc	20	20	20
Microcrystalline cellulose	45	60	70
Total weight	500	500	500

FH1: tablet with HPMC K15(75mg), FH2: tablet with HPMC K15(50mg), FH3:tablet with HPMC K15(60mg).

Formulations Table of All Herbal Tablets

Table 5: Formulation of All herbal tablets with Different polymers.

Ingredients(mg)	FX1	FX2	FX3	FS1	FS2	FS3	FG1	FG2	FG3	FH1	FH2	FH3
Licorice	250	250	250	250	250	250	250	250	250	250	250	250
Xanthan gum	75	60	50	-	-	-	-	-	-	-	-	-
Sodium Alginate	-	-	-	75	60	50	-	-	-	-	-	-
Gaur gum	-	-	-	-	-	-	75	60	50	-	-	-
HPMC K15	-	-	-	-	-	-	-	-	-	75	60	50
Sodium bicarbonate	100	100	100	100	100	100	100	100	100	100	100	100
Magnesium salt of stearic acid	10	10	10	10	10	10	10	10	10	10	10	10
Talc	20	20	20	20	20	20	20	20	20	20	20	20
Microcrystalline cellulose	45	60	70	45	70	60	45	60	70	45	60	70
Total weight	500	500	500	500	500	500	500	500	500	500	500	500

Precompression studies

"The angle of repose can potentially be measured by applying various procedures:

1. Constant height method
2. Constant base method
3. Inclined table method

The constant height approach was employed to ascertain the angle of repose for the powder. The powder mixture was introduced into a funnel to form a heap, and the

funnel was positioned so that the apex of the heap just contacted its lower tip**.**

Following the measurement of the base diameter and height of the heap, the process was repeated three times to achieve an average diameter. The angle of repose was subsequently calculated using the formula:
θ is calculated as the tangent inverse of (h/r)
where:
h = height of the cone created by the powder
r = radius of the cone generated by the powder

Mass Density
Mass or Bulk density is characterized by the weight of the powder within a specific volume relative to its mass volume. To determine this, a measuring cylinder is filled with a pre-weighed amount of powder, and the initial weight is recorded. The bulk density is then calculated by Implementing the formula:

The bulk density (Db) is calculated by dividing the mass of the powder (m) by its bulk volume (Vb)
Where:
- m indicates the mass of the powder
- Vb refers to the bulk volume taken up by the powder

Hausner's Ratio=Tapped density (D_t)/Bulk density (D_b)
Preparation of Herbal Tablet Formulations

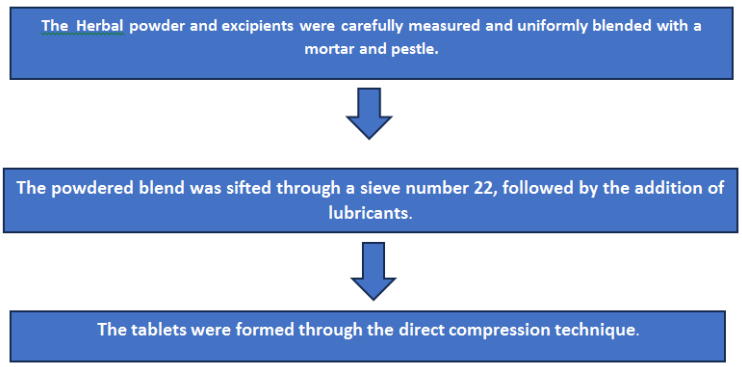

Fig. 2: Herbal Tablets.

Post-compression studies
Weight difference
The mass of Each of the twenty tablets was weighed individually, and the average weight was subsequently calculated. Using both the individual weights and the average weight, the percentage deviation was then determined as follows:

Weight Variation = (Weight of an individual tablet / Average weight of all tablets) × 100

Compacted density
compact density is measured Utilizing a density tester, which holds a Graduated measuring tube filled with a known powder mass. The cylinder is secured on the tester, which taps it 100 times at an initial 14 mm tall, incrementing by 3 millimeters per tap, to achieve a consistent volume. Tapped density is calculated as follows:

Tapped density (Dt) is calculated as the mass of the powder (M) divided by the final tapped volume (Vt)
Where:
- M stands for the mass of the powder
- Vt signifies the volume obtained after tapping

Carr's Compressibility Index
The compressibility index, which is determined using both tapped and bulk densities, is calculated with the following formula:

%Compressibility Index = (Dt - Db) / Dt × 100

Hausner's index
Hausner's index, a measure of flowability, is obtained from dividing tapped density by bulk density**:**

Durability
The toughness of the tablets was evaluated using a Monsanto hardness tester, with the results expressed in kg/cm².

Width
The Width of each tablet is measured using Vernier calipers, with the measurements recorded in millimeters (mm).

Friability
To assess friability, a Roche friability tester is operated on each batch and twenty tablets are weighed together to record an original weight. The formulations are then placed in this tester, which rotates them 100 times at around 25 Rotations per minute over 4 minutes. Subsequently, After rotation, The tablets are taken out and dusted, and their final weight is recorded. Friability is calculated as follows:

Friability Percentage = (Original weight - Final weight / Starting weight) × 100

DISSOLUTION STUDIES

In-vitro Dissolution assessments

In vitro, drug release experiments were conducted using a USP XXIV dissolution apparatus type 2. The dissolution medium, consisting of 900 ml of 0.1N HCl, was maintained at a temperature of 37±1°C for 8 hours, with stirring at 50 rpm. At predetermined time intervals, 5 ml samples were withdrawn from the dissolution medium and replaced with an equivalent volume of drug-free dissolution fluid. The collected samples were then filtered through a 0.45 µm membrane filter, and the amount of drug released was analyzed after appropriate dilution using a UV/Vis spectrophotometer at a wavelength of 250 nm.

In vitro Investigation of Antiulcer Properties

Acid-Neutralizing Capacity (ANC)

The ANC test was performed on extract samples quantities of 100 mg, 500 mg, 1000 mg, and 1500 mg, with a 500 mg sample of Aluminium hydroxide and Magnesium hydroxide mixture serving as the reference standard.

- Solution Preparation: Each extracted sample was diluted to A concluding volume of 70 milliliters by adding five mL of the sample and topping it up with water, followed by stirring for one minute.
- Acid Addition: To both the test samples and the standard, 30 mL of 1.0 Normal Hydrochloric acid was added, and the mixtures were Agitated for 15 minutes
- Indicator and Titration: A few drops of phenolphthalein were added as an indicator. The unreacted HCl in each solution was then Titrated with 0.5 N sodium hydroxide solution until a pink color was observed, indicating the endpoint.

Calculation of Moles of Acid Neutralized: The quantity of acid neutralized (in moles) were determined using the formula

Moles of Acid Neutralized

(HCl Volume × HCl Normality) - (NaOH Volume × NaOH Normality)

Calculating ANC for each gram of Extract: The **ANC (mEq /g)** was determined by Calculating the moles of HCl neutralized divided by the weight (in grams) of the antacid or extract:

$$\textbf{ANC per gram} = \frac{\text{Moles of HCL Neutralized}}{\text{Weight of Extract (g)}}$$

RESULTS AND DISCUSSION

Phytochemical analysis

- Licorice extract is analyzed phytochemically to identify and quantify the various bioactive compounds present.
- Licorice (*Glycyrrhiza glabra)* contains a range of phytochemicals that are responsible for its medicinal properties and anti-ulcer activities.
- Licorice contains several bioactive compounds. Alkaloids in licorice contribute to its anti-inflammatory and analgesic properties. Flavonoids, such as Liquiritin have antioxidant and anti-ulcer effects, protecting the stomach lining.
- Tannins help in astringent actions, supporting wound healing and reducing inflammation.
- Saponins, including glycyrrhizin, are known for their expectorant and immune-boosting activities. Terpenoids offer antimicrobial and antioxidant benefits, aiding in skin health and respiratory relief.
- Glycosides like glycyrrhizin exhibit strong anti-inflammatory and antiviral properties. Phenolic compounds found in Licorice have strong antioxidant effects, which help protect cells from oxidative stress.
- Phytochemical screening revealed that the hydro-ethanolic extracts of Glycyrrhiza glabra tested positive for saponin, flavonoids, alkaloids, steroids, terpenoids, tannins, and glycosides, but tested negative for carbohydrates, proteins, and phenolic compounds.

Table 6: Screening of phytochemicals in ethanolic extract of Licorice.

S.NO	Phytochemicals	Test performed	results
1	Astringents	Ferric ion test	+
2	Alkaloids	Dragendroff's test	+
3	Saponins	Froth test	+
4	Carbohydrates	Molisch's test	-
5	Terpenoids	Salkowski's test	+
6	Phenolics	Ferric sulphate test	-
7	Polyphenols	NaOH solution test	+
8	Glycosides	Keller-Killani reaction	+
9	Proteins	Copper sulphate test	-

(+ indicates presence, - indicates nonexistence of Bioactive compounds

Determination of absorption maxima in 0.1N HCL of the Licorice extract

Spectrophotometric analysis of absorption maxima

The absorption peak was detected by detecting a 10 µg/ml liquorice sample in a 0.1 N HCl buffer across its wavelength range of 200 to 400 nm using a UV-visible spectrophotometer. The resultant spectrum is displayed.

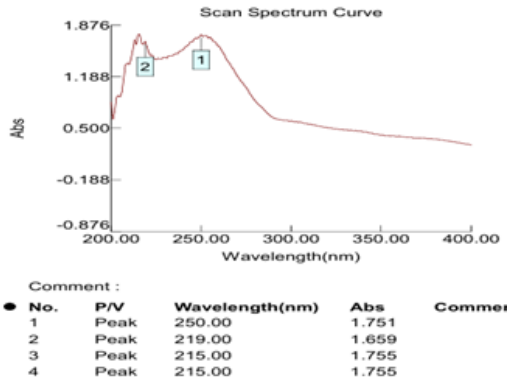

Fig. 3: Absorption maxima of Licorice extract in 0.1N HCL.

Preparation of a Standard Curve for Licorice Extract

Standard formulations of liquorice extract were produced at levels of 50, 100, 150, 200, 250, and 300 µg/ml from a stock solution using 0.1 N hydrogen chloride (HCL). The luminescence of each concentration was obtained at the maximum absorption spectrum of 250 nm using a UV spectrophotometer and a blank as a reference.

Table 7: Standard calibration curve values of Licorice extract.

S.NO	Concentration µg/ml)	Absorbance at 251nm
1	5	0.126±0.011
2	10	0.396±0.013
3	15	0.549±0.025
4	20	0.734±0.021
5	25	0.981±0.024

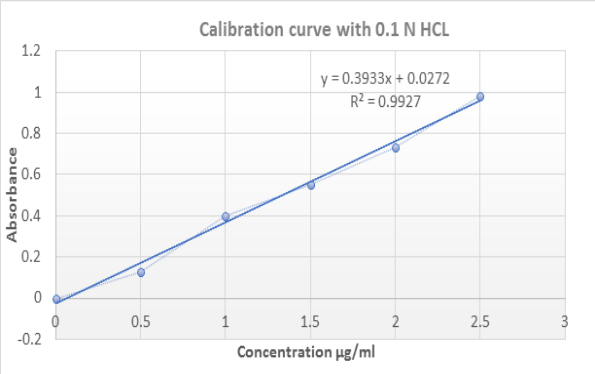

Fig. 4: standard graph of Licorice extract.

The standard curve for Licorice was plotted using UV spectrometry at an absorption maximum of 250 nm in 0.1N HCl. Within an inverse correlation coefficient (R^2) for values ranging from 5 to 25 µg/ml was calculated as 0.9927, yielding the equation y=0.3933x+0.0272y = 0.3933x + 0.0272y=0.3933x+0.0272.

Precompression characteristics

The pre-compression characteristics for natural medications include the Hausner ratio, the Carr's Compressibility Index, density at the tap (g/cm³), total density (g/cm³), and angle of repose (θ). These metrics provide useful information on the compressibility of the tablet formulation.

- The formulation FX1 contains xanthan gum(75mg) with a bulk density of 0.50, a tap density of 0.55, a Compressibility Index of 10.08, a Hausner Coefficient of 1.11, and an angle of repose of 34.93.
- The formulation FX2 contains xanthan gum(60mg) with a bulk density of 0.45, a tap density of 0.50, Carr's index of 9.00, Hausner's ratio of 1.09, and an angle of repose of 31.61.
- The formulation FX3 contains xanthan gum(50mg) with a bulk density of 0.47, a tap density of 0.52, Carr's index of 9.50, Hausner's ratio of 1.10, and an angle of repose of 28.25.
- The formulation FS1 contains sodium alginate(75mg) with a bulk density of 0.41, a tap density of 0.47, Carr's index of 12.35, a Hausner Coefficient of 1.14, and an angle of repose of 38.44.
- The formulation FS2 contains sodium alginate (60mg) with a bulk density of 0.43, a tap density of 0.50, a compression index of 13.00, Hausner's ratio of 1.14, and an angle of repose of 36.03.
- The formulation FS3 contains sodium alginate (50mg) with a bulk density of 0.45 a tap density of 0.50, Carr's index of 9.00, Hausner's ratio of 1.09, and an angle of repose of 38.44.
- The formulation FG1 contains guar gum(75mg) with a bulk density of 0.41, a tap density of 0.47, Carr's index of 12.00, Hausner's ratio of 1.14, and an angle of repose of 35.29.
- The formulation FG2 contains guar gum(60mg) with a bulk density of 0.45, a tap density of 0.50, Carr's index of 9.00, a Hausner Ratio of 1.09, and an angle of repose of 38.44.
- The formulation FG3 contains guar gum (50) with a bulk density of 0.41, a tap density of 0.47, Carr's index of 12.00, Hausner's ratio of 1.14, and an angle of repose of 37.48.
- The formulation FH1 contains HPMC K15(75mg) with a bulk density of 0.51, a tap density of 0.49, Carr's index of 9.00, Hausner's ratio of 1.09, and an angle of repose of 39.81.
- The formulation FH2 contains HPMC K15(60mg) with a bulk density of 0.45, a tap density of 0.50, Carr's index of 13.00, Hausner's ratio of 1.14, and an angle of repose of 36.57.
- The formulation FH3 contains HPMC K15(50mg) with a bulk density of 0.43, a tap density of 0.50, Carr's Compressibility Ratio of 10.00, Hausner Ratio of 1.10, and an angle of repose of 34.93.

The post-compression studies of F3 and F10 Indicate good results. When compared with all other formulations, the parameters of F3 and F10 are classified as good and excellent.

Table 8: Precompression parameters of formulations.

Formulation	Bulk density (g/ml)	Tapped density (g/ml)	Carr's index (%)	Hausner's ratio	Angle of repose (°)
FX1	0.50 ±0.015	0.55±0.016	10.08±0.03	1.11±0.026	34.93°
FX2	0.45±0.013	0.50±0.015	9.00±0.025	1.09±0.025	31.61°
FX3	0.47±0.014	0.52±0.016	9.50±0.025	1.10±0.016	28.25°
FS1	0.41±0.012	0.47±0.014	12.35±0.025	1.14±0.016	38.44°
FS2	0.43±0.013	0.50±0.025	13.00±0.025	1.14±0.026	36.03°
FS3	0.45±0.013	0.50±0.015	9.00±0.015	1.09±0.015	34.51°
FG1	0.41±0.012	0.47±0.014	12.00±0.023	1.14±0.027	35.29°
FG2	0.45±0.013	0.50±0.017	9.00±0.015	1.09±0.025	38.44°
FG3	0.41±0.012	0.47±0.014	12.00±0.024	1.14±0.027	37.48°
FH1	0.51±0.015	0.49±0.015	9.00±0.015	1.09±0.026	39.81°
FH2	0.45±0.019	0.50±0.025	13.00±0.025	1.14±0.027	36.57°
FH3	0.43±0.012	0.50±0.014	10.00±0.015	1.10±0.011	34.93°

Post-compression criteria of formulation

Post-compression characteristics give details on the thickness, hardness, weight variation, disintegration, stability studies, and assay of compressed tablets. These metrics are essential for quality control, as they define tablet quality. Adjustments in the disintegrant-to-binder ratio can affect tablet hardness, friability, and disintegration time.

- The formulation FX1 shows a weight variation of 0.495, hardness of 6.0, thickness of 5.0, friability of 0.403, Floating delay of 89 seconds, and a buoyancy duration of 11.30 hours.
- The Dosage form FX2 shows a weight variation of 0.500g, hardness of 6.2, thickness of 5.2, friability of 0.406, onset of floatation of 65 seconds, and a floatation period of 12.00 hours.
- The Pharmaceutical preparation FX3 shows a weight variation of 0.502g, hardness of 6.1, thickness of 5.1, friability of 0.403, floating lag time of 85 seconds, and a floating duration time of 11.40 hours.
- The formulation FS1 shows a weight variation of 0.493g, hardness of 6.3, thickness of 5.3, friability of 0.719, Lag period before buoyancy of 46 seconds, and a floating duration time of 10.10 hours.
- The formulation FS2 shows a weight variation of 0.500g, hardness of 6.4, thickness of 5.2, friability of 0.659, floating lag time of 15 seconds, and a retention time of 10.30 hours.
- The Drug formulation FS3 shows a weight variation of 0.493g, hardness of 6.0, thickness of 5.1, friability of 0.403, Float onset time of 20 seconds, and a floating duration time of 10.00 hours.
- The formulation FG1 shows a weight variation of 0.484g, hardness of 6.2, thickness of 5.3, friability of 0.403, Time to float of 100 seconds, and a buoyant time of 12.30 hours.
- The Pharmaceutical composition FG2 shows a weight variation of 0.475g, hardness of 6.1, thickness of 5.0, friability of 0.687 Buoyancy lag time of 18 seconds, and a float duration time of 12.50 hours.
- The formulation design FG3 shows a weight variation of 0.476g, hardness of 6.3, thickness of 5.2, friability of 0.617, Initial buoyancy period of 10 seconds, and a floating duration time of 12.10 hours.
- The formulation FH1 shows a weight variation of 0.483, hardness of 6.1, thickness of 5.1, friability of 0.562, Buoyancy delay of 135 seconds, and a float
- Time of 13.40 hours.
- The Therapeutic formulation FH2 shows a weight variation of 0.495, hardness of 6.0, thickness of 5.0, friability of 0.340, floating lag time of 45 seconds, and a Hovering duration time of 13.30 hours.
- The formulation FH3 shows a weight variation of 0.496, hardness of 6.4, thickness of 5.3, friability of 0.499 Floating delay time of 62 seconds, and a retention time of 13.22 hours.

Table 9: Post-compression parameters of formulation.

Formulations	Weight variation(gm)	Hardness (kg/cm^3)	Thickness (mm)	Friability (%)	Floating lag time (min)	Floating duration time (hr)
FX1	0.495±0.0492	6.0±0.020	5.0±0.020	0.585±0.017	89 sec	11.30±0.044
FX2	0.500±0.0493	6.2±0.025	5.2±0.026	0.300±0.018	65 sec	12.00±0.040
FX3	0.502±0.049	6.1±0.022	5.1±0.023	0.460±0.017	85sec	11.40±0.046
FS1	0.493±0.048	6.3±0.027	5.3±0.029	0.402±0.016	46sec	10.10±0.046
FS2	0.500±0.043	6.4±0.029	5.2±0.020	0.400±0.015	15 sec	10.30±0.040
FS3	0.493±0.048	6.0±0.020	5.1±0.026	0.362±0.019	20 sec	10.00±0.043

FG1	0.484±0.047	6.2±0.025	5.3±0.023	0.403±0.013	100sec	12.30±0.047
FG2	0.475±0.046	6.1±0.022	5.0±0.025	0.449±0.014	18 sec	12.50±0.042
FG3	0.476±0.046	6.3±0.027	5.2±0.029	0.617±0.013	10 sec	12.10±0.042
FH1	0.483±0.047	6.1±0.022	5.1±0.020	0.402±0.018	135 sec	13.40±0.043
FH2	0.495±0.048	6.0±0.020	5.0±0.026	0.608±0.017	45 sec	13.30±0.040
FH3	0.496±0.046	6.4±0.027	5.3±0.023	0.385±0.015	62 sec	13.22±0.049

***In-vitro* drug assessment of drug release**

Table 10: % of Drug release of Licorice formulations with xanthan gum.

Xanthan gum	FX1 (70mg)	FX2 (60mg)	FX3 (50mg)
0	0	0	0
30min	3.7±0.026	4.2±0.028	4.3±0.020
1hr	11.27±0.023	14.3±0.024	14.9±0.021
2hr	14±0.027	17.78±0.025	21.9±0.025
3hr	17.78±0.025	20.7±0.023	29±0.029
4hr	20.29± 0.023	26.9±0.028	31.6±0.024
5hr	27.75±0.027	32±0.027	33.22±0.025
6hr	29.41±0.026	33.9±0.021	35.1±0.021
7hr	32.71±0.023	37.6±0.027	44.3±0.023
8hr	45.88±0.020	54.6±0.024	57.6±0.021

The data shows that the release rates of formulations FX1, FX2, and FX3, which contain xanthan gum amounts of 70 mg, 60 mg, and 50 mg, respectively, were measured over 8 hours. Formulation FX3, with the lowest amount of xanthan gum (50 mg), released the drug faster and reached 57.6% release by the end of 8 hours. In contrast, FX1, which had the highest amount of xanthan gum (70 mg), showed a slower release, reaching only 45.88%. This pattern suggests that as the xanthan gum concentration decreases, the drug is released more quickly. Higher xanthan gum levels form a thicker gel barrier, which slows down drug release, while lower levels lead to a faster release due to a less dense gel matrix.

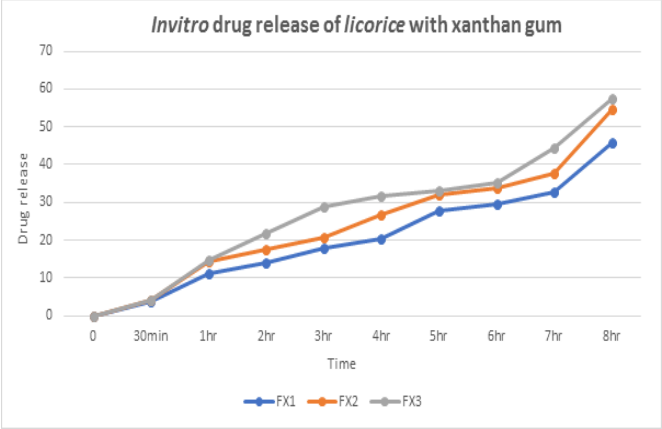

Fig. 5: *Invitro* drug release of *licorice* with xanthan gum.

Table 11: % of Drug release of Licorice tablet with Sodium alginate.

Sodium Alginate	FS1(70mg)	FS2 (60mg)	FS3 (50mg)
0	0	0	0
30min	15.6±0.027	16±0.026	16.8±0.025
1hr	17.3±0.029	18.1±0.025	20.7±0.026
2hr	20.2±0.024	21.4±0.022	22.6±0.020
3hr	22.8±0.025	23.1±0.022	29.3±0.027
4hr	25.2±0.021	26.2±0.024	32.1±0.022
5hr	26.6±0.024	28±0.026	34.3±0.023
6h	31.6±0.020	32.8±0.028	36.6±0.027
7hr	34.6±0.029	39.3±0.020	57.2±0.028
8hr	40.1±0.020	58.1±0.029	71.2±0.024

The data illustrates the drug release profiles of Licorice tablets formulated with varying amounts of sodium alginate (70 mg, 60 mg, and 50 mg) over 8 hours. In this study, the formulation with the lowest sodium alginate concentration (FS3 at 50 mg) exhibited the fastest release rate, reaching 71.2% after 8 hours. Conversely, FS1, with the highest sodium alginate content (70 mg), demonstrated a slower release, achieving only 40.1% in the same timeframe.

These findings indicate that as sodium alginate concentration decreases, the drug release rate increases. This trend suggests that a higher sodium alginate content forms a denser gel barrier, slowing the drug release,

while lower concentrations result in a less restrictive gel, allowing for quicker drug release.

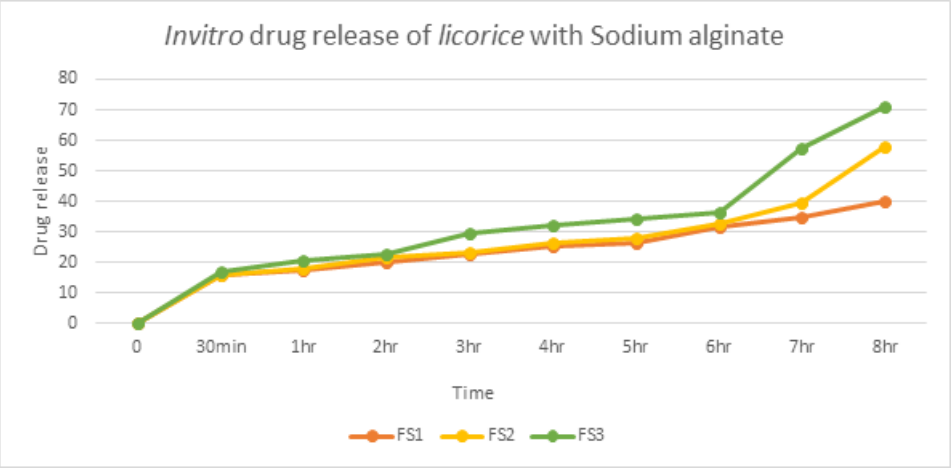

Fig. 6: *Invitro* drug release of *Licorice* with Sodium Alginate.

Table 12: % of Drug release of Licorice tablet with Guar gum.

Guar gum	FG1(70mg)	FG2(60mg)	FG3(50mg)
0	0	0	0
30min	3.74±0.027	4.2±0.021	5.3±0.027
1hr	11.27±0.026	14.9±0.021	15.5±0.025
2hr	14±0.023	17.78±0.028	21.9±0.024
3hr	17.2±0.024	20.7±0.026	29±0.020
4hr	20.29±0.026	26.9±0.021	31.6±0.026
5hr	27.75±0.020	32±0.020	34.22±0.021
6h	29.41±0.029	35.9±0.021	37.1±0.029
7hr	32.71±0.026	39.6±0.027	44.3±0.027
8hr	45.88±0.023	52.6±0.020	57.6±0.027

The data shows that Licorice tablets with different guar gum amounts (70 mg, 60 mg, and 50 mg) release the drug at different rates over 8 hours. The tablet with the lowest guar gum (FG3 at 50 mg) released the most, reaching 57.6% in 8 hours, while the tablet with the highest guar gum (FG1 at 70 mg) released only 45.88% in the same time.

This pattern suggests that less guar gum results in faster drug release. Higher guar gum levels seem to create a thicker gel around the tablet, slowing down the release. With lower guar gum, the gel layer is thinner, allowing quicker drug release. Overall, guar gum plays a key role in controlling the release rate, with higher amounts slowing it down for a more gradual release.

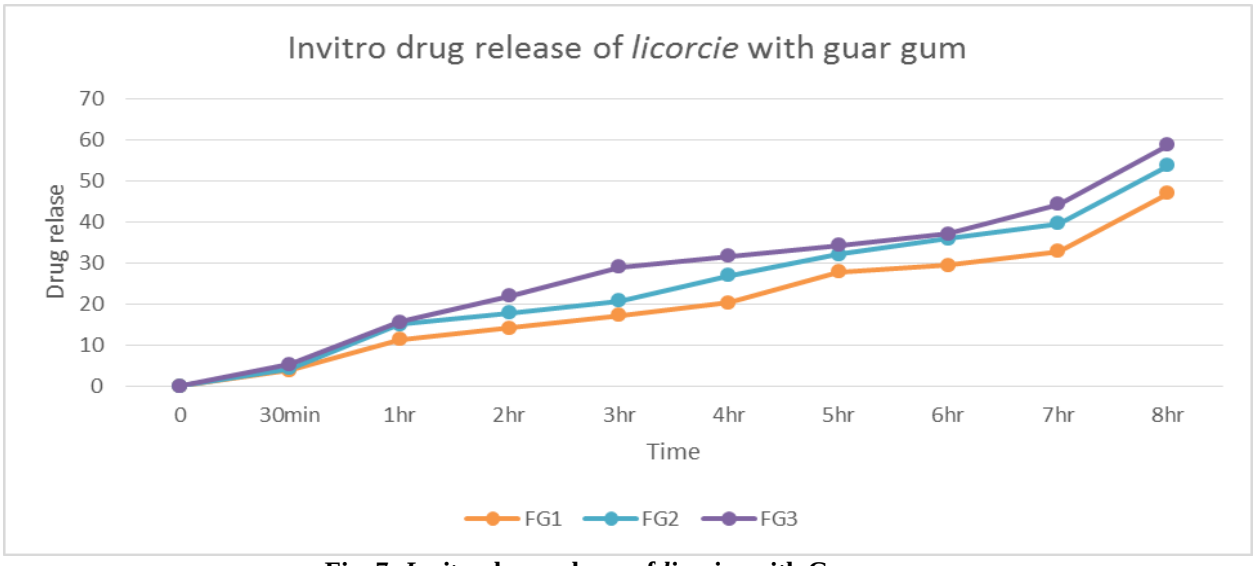

Fig. 7: *Invitro* drug release of *licorice* with Guar gum.

Table 13: % of Drug release of Licorice tablet with HPMC K15.

HPMC K15	FH1(70mg)	FH2(60mg)	FH3(50mg)
0	0	0	0
30min	15.1±0.025	16.2±0.021	19.7±0.023
1hr	17.7±0.026	19.3±0.023	21.7±0.029
2hr	22.6±0.020	20.5±0.021	24.8±0.022
3hr	25.4±0.026	27.2±0.028	30.7±0.029
4hr	26.9±0.021	28.3±0.023	34.5±0.028
5hr	29.5±0.021	30.7±0.029	36.1±0.025
6h	32.1±0.022	36.2±0.028	39.3±0.020
7hr	33.5±0.025	38.5±0.021	40.8±0.025
8hr	36.4±0.022	40.6±0.020	44.3±0.027

The data shows how different amounts of HPMC K15 (70 mg, 60 mg, and 50 mg) affect the drug release from Licorice tablets over 8 hours. The tablet with the least HPMC K15 (FH3 at 50 mg) released the most drug, reaching 44.3% by the end of 8 hours. In contrast, the tablet with the most HPMC K15 (FH1 at 70 mg) released only 36.4%.

This pattern suggests that reducing the amount of HPMC K15 increases the drug release rate. Higher amounts create a thicker gel barrier that slows release, while lower amounts result in a thinner gel, allowing for faster release. Overall, HPMC K15 significantly influences the drug release rate, with more of it leading to slower and more controlled release.

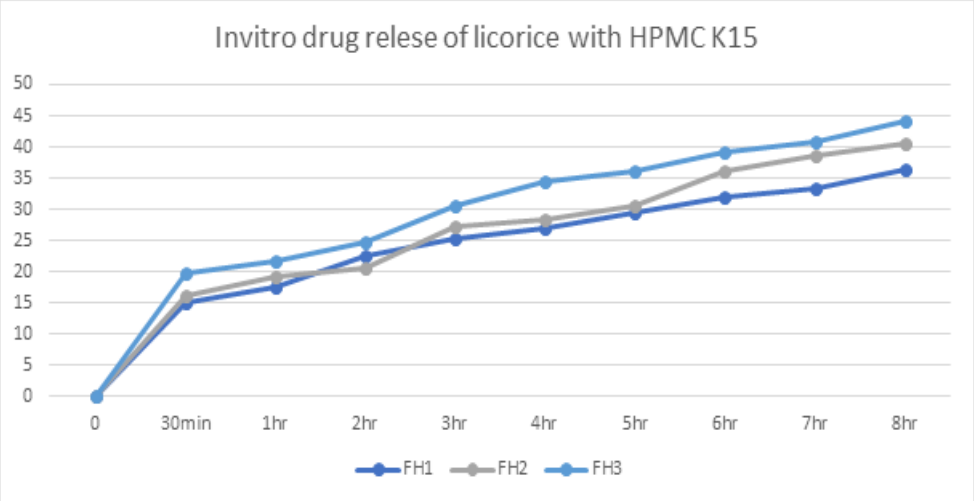

Fig. 8: *Invitro* drug release of *Licorice* with HPMC K15.

8hr % drug release formulations

Table 14: 8hr % drug release formulations.

Time	FX1	FX2	FX3	FS1	FS2	FS3	FG1	FG2	FG3	FH1	FH2	FH3
	75mg	60mg	50mg	75mg	60mg	**50mg**	75mg	60mg	50mg	75mg	60mg	50mg
8hr	45.88	54.6	57.6	40.1	58.1	**71.2**	46.88	53.6	58.5	36.4	40.6	44.3

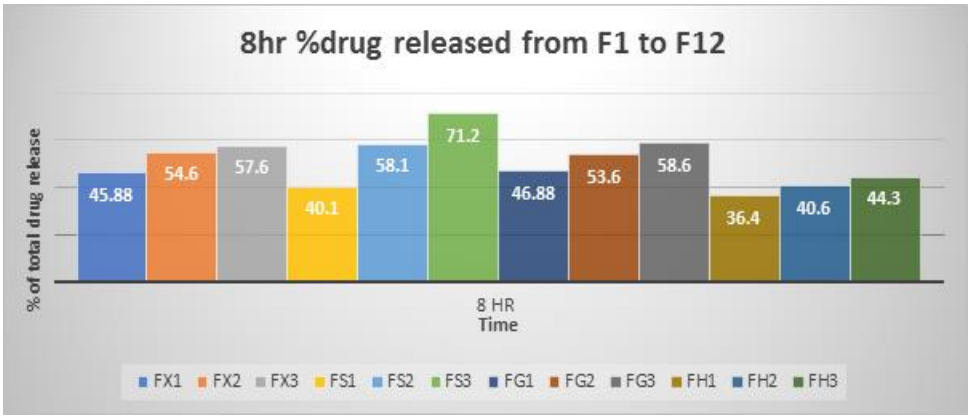

Fig. 9: 8hr %drug released from F1 to F12.

Based on the above results

- **Xanthan Gum (FX formulations):** FX3 (50 mg) exhibited the highest drug release at 57.6%, whereas FX1 (75 mg) had the lowest at 45.88%. This indicates that lower concentrations of xanthan gum facilitate faster drug release.
- **Sodium Alginate (FS formulations):** FS3 (50 mg) also had the highest release at 71.2%, while FS1 (75 mg) showed the lowest at 40.1%. This further confirms that a reduced amount of sodium alginate promotes quicker drug release.
- **Guar Gum (FG formulations):** FG3 (50 mg) achieved a release of 58.5%, in contrast to FG1 (75 mg) at 46.88%. This follows the same trend as the previous formulations, where lower guar gum concentrations enhance release speed.
- **HPMC K15 (FH formulations):** FH3 (50 mg) released 44.3%, while FH1 (75 mg) had the lowest release at 36.4%. Again, lower concentrations resulted in a faster release.

In summary, the data reveals that decreasing the concentrations of xanthan gum, sodium alginate, guar gum, and HPMC K15 leads to an increase in drug release rates across all formulations. This pattern suggests that higher levels of these materials form denser gel barriers that slow down drug release, while lower concentrations enable a quicker release.

Each formulation type demonstrates a clear relationship between polymer concentration and drug release rate, highlighting the role of these components in controlling the release process**.**

***Invitro* ANC**

The acid-neutralizing capability of the aqueous extract was assessed at four concentrations: 100 mg, 500 mg, 1000 mg, and 1500 mg. The findings were compared to a 500 mg standard of Aluminum Hydroxide and Magnesium Hydroxide [Al $(OH)_3$ + $Mg(OH)_2$].The calculations were as follows:

mEq= Volume of NaOH (mL)×Normality of NaOH

ANC (mEq/g) = mEq of acid consumed /weight of sample in grams

Results showed ANC values for the extract at At concentrations of 100 mg, 500 mg, 1000 mg, and 1500 mg concentrations as 182.5, 170, 191, and 188.33 mEq/g, respectively. Notably, the 1500 mg extract exhibited a higher acid-neutralizing capacity than the standard [Al $(OH)_3$ + Mg $(OH)_2$], which recorded 260 mEq/g. These findings are illustrated in Table and Graph 1**.**

Table 15: Effect of Aqueous Extract of an Acid Neutralizing Capacity.

S.NO	Concentration (mg)	Volume of NaOH consumed (ml)	mEq of Acid consumed(mEq)	ANC per gram of antacid (mEq/g)
1	100	3.65	18.25	182.5
2	500	17	85	170
3	1000	38.2	191	191
4	1500	56.5	282.5	188.33
5	500mg Al $(OH)_3$+Mg $(OH)_2$	26.7	130	260

In this study, we tested different concentrations of the antacid of 100 mg, 500 mg, 1000 mg, and 1500 Mg and measured how much NaOH was needed during titration for each concentration. The results demonstrated that with increasing concentrations of the antacid increased, the volume of NaOH consumed also increased.

This increase in NaOH volume indicates the antacid's effectiveness in neutralizing acid, known as acid-neutralizing capacity (ANC), which is important for assessing its effectiveness. The amount of acid neutralized (in mEq) also went up with higher concentrations of the antacid. This suggests that higher concentrations of the antacid are better at neutralizing stomach acid, which is expected since more active ingredients generally provide more acid neutralization.

The ANC per gram is highest at the 1000 mg concentration, while the values for 500 mg and 1500 mg are lower. This discrepancy could be due to factors like solubility and interactions among the antacid components. Additionally, saturation effects at higher concentrations may also play a role in these variations.

(Almg is Al $(OH)_3$+Mg $(OH)_2$,100mg 500m 1000mg 1500mg of aqueous extract)

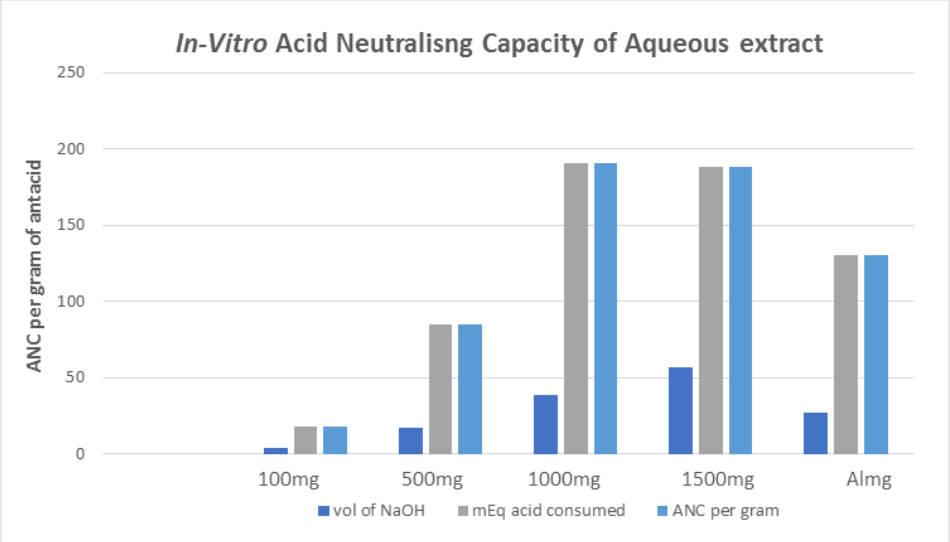

Fig. 10: In-Vitro Acid Neutralisng Capacity of Aqueous extract.

This study shows that higher concentrations of the antacid enhance its capacity to neutralize gastric acid, as indicated by the greater vol of NaOH consumed and the increased mEq of acid neutralized. However, the variability in ANC per gram suggests that additional research may be required to optimize the formulation. Overall, this analysis emphasizes the significance of concentration in improving the effectiveness of antacids in reducing gastric acidity.

SUMMARY AND CONCLUSION

The phytochemical analysis of Licorice (Glycyrrhiza glabra) reveals a variety of bioactive compounds that contribute to its medicinal properties, such as anti-ulcer, anti-inflammatory, and antioxidant effects. Hydro-ethanolic extracts showed the presence of saponins, flavonoids, alkaloids, steroids, terpenoids, tannins, and glycosides, while carbohydrates, proteins, and phenolic compounds were not detected. Notable compounds like glycyrrhizin exhibit strong anti-inflammatory and antiviral effects, and flavonoids like liquiritin provide antioxidant protection for the stomach lining, emphasizing Licorice's potential as a natural remedy for gastrointestinal and immune health.

A standard calibration curve for Licorice extract was developed using UV spectrophotometry, showing a linear response between 5-25 µg/ml at an absorption maximum of 251 nm, with a correlation coefficient of 0.9927. The equation, y = 0.3933x + 0.0272, allows for accurate determination of unknown concentrations.

Quality assessments of Licorice-based herbal tablet formulations confirmed their suitability. Key pre-compression and post-compression parameters indicated good flow and compressibility, particularly in formulations FX3 and FS3. Post-compression parameters like weight, hardness, friability, and floating duration were stable, with formulations F3 and F10 demonstrating optimal floating duration and tablet quality, making them strong candidates for further development.

In vitro studies revealed that lowering the concentrations of xanthan gum, sodium alginate, guar gum, and HPMC K15 in Licorice tablets significantly speeds up drug release. Reduced polymer levels create less dense gel barriers, allowing for faster release, while higher concentrations result in thicker barriers that slow down release. This trend highlights the importance of polymer concentration in controlling drug release rates.

The acid-neutralizing capacity (ANC) analysis showed that higher concentrations of the aqueous extract enhance its effectiveness, as indicated by increased NaOH consumption and acid neutralization. The 1000 mg concentration yielded the highest ANC per gram, suggesting an optimal concentration for efficacy. Variations in ANC at higher concentrations may be due to solubility or interaction effects, suggesting further optimization is needed. Overall, these results emphasize the significance of concentration in improving the antacid's ability to neutralize gastric acidity.

This research highlights Licorice's promise as an effective natural treatment, demonstrating the significant impact of concentration on its medicinal properties and acid-neutralizing capacity. Further improvements in formulations could increase its efficacy in promoting gastrointestinal health**.**

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