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Extraction and Evaluation of Mucilage of Persea *Duthiei* as a Tablet Binder

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ABSTRACT

The aim of present study is to extract the mucilage from *Persea duthiei* barks, characterization, and evaluation of binding properties of mucilage by using as a tablet binder. Mucilage isolated from the barks of *Persea duthiei* plant, family *Lauraceae* by laboratory modified method. The isolated mucilage was subjected to phytochemical screening and various physicochemical characterizations intended for the introduction of new plant excipient in tablet formulations. To investigate the binding efficacy of isolated mucilage different concentrations (0.25-6% w/v) of binder solutions of *Persea duthiei* was used for the formulation of granules and tablets. The micromeritic properties like bulk density, tapped density, angle of repose, Carr's index and Hausner's ratio of prepared granules were evaluated. The results revealed that granules have good flow properties and all parameters within the standard limits when compared with starch as standard binder. For understanding and selecting a perfect ratio or concentration of isolated polymer, different parameters of tablet were evaluated according to IP. Which include (appearance, weight variation, friability, hardness and *in-vitro* drug release). The appearance of the formulated tablets prepared from the mucilages of *Persea duthiei* was good. The *in-vitro* drug release profile of the tablets prepared using mucilage was found to be 96.13± 0.30 at 0.50 % w/v concentration mucilage within 45 minutes. The result shows that *Persea duthiei* can be used as an alternative binder to starch.

Keywords: *Persea duthiei,* tablet binder, phytochemical characterization and famotidine granules.

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INTRODUCTION:

Tablets are universally most commonly used solid dosage forms, which may be defined as "unit forms of solid medicaments prepared by compaction."[1] it consists of a mixture of powders that are compacted in a die to produce a single rigid body. The agents used to impart cohesive character to the powdered material are referred as binders or granulators. [1] They impart cohesiveness to the tablet formulation, that ensures the tablet remain in intact form after compression, as well as it helps in improving the free-flowing character by the formulating granules of desired hardness and size.

The binders are mostly obtained from natural source, like starch, gelatin, and sugars (sucrose, glucose, dextrose, lactose) and mucilage. Natural and synthetic gums that have been used include acacia, sodium alginate, extract of irish moss, karaya gum, ghatti gum. There are various mucilage have been used as a binder, are mucilage of the senna, agar, isabgol husks. The other binders are carboxymethylcellulose, methyl cellulose, polyvinylpyrrolidone, etc. [2] The main criteria for selecting a binder is its compatibility with the other ingredient of tablet. Secondarily, it must impart sufficient cohesiveness to granules to during processing (sizing, lubrication, compression, and packaging), however it should permit the tablet to disintegrate and the drug to dissolve upon ingestion, releasing the active ingredients for absorption. [3]

The quantity of binder used must be considerable because it influences the characteristics of the compressed tablets. The use of too much binder or too strong a binder will make a hard tablet that will not disintegrate easily and will cause too much wear of punches and dies. Nowadays the pharmaceutical scientists all over the world are more interested in natural drugs and excipient, beacuse the synthetic polymers used as excipients suffer from many disadvantages such as: high cost, toxicity, non-biodegradability, non-biocompatibility and environmental pollution caused during their synthesis. [4, 5]

Scientifically and technically mucilage is a naturally occurring, high molecular weight (200,000 or above), organic plant product which have unknown detailed structure. [2] Mucilage is usually normal products of metabolism formed within the cell (intracellular formation), a water-storage reservoir, and a give protection to germinating seeds. They often found in the epidermal cells of leaves. [6] e.g. mucilage obtained from the cell wall of seed epidermis (Isabgol mucilage), from endodermis (fenugreek) from the leaf (senna) from bark (cinnamon) etc. the mucilage obtained from special secretion cells: squill mucilage obtain from algae: agar. [7]

Chemically, mucilage is made up of monosaccharide units joined by glycosidic bonds. [8] They are not soluble in alcohol but dissolve, in water. [5] Natural mucilage is either water soluble or absorbs water and swell in water to form sticky, colloidal viscous suspension or translucent solution. [9] In the pharmaceutical preparations, mostly mucilage is used. They also have been used as matrix for sustained and controlled release drugs. [10]

Persea duthiei commonly known as Bay tree or Gul-e-namair, widely distributed around Nainital, Western Himalayas in Pakistan and India to Burma. This evergreen, small or medium-sized tree grow up to 13m mostly at altitude of 2500m [11] The roots are bitter, pungent, astringent and used in inflammation, asthma, pain, and foul breath. The bark extract is traditionally used as a binder in making chapati of maduwa (Ragi flour). It holds the dough tightly and prevents chapatti from breaking. The aim of our study is to extract the mucilage from bark of *Persea duthiei* and study the potential of the mucilage as a natural binder. Famotidine is taken as a model drug. This is an antihistaminic drug (H2 antagonist), prescribed for gastric ulcer, duodenal ulcer, Zollinger- Ellison syndrome and gastroesophageal reflux disease. It orally recommended dose is 40 mg daily, for 4-8 week. [12]

MATERIALS AND METHOD

Famotidine received as a gift sample from yarrow chem. Mumbai, Lactose, magnesium stearate, talc, croscarmellose sodium and acetone were purchased from CDH Delhi.

Collection and identification of *Persea duthiei*

The plant specimen was collected from local area of village Bantoli near Abboutmount located in Barakot, Lohaghat Distt. Champawat (Uttarakhand, India) and was subjected for identification at ICAR –National Bureau of plant Genetic Resources Regional Station, Niglat, Bhowali. Dr. I.S. Bisht, Principle Scientist, identified the plant. A voucher Specimen (reference no. AF-01) deposited and identification of plant was confirmed.

Isolation of mucilage[13]

The collected barks of *Persea duthiei* were thoroughly washed by tap water. The rough surfaces of bark were peeled and then 200g of the bark were shredded. The shredded barks were then boiled at 80°C in 400ml of distilled water for 3h with occasionally stirred and thick mass was obtained. It was kept at room temperature to cool down, for 2-3h, and then allowed to stand for overnight below 20°C. Next day a thick solution was then separated from marc by filtration using 4 folds muslin cloth. The mucilage was then precipitated with 800ml (2:1) of ethanol in thick solution using magnetic stirrer. The precipitated mucilage was then filtrated (figure 1A) and dried in hot air oven at 50-55°C for 12h or more, until a proper dried mass of mucilage not occur. The dried mucilage was powdered in mortar pestle and passes through sieve #72 and then stored in well closed container (figure 1B).

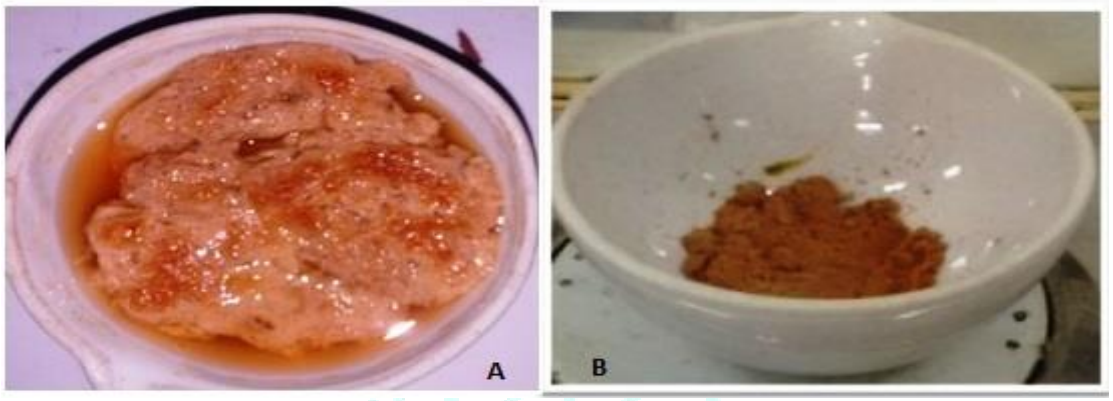

Figure 1.A Precipitated mucilage **B. Isolated mucilage in fine powdered form**

Percentage yield

Percentage yield of mucilage calculated by the given formula

$$\text{Percentage yield} = \frac{\text{Practical yield}}{\text{Theoretical yield}} \times 100$$

Phytochemical screening of extracted mucilage [13]

The phytochemical screening of extracted mucilage, such as ruthenium red test, enzyme test, swelling test, iodine test, precipitation test and Molisch's test, were conducted for confirmation of mucilage. Although test for carbohydrate, gums, tannins and phenolic compounds, protein, amino acid, alkaloid, glycoside, fats and oils flavonoids, steroids, were done by standard test procedures.

Physicochemical Characterization of Isolated Mucilage

Organoleptic evaluation

Evaluation of mucilage by color, odor, taste, size, shape and touch, texture, etc. it is a qualitative evaluation based on the study of morphological and sensory profile of whole mucilage or test sample, so it is also called morphological evaluation. Organoleptic evaluation means conclusion drawn from impressions on organ of senses. [7]

Determination of pH of the mucilage:

The pH of mucilage was determined, by preparing 1% suspension of the extracted mucilage the readings were noted using a digital pH mete. [14]

Determination of viscosity of Mucilage

The viscosity of the (1% w/v) mucilage was determined using Brookfield Viscometer. Sample was placed in adapter for 24h undisturbed prior from the study. The viscosity measured at 5, 10, 20, 50, 100 rpm at 25 °C using spindle no. 5. [14]

Solubility test

10mg of mucilage extract was taken and dissolved in 10ml of different solvent (distilled water, hot distilled water, acetone, ethanol, and chloroform). Then further solubility profile was

determined by taking absorbance in UV spectrophotometer and recorded.

Swelling index

The swelling index of the powdered mucilage was studied in 0.1N HCl solution, phosphate buffer (pH 4.5) solution, and distilled water. 1gm Mucilage was introduced in 25ml of glass-stopper measuring cylinder. Different solutions were added in it up to 25ml and the mixture thoroughly shaken in every 10min for 1h and allowed to stand for 3h at room temp. Swelling index (SI) is expressed as a percentage and calculated according to the following equation.[15]

$$S.I. = \frac{Xt - Xo}{Xo} \times 100$$

Where X_0 = initial height of mucilage in graduated cylinder and X_t = final height. [16]

Moisture content

5g weight of the mucilage powder was put into the moisture content analyzer (A&D MX-50, Japan). The machine was then set to 180°C for 30 min. The value of the moisture content of the mucilage powder was recorded. The procedure was repeated twice and the mean was taken as the moisture content.[4]

Determination of total ash value

Total ash value and acid insoluble ash content were determined as per WHO procedure.[17]

Loss on drying

1.5 g of the powdered sample was weighed and transferred into a previously weighed flat and thin China dish and dried in the oven at 105°C, until two consecutive weighing do not differ by more than 0.5 mg. and calculated by the formula [11]

$$\%\text{Loss on drying} = \frac{W2 - W3}{W2 - W1} \times 100$$

Where W1 = Weight of the empty China dish in grams,

W2 = Weight of the bottle with sample in grams (before drying),

W3 = Weight of the bottle with sample in grams (after drying) - as time specified,

Bulk density

Bulk density of *Persea duthiei* mucilage powder was determined by the three-tap method. Weighed quantity of mucilage powder was carefully putted into a 50 ml graduated cylinder. The cylinder was dropped onto a hard wood surface 3 times from a height of 2.5 cm at an interval of 2 seconds. The bulk density was obtained by dividing the weight of the sample by volume of the sample contained in the cylinder. [18]

Tapped Density

Tapped density is the ratio of weight of mucilage powder to its tapped volume. The weighed quantity of dry powder was taken in a graduated cylinder. The cylinder was placed on the tap density tester. The volume of powdered bed is measured after each increment of 250 drops until the difference of last two volume measurement is 0.5 ml [18]

Hausner's index: This was calculated as the ratio of tapped density to bulk density of the samples and calculated by [17] 19

$$\text{Hausner's ratio} = \frac{\text{Tap density}}{\text{Bulk density}}$$

Carr's index / compressibility index (%): The Carr's compressibility index (C %) was calculated using by the following equation: [19]

$$\text{Carr's index} = \frac{(\text{Tap density} - \text{Bulk density})}{\text{Tap density}} \times 100$$

Angle of repose: Angle of repose was determined by fixed funnel method in which the funnel was fixed on a clamp such that its tip should be 2 cm above from surface and a graph paper placed underneath the funnel. Then powder was poured through the funnel and pile is formed. The mean diameters of the base of the powder cones were determined and the tangent of the angle of repose calculated using the following equation: [16]18

$$\tan\theta = \frac{h}{r}$$

Where h = height of the heap, r = radius of the heap

FTIR Spectrophotometric Analysis

Drug identification and the drug excipients compatibility was performed by using Fourier transform infrared spectrum (FTIR). The study was carried out by taking FTIR spectrum of famotidine, lactose monohydrate, croscarmellose sodium, talc, magnesium stearate individually and then mixture of isolated mucilage + famotidine drug and mixture of all ingredients were applied into analyzing plate having a crystal. The spectrum of Famotidine alone was compared with the spectrum of *Persea duthiei* and other excipients, and then change in the standard peaks was carefully examined. [18]

Preformulation studies of Famotidine

Preformulation studies of famotidine were performed included compatibility studies by FTIR. The λ_{max} of the famotidine was found to be 266.5nm which was determined with the help of UV Spectrophotometer.

Preparation of Granules by Wet Granulation Method

Famotidine was used as a model drug to prepare granules. Lactose was used as diluents, croscarmellose sodium as a disintegrating agents, magnesium stearate, talc used as lubricant and glidant respectively. All tablet ingredients were weighed, calculated for 100 tablets according to the formula (Table 5.3). Formulation of famotidine tablet (40 mg) prepared by wet granulation technique. Famotidine, lactose, and croscarmellose sodium powder (50% of total weight) were homogenously dry mixed for 5 minutes using mortar and pestle. Mixtures of powders were then passed through sieve no: 40. The *Persea duthiei* mucilage used as a binder solution, at various concentrations of 0.25%, 0.5%, 1%, 2%, 3%, 4% and 6% (w/v) for the preparation of granules by wet granulation method. [5, 9] The moistened coherent dough was prepared and the it was passed through sieve no: 16 and granules were dried at 50°C for 30 min. The dried granules were re-sieved through sieve no. 20. [5, 14]

Evaluation Parameters of Prepared Granules

The prepared granules were then evaluated for flow properties (by measuring angle of repose), bulk density, tapped density, Carr's compressibility index and Hausner's ratio. [18, 19]

Formulation and Evaluation of Famotidine Tablet

Preparation of Tablets

The prepared granules were properly mixed with crosscamellose sodium (remaining 50% of total amount) talc and magnesium stearate, compressed into 16 stationary

rotatory punching machine (Cadmach India) with 6mm round flat faced upper and lower punches. The Tablets were stored in tightly closed glass container and evaluated for following parameters. [5]

Table 1: Composition of Tablets.

Ingredients	Formulations							
	F1	F2	F3	F4	F5	F6	F7	ST1
Famotidine	40 mg	40 mg	40 mg	40 mg	40 mg	40 mg	40 mg	40 mg
Lactose	51mg	51 mg	51 mg	51 mg	51 mg	51 mg	51 mg	51 mg
Cros Carmellose Sodium	4 mg	4 mg	4 mg	4 mg	4 mg	4 mg	4 mg	4 mg
Magnesium stearate	2 mg	2 mg	2 mg	2 mg	2 mg	2 mg	2 mg	2 mg
Talc	3 mg	3 mg	3 mg	3 mg	3 mg	3 mg	3 mg	3 mg
Binder conc. %	0.25	0.5	1	2	3	4	6	---
Starch	---	---	---	---	---	---	---	6

Evaluation of Tablet

General appearance

It involves measurement of organoleptic properties such as a tablet's size, shape, color, presence or absence of odor, surface texture parameters. [1]

Dimension

The dimensions of the tablets are mainly thickness and diameter is considered. The tablet should have uniform thickness and diameter. The diameters of tablet were measured by using vernier calipers. [4]

Weight variation

Weight variation was carried out to ensure that, each of tablets contains the proper amount of drug. 20 tablets randomly selected, weighed and the average weight of per tablet is calculated, then tablets are weighed individually. The average weight of 20 tablets was compared with the individual tablets and the percentage of weight variation was calculated by using the following formula

$$\text{Percentage weight variation} = \frac{\text{Individual weight} - \text{Average weight}}{\text{Average weight}} \times 100$$

According to the IP, percentage weight variation should pass for at least 18 out of 20 tablets [18, 19]

Disintegration time

Six tablets were selected randomly from each batch and placed in disintegration apparatus, 900 ml of 0.1N HCl was used as disintegration medium and the temperature was maintained at 37±2° C throughout the experiment; a disc is also added to each tube. The assembly was suspended in the beaker containing 0.1 N HCl, the procedure carried out as per IP 2014. [13, 20]

Hardness

Three tablets were selected randomly from each batch to perform this test. Monsanto hardness tester was used for measurement of hardness. Tablet was placed between spindle and anvil of the tester and the calibrated length adjusted to zero. The knob was then screwed to apply a diametric compression force on the tablet and the position of the calibrated length at which the tablet broken was recorded in kg/cm^2 units. A mean hardness was calculated for each batch and thus their standard deviations were calculated. [21]

Friability test

The friability test was done by using Roche friabilator, the test was carried out as per IP 2014.

The *in-vitro* drug release

it was carried out as per IP 2014 (famotidine tablet monograph) [20] The *in-vitro* drug release of all famotidine tablet formulations were carried out in IP dissolution apparatus-I (paddle type), which was rotated at a speed of 50 rpm using 900 ml buffer (pH 4.5) as dissolution medium, for 45 minutes and the temperature maintained at 37±0.5°C. The sampling was done at 5 minutes time interval and 5ml sample was withdrawn and replaced immediately with the equal volume of dissolution medium to maintain sink condition, the sample were analyzed by UV Spectrophotometric at λ_{max} 266.5nm.

Accelerated Stability Studies

All the formulations were underwent for stability testing and placed in stability chamber at various temperature viz. 25°C/60% RH, 30°C/65% RH and 40°C/75% RH as per ICH guidelines and various physicochemical parameter (appearance, percentage drug content and release profile) were monitored periodically for 3 months.[23]

RESULTS AND DISCUSSION:

Isolation of Mucilage

The mucilage was successfully extracted from the bark of *Persea duthiei*, the percentage yield of mucilage were determined in two different solvents, in ethanol and it was found to be 5.62 % and in acetone it was found to be 3.6%. The high percentage yield was found in ethanol.

Phytochemical Screening of Extracted Mucilage

The Phytochemical screening of extracted mucilage was done and results are shown in Table 2. After phytochemical screening of isolated mucilage showed all test (ruthenium test, precipitation test, enzyme test, swelling test, and iodine test for absence of starch) of mucilage was positive and the presence of carbohydrates and some alkaloids presence was confirmed.

Table 2 Phytochemical screening of isolated mucilage:

S.No.	Test for	Name of test	Observation
1.	Test for carbohydrate		
	General test	Molisch's test	Present
	Test for reducing sugars	Fehling's and Benedict's test	Present
	Test for pentose sugars.	General test	Present
	Test for hexose sugar(for galactose)	Tolllen's pholoroglucinol test	Present
	Test for non- reducing polysaccharides	Iodine test	Absent
2.	Test for gums	Fehling's test , Benidict's test	Absent
3.	Test for tannins and phenolic compounds:	Pot. Dichromate, Dilute HNO3 test, Acetic acid test, 5% Ferric chloride test	Absent
4.	Test for protein	Biuret test, Millon test, Xanthoprotein test	Absent
5.	Test for amino acids	tryptophan Test, tyrosine	Absent
6.	Test for mucilage	Precipitation test, Ruthenium test, Enzyme test, Swelling test Iodine test	Present
7.	Test for alkaloid	Dragendorff's test, Hayer's test, Mayer's test, Wagner's reagent.	Present
		Tannic acid test	Absent
8.	Test for glycoside	Baljet's test, Legal's test, Keller-Kiliani test, Foam test	Absent
9.	Test for fats and oils	Filter paper test	Absent
10.	Test for steroid:	Salkowaski reaction, Liebermann-Burchadreaction	Absent
11.	Test for flavonoids	General test, Shinoda test	Absent
12.	Test for inorganic constituents	Test calcium, magnesium, iron sulphate, phosphate, chloride, carbonate.	Absent

Physicochemical Characterization of Mucilage

The organoleptic characteristics of mucilage were studied, it was found that, the mucilage have brownish to light brick red color, odorless, tasteless and fine sticky powder (shown in figure 1A).

Figure 2. A) Binder solution of *Persea duthiei* mucilage, B Prepared Granules

The pH of 1% w/v mucilage suspension was found to be 6.5-7.0.

The viscosity was measured by Brookfield viscometer and rheogram (figure 3) shows that as the rate of shear increases, the viscosity of solution decreases so the solution of mucilage exhibiting psuedoplastic flow properties.

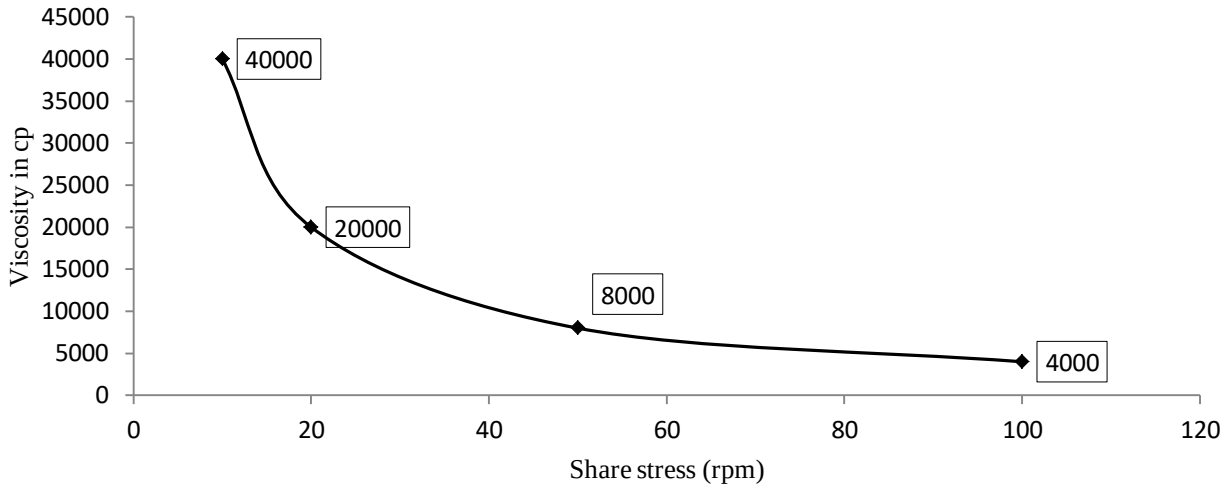

Figure 3 Rheogram of viscosity (cp) vs shear rate (rpm)

The mucilage was found soluble in hot and cold water, but it was insoluble in ethanol, acetone, ether, DSMO. It gives a viscous solution (figure 2A) with water on standing for 3-4 h at room temperature.

The Swelling index was done in distilled water, 0.1N HCl, pH 4.5 buffer solution and it was found to be 12% in distilled water and in 0.1 N HCl and pH 4.5 buffer solution it was found comparatively very less. The LOD and moisture content were found to be 6 % and 8.32% respectively. The total ash content was found to be 6 mg/g. The acid insoluble ash content was found to be 1.96 mg/g whereas the water soluble ash content was found 1.6 mg/g respectively in mucilage.

The Micromeritic properties of mucilage were also determined, the flow properties of mucilage was determined in terms of angle of repose, which has shown an excellent flow. Bulk density and tapped density was found to be (0.26 g/ml), (0.32 g/ml) respectively. Hausner's index was found to be 1.23 and compressibility index (18.75 %) both had not well but fair passable according to standards.

FTIR Spectrophotomatric Analysis

The Fourier transform infrared spectrum (FTIR) of mucilage was done, for determination of compatibility between drug and mucilage. Figure 5 showed the FTIR spectra of mucilage alone. It helps in identification of a compound based on the functional groups present in it. The characteristic functional groups were determined and the characteristic absorption band were found at 2922.42 cm^{-1} (CH_2 asymmetric alkenes), 1614.18 cm^{-1} (C=C¹aromatic ring), 1456.03 cm^{-1} (CH_2 symmetric alkenes), 1376.84 cm^{-1} (O-H bonding), 1032.4 cm^{-1} (C=O stretching) and 526.15 cm^{-1} (C- C-O carbon skeleton).

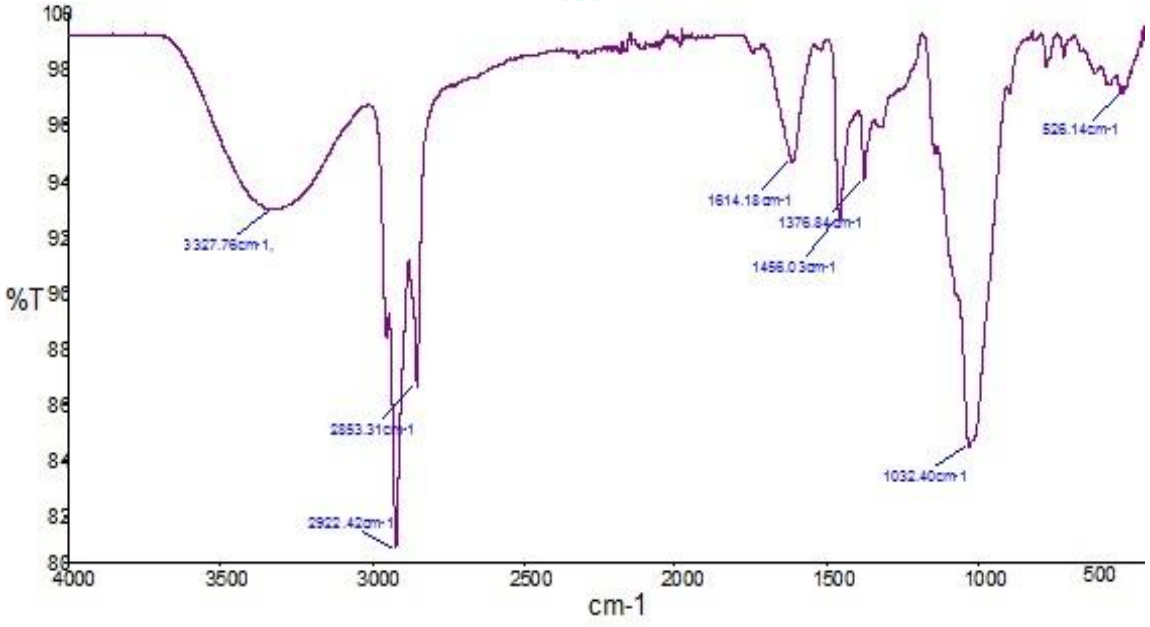

Figure 5 IR spectra of *Persea duthiei* mucilage

The FTIR spectrum of famotidine (figure 6) was observed and the characteristic functional groups were determined and showed characteristic absorption band at 3397.94 cm^{-1} (NH_2 stretching), 3101.25 cm^{-1} (C-H alkenes stretching), 1634.49cm^{-1} (NH_2 scissoring δ, bending) 1598.62 cm^{-1} (N-H bending), 1530.65cm^{-1} (NH_2 bending), 1330.16 cm^{-1} (-SO_2 is stretching vibration), 1160 cm^{-1} (-SO_2 is stretching), 901.28 cm^{-1} (S-N stretching), 607.2 and 541.73 cm^{-1} (S-N group scissoring and wagging), these peaks were matched with the reference peaks of famotidine which confirmed that the drug is famotidine.

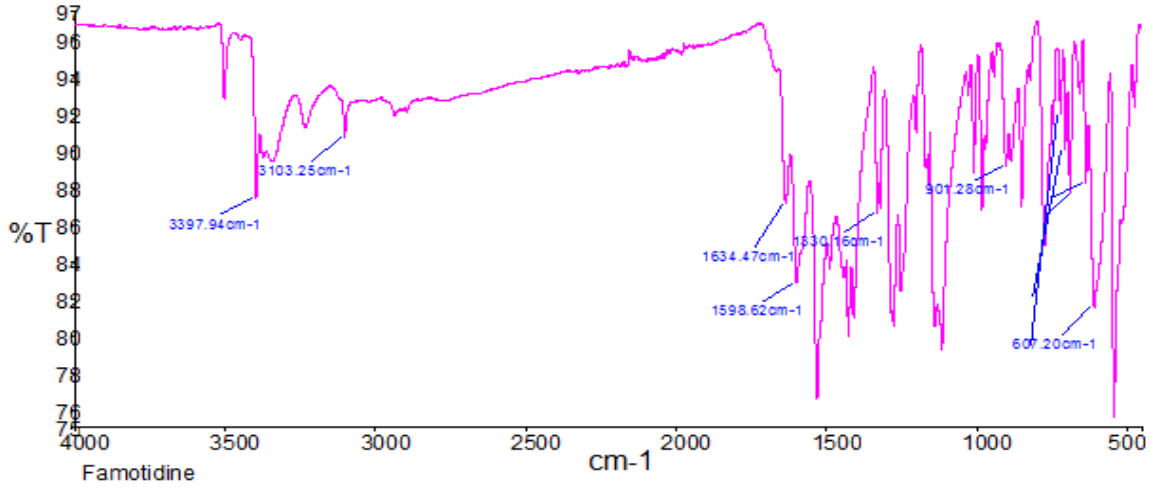

Figure 6. IR spectra of famotidine drug

The IR spectrum of physical mixture of famotidine, mucilage+ other tablet excipients was analyzed and compared with the pure drug. From the study it was observed that the various characteristic peak of drug remain intact or with slight or no change, and it was found that there was no chemical interaction between mucilage, famotidine drug and other excipient. The compatibility of mucilage with drug and excipients confirmed, so mucilage can be utilized in the preparation of tablets.

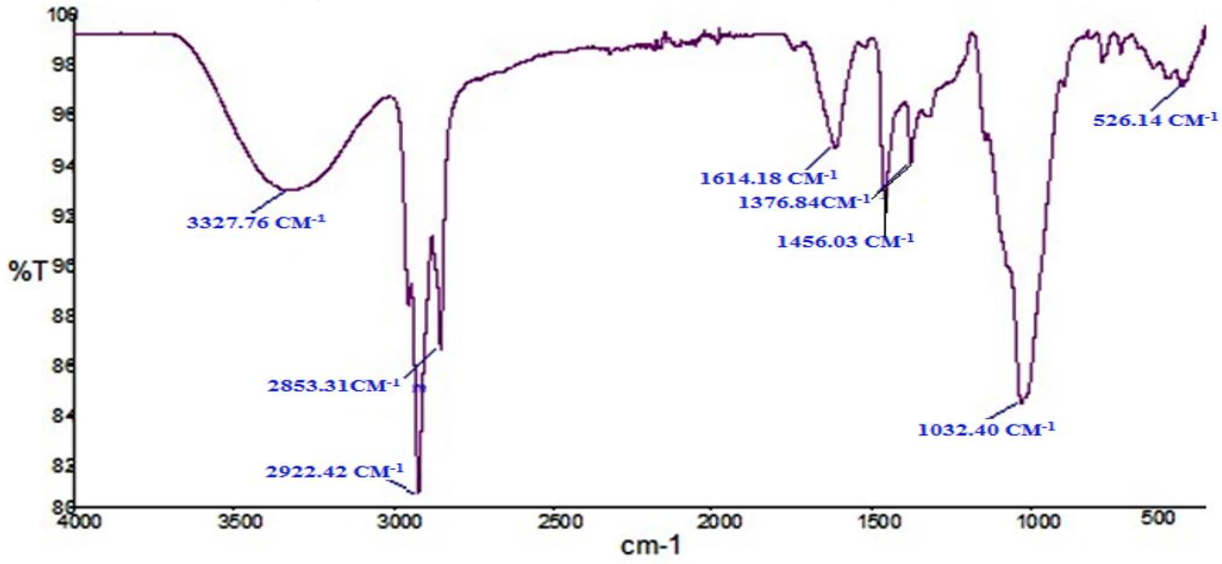

Figure 5 IR spectra of famotidine drug + mucilage+ other tablet excipient

Preparation of Granule and Evaluation of Prepared Granule

The granules were successfully prepared by wet granulation method then evaluated for flow properties by measuring angle of repose, bulk densities, tapped densities, Carr's /compressibility index and Hausner's ratio. Table 3 represents all the evaluated parameters of prepared granules using *Persea duthiei* mucilage and starch. Batch P1, P2, P3, P4, P5, P6 and P7 represent the different concentrations of binder like 0.25%, 0.5%, 1%, 2%, 3%, 4% and 6% respectively and batch S1 represents the granules prepared with 6% binder concentration of starch as a standard binder.

The results revealed that granules have good micromeritic properties and all parameters within the standard limits. On the basis of experiment the angle of repose of all batches were found below 25°, that means all batch of granules have a good flow properties, but the batch P2, S1, P3 have a minimum angle of repose (< 25°) so these formulations have good flow ability. The batch P4 has good flow whereas P2, P3, P5, P6 and batch S1 have fairly passable flow but batch P7 comes under poor flow as per standards.

Table 3 Evaluation Parameters of Prepared Granules

Batch	Bulk density (gm/ml)	Tapped density (gm/ml)	Hausner'ratio	Carr's index	Angle of repose
P1	0.45±0.0003	0.55±0.012	1.22	17.73	13.38°±0.59
P2	0.44±0.0003	0.56±0.012	1.26	20.85	11.87°±1.0
P3	0.50±0.007	0.62±0.012	1.23	19.27	11.71°±0.99
P4	0.58±0.0001	0.69±0.0001	1.20	16.67	15.79°±0.84
P5	0.54±0.009	0.69+0.0005	1.26	20.89	18.02°±0.62
P6	0.54±0.0005	0.68±0.005	1.24	19.64	18.68°±0.66
P7	0.44±0.012	0.62±0.028	1.42	29.51	18.51°±0.7
ST(std)	0.46±0.001	0.56±0.012	1.23	18.92	7.85±0.74

Mean±SD (n=3

Formulation and Evaluation of Famotidine Tablet

The tablets were then compressed and post compressional study was conducted on tablets. The evaluation parameters of prepared tablets by using *Persea duthiei* mucilage and starch are given in Table 4. Batches TP1, TP2, TP3, TP4, TP5, TP6 and TP7 represent the various concentrations of binder like 0.25%, 0.5%, 1%, 2%, 3%, 4% and 6% respectively, MF represents the marketed formulation and TS, represents the granules prepared by using 6% binder concentration of starch as a standard binder. It was found that all batches of tablets (figure 7) have same size, shape thickness, and diameters, except marketed formulation. The marketed formulations have thickness of 3±0.0 mm and 6.1±0.0 mm diameter.

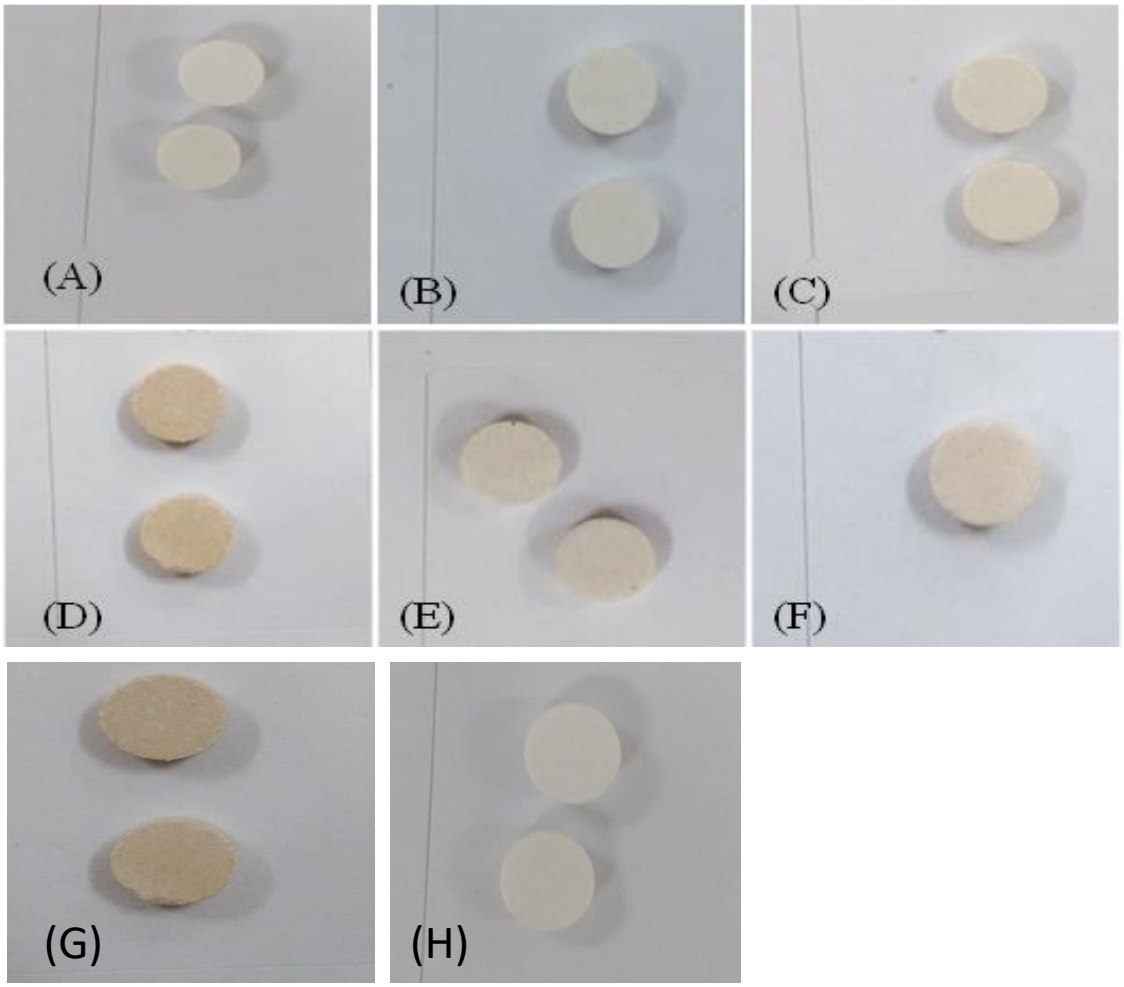

Figure 7 Various formulations (A=TP1, B=TP2, C=TP3, D=TP4, E=TP5, F=TP6, G=TP7, H=TS1)

The binder concentration has a significant impact on hardness, on increasing the binder concentration from 0.25%-6%, in batches TP1, TP2, TP3, TP4, TP5 and TP6, there an increase in hardness of tablets (2.67-5.5kg/cm^2

respectively) was observed, because a thick and viscous gel formed at higher binder concentration, which probably make a coating on the particles and hold them tightly.

The binder concentration also influences the friability. The friability was decreased from 1.55- 0.22 on increasing the concentration of mucilage from 0.25- 6%, all batches have shown good mechanical strength, except formulation TP1, it was found to be 1.55±0.185, therefore the batch TP1 failed the friability test as per IP limits. The weight variations of all batches were found within the IP limits, and the content uniformity of all batches was within the specified IP limits, except formulation TP1and MF, which was found to be 95%. The binder concentration also influences the mean disintegration time, it was increased from 2.79-12.28min as the binder concentration was increased.

Table 4 Evaluation parameters of prepared tablets

Batch	Evaluation parameters							
	Organoleptic properties				Hardness (Kg/cm²)	Drug content	Friability	Disintegration time (Min)
	Shape	Thickness (mm)	Diameter (mm)	Weight variation				
TP1	Round flat	2.6±0.0	6±0.0	±0.92	2.67±0.29	90.3±0.0007	1.55±0.185	2.79±0.08
TP2	Round flat	2.6±0.0	6±0.0	±1.18	3.83±0.29	97.17±0.001	0.29±0.045	4.43±0.086
TP3	Round flat	2.6±0.0	6±0.0	±0.84	3.00±0.5	97.93±0.002	0.24±0.063	4.81±0.044
TP4	Round flat	2.6±0.0	6±0.0	±1.29	3.33±0.29	99.33±0.006	0.76±0.009	6.52±0.19
TP5	Round flat	2.6±0.0	6±0.0	±0.87	4.00±0.5	97.8±0.008	0.164±0.04	8.22±0.123
TP6	Round flat	2.6±0.0	6±0.0	±1.08	4.33±0.28	40.11±0.002	0.67±0.095	9.03±0.136
TP7	Round flat	2.6±0.0	6±0.0	±0.86	5.5±0.5	100.28±0.01	0.22±0.28	12.28±0.5
TS1	Round flat	2.6±0.0	6±0.0	±1.42	3.00±0.00	97.63±0.002	0.33±0.17	1.83±0.21
MF	Round flat	3±0.0	6.1±0.0	±0.92	2.50±0.00	86.45±0.004	0.049±0.01	0.59±0.06

***Mean±SD (n=3),**

The *In-Vitro* Drug Release

The *in-vitro* drug release of all formulation was carried out in IP dissolution apparatus-I (paddle type). The *in-vitro* drug release was found between 60.32-99.60% for all formulations in 45min. The release pattern was significantly altered with the time. The lower concentration of binder influences the drug release, in case of formulation TP1 and TP2, the binder concentration was low 0.25 and 0.5% respectively, the release was found to be 48.98± 0.23 % and 41.02± 1.24 % in first 5 min respectively, but when the binder concentration was increased from 0.5 to 6% a decrease in the drug release was observed. The four formulations TP1, TP2, TS1 (standard) and MF (marketed) shown the similar pattern of drug release (figure 7 and figure 8). The study reveals that the formulation TP2, which contain 0.5% isolated mucilage works similar to TS1 (contain 6% starch binder). This shows, the dissolution test was found to be in accordance to IP 2014. The formulations TP6 and TP7 were found unable to show desired release. Among all formulation prepared isolated binder the batch TP2 having very low concentration i.e. (0.5%) shows good drug release similar to standard and marketed formulation.

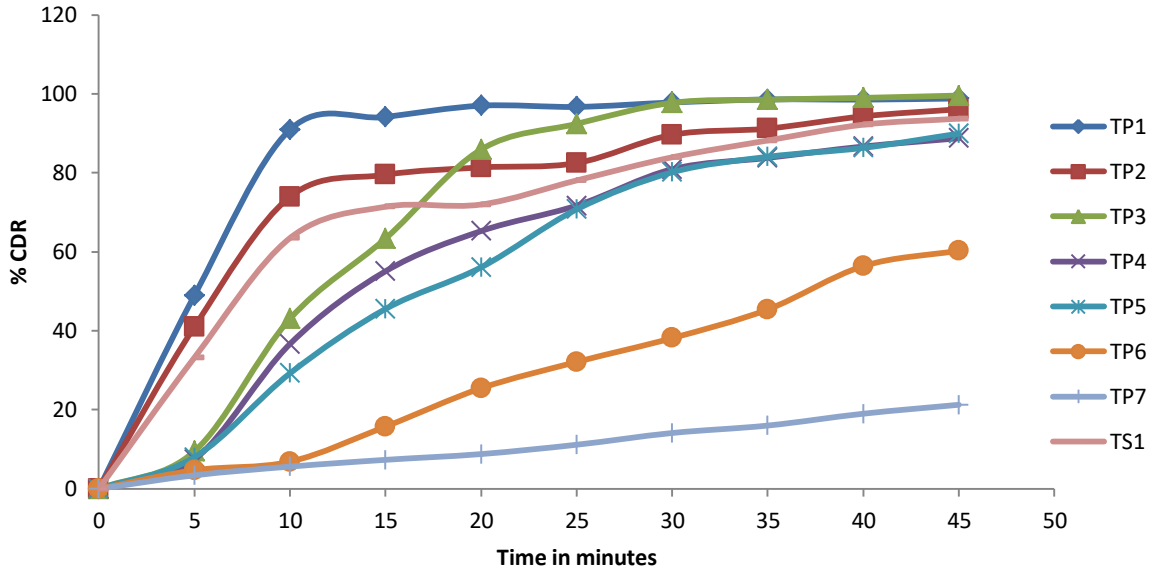

Figure 7 Percentages Cumulative Drug Release of TP1, TP2, TP3, TP4, TP5, TP6, TP7, and TS1

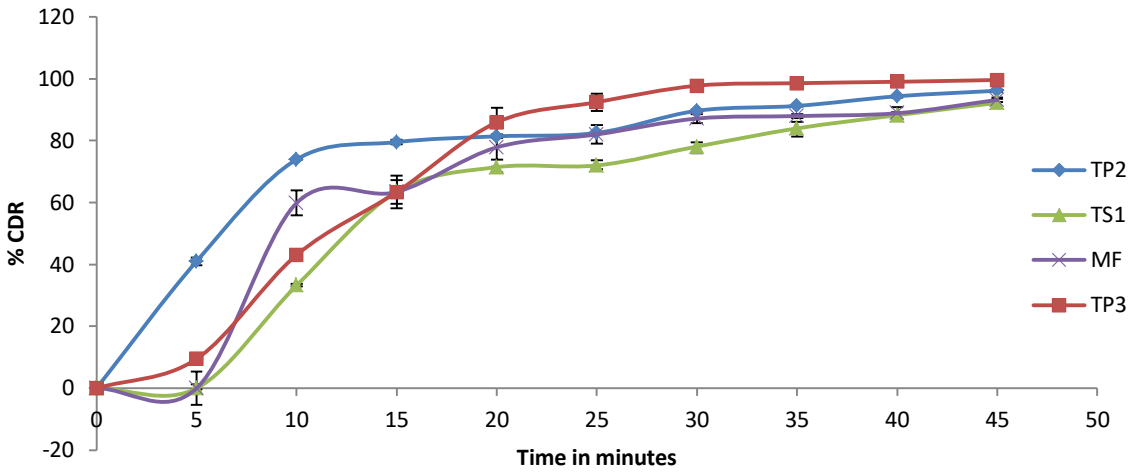

Figure 8 Percentage Cumulative Drug Release of TP2, TP3, TS1, MF formulations

Stability Study

The stability study of optimized batch was carried out at 25°C/60% RH, 30°C/65% RH and 40°C/75% RH as per ICH guidelines. The tablets of all batches were found to be stable at such condition and other parameters were found to be unaffected and were under Pharmacopoeial limits.

CONCLUSION

The main objective of our study was extraction of mucilage and establishment of the extracted mucilage as a natural binder. The search was ended with a success that our mucilage acts better as a natural binding agent, the mucilage has shown good results in lower concentration (0.5%) it shows similar results when compared with 6% starch. this study gives an idea that the isolated mucilage may be useful where the dose of the active is very high (about 90% or above) in case of tablet then required concentration of excipients is 10% or less, for that case this isolated natural binder will best option. In future, the *Persea duthiei* mucilage may be exploited as an emulsifying agent, as a suspending agent or can be used in matrix forming polymer in novel drug delivery system.

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