Nutraceutical Potential of Prosopis cineraria Pods: Formulation and Evaluation of a Digestive Powder

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Abstract:

Prosopis cineraria, commonly known as Khejri, is a nutritionally rich plant with significant medicinal properties, particularly in digestive health and diabetes management. The pods of Prosopis cineraria are rich in dietary fiber, polyphenols, flavonoids and essential minerals, making them a promising functional ingredient for digestive health and metabolic regulation. This study aims to explore the nutraceutical potential of Prosopis cineraria pods by formulation and evaluation of a digestive powder with a focus on gut health and diabetes management. The formulation of digestive powder was developed using optimized processing techniques to ensure the retention of bioactive compounds. The digestive powder was formulated using a standardized process including drying, milling, and blending with complementary natural ingredients to enhance palatability and efficacy. Physicochemical properties, including moisture content, pH, solubility, and particle size, are analysed to assess stability and quality. The findings indicate that Prosopis cineraria pods can be effectively utilized in a digestive powder formulation with potential anti-diabetic and gut health benefits. The results suggest that the incorporation of Prosopis cineraria pods into a well-formulated digestive powder offers a scientifically supported, plant-based alternative to conventional digestive aids and diabetic management supplements.

Keywords: Prosopis cineraria, Pods, Nutraceutical, Digestive powder, Prebiotic, Anti-diabetic

List of Abbreviations:

pH: Potential of Hydrogen

SCFAs: Short Chain Fatty Acids

PUFA: Polyunsaturated Fatty Acid

NaCl: Sodium chloride

Introduction:

Digestive health is a key aspect of overall well-being, influencing nutrient absorption, metabolism, and disease prevention. Poor digestion can lead to gastrointestinal discomfort, nutrient deficiencies, and metabolic disorders such as diabetes. The human gut microbiome, which consists of trillions of beneficial bacteria, plays a fundamental role in digestion and overall health. A balanced gut microbiome supports efficient digestion, enhances immune function, and produces essential metabolites like short-chain fatty acids (SCFAs), which contribute to metabolic health. Dietary components, including fiber and bioactive compounds from plant-based sources, have a significant impact on gut microbiota composition and function[(1)]. The growing global interest in nutraceuticals has been led to extensive research on plant-based functional foods with health benefits beyond basic nutrition. Herbal formulations have been widely explored for their potential to support digestive functions naturally, with *Prosopis cineraria* emerging as a promising plant due to its traditional and scientifically recognized medicinal properties. Prosopis cineraria, commonly known as the Khejri tree, is a hardy, drought-resistant species predominantly found in arid and semi-arid regions of India, Pakistan, and the Middle East.

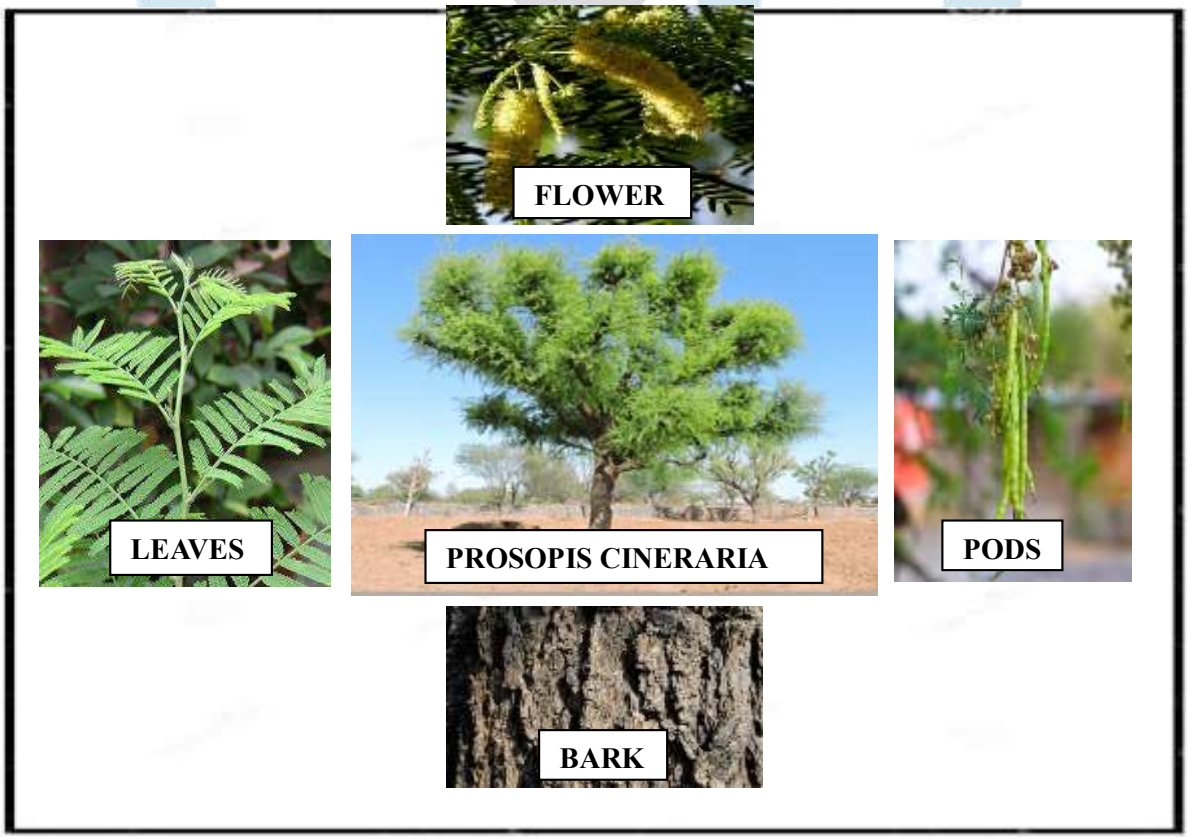

Fig.1: Prosopis cineraria

It is an integral part of the traditional diet and medicine in these regions, with its pods (locally known as Sangri) consumed as food and used for therapeutic purposes. These pods contain high amounts of fibre, proteins, essential minerals (iron, calcium, and phosphorus), and bioactive compounds such as flavonoids, alkaloids, tannins, and polyphenols, which exhibit antioxidant, anti-inflammatory, and anti-diabetic properties[(2)]. In traditional medicine, Prosopis cineraria pods have been used for their gastroprotective effects, aiding in digestion, reducing bloating, and preventing constipation[(3)]. The high fibre content supports gut motility, while its bioactive

components may enhance enzymatic activity and promote beneficial gut microbiota[4]. For individuals with diabetes, proper digestion and metabolism are crucial for maintaining stable blood glucose levels. Hence, developing a standardized digestive powder using Prosopis cineraria pods can provide a natural, functional dietary supplement for digestive and metabolic health[5].

The formulation of a Prosopis cineraria-based digestive powder presents an innovative approach to leveraging the plant's nutraceutical potential. By incorporating complementary digestive aids such as ginger, black pepper, ajwain, flaxseed and cardamom, the formulation can enhance gut motility, alleviate gastrointestinal discomfort, and contribute to overall digestive well-being. Moreover, evaluating the powder ensures its efficacy and safety for consumer use.

As the demand for plant-based, natural health solutions continues to rise, Prosopis cineraria pods offer a valuable resource for developing a sustainable and effective digestive health supplement. Further research and clinical validation will be essential in unlocking their full potential as a functional food ingredient in modern nutraceutical applications[6].

This study focuses on the formulation of a scientifically validated digestive powder using Prosopis cineraria pods. The product development will involve optimizing the drying, grinding, and mixing processes to ensure uniform particle size and bioavailability of active compounds.

Ideal characteristics of Digestive Powder:

(1) It should be effective in promoting digestion and relieving bloating.
(2) It should help to stimulate appetite and digestive enzyme secretion.
(3) It should contain natural ingredients with proven digestive benefits.
(4) It should support regular bowel movements and gut health.
(5) It should have a fine, dry and uniform texture.
(6) It should be mix easily in water.
(7) It should have a pleasant taste and aroma.

Advantages of digestive powder from Prosopis cineraria pods:

1. **Aids digestion** – Rich in fibre, preventing constipation.
2. **Regulates blood sugar –** Helps to control glucose levels naturally.
3. **Boosts gut health** – Supports beneficial gut bacteria.
4. **Provides antioxidants** – Reduces oxidative stress and inflammation.
5. **Supports weight management** – Enhances satiety and metabolism.
6. **Improves insulin sensitivity** – Beneficial for diabetes control.

Materials and Methods:

The present research paper deals with the formulation and evaluation of digestive powder for improving digestive health by using natural ingredients i.e. Prosopis cineraria pods powder, ginger powder, black pepper powder, ajwain powder, flaxseed powder, cardamom powder and black salt. All the ingredients authenticated at

Pharmacognosy department of Nandkumar Shinde College of Pharmacy, Vaijapur. The details of ingredients used to formulate digestive powder is given below:

[1] Prosopis cineraria:

Fig. 2: Prosopis cineraria pods

- **Synonym:** Jhand, Khejri, Khej, Ghaf, Sangri[7,8]
- **Biological source:** It is bean like pods of Prosopis cineraria.
- **Family:** Fabaceae[9]
- **Category:** Prebiotic
- **Chemical Constituents:** The major chemical compounds seen are 18% protein, 2% fat, 26% crude fibre, 56% total carbohydrates, and Ash 4%, Ca 414, P 400, Zn 4, Fe 19 and Mn 4 mg per 100 gm., High level of vitamin C 523 mg/100 gm., 0.99% Amino acids, 3.5% of fatty oil containing oleic acid and linoleic acids (80%), Non-glycosidic polyphenolics, Gallic acid, Patuletin, Luteolin, Prosogerin – E (6, 7-dihydroxy-3‟, 4‟, 5‟- trimethoxyflavone), Glycosidic polyphenolics, Patulitrin, Rutin[10].
- **Pharmacological Activity:**
  - i. **Prebiotic Activity:** The dietary fiber and oligosaccharides in Prosopis cineraria pods can act as prebiotics, supporting the growth of beneficial gut microbiota. This enhances digestion and overall gut health.
  - ii. **Laxative Effect:** The fiber content promotes regular bowel movements, reducing constipation and improving stool consistency.
  - iii. **Carminative & Anti-flatulent:** Traditionally, the pods are used to reduce bloating, gas, and indigestion, possibly due to flavonoids and alkaloids that regulate gut motility[11].

[2] Ginger:

Fig. 3: Ginger

- **Synonym:** Gingerin, Rhizoma zingiberis, Zingibere, Ginger Officinale.
- **Biological source:** The ginger is the rhizomes of Zingiber officinale Roscose.
- **Family:** Zingiberaceae[12]
- **Category:** Carminative
- **Chemical Constituents:** Numerous active ingredients are present in ginger including terpenes and oleoresin which called ginger oil. Ginger also constitutes volatile oils approximately 1% to 3% and non-volatile pungent components oleoresin. The major identified components from terpene are sesquiterpene hydrocarbons and phenolic compounds which are gingerol and shogaol and lipophilic rhizome extracts, yielded potentially active gingerols, which can be converted to shogaols, zingerone, and paradol[13].
- **Pharmacological Activity:**
  i. **Digestive Enzyme Stimulation:** Ginger boosts the secretion of amylase, lipase, and proteases, enhancing carbohydrate, fat, and protein digestion.
  ii. **Gut Motility Regulation**: It accelerates gastric emptying and modulates peristalsis, preventing bloating, constipation, and diarrhea.
  iii. **Gastroprotective & Anti-Ulcer Activity:** It reduces gastric acid secretion, enhances mucus production, and protects against ulcers and oxidative stress[14].

[3] Black Pepper:

Fig. 4: Black Pepper

- **Synonym:** Kalimirch, Piper nigrum
- **Biological source:** Black Pepper is the dried, unripe fruit of the perennial plant Piper nigrum L.
- **Family:** Piperaceae
- **Category:** Bioavailability enhancer
- **Chemical Constituents:** Black pepper contains about 5–9% of the alkaloids piperine and piperettine and about 1.2– 5% of volatile oil. Essential oil is a small portion of a plant material, which consists mainly of terpenes, sesquiterpene, and their derivatives[15].
- **Pharmacological Activity:**

  Piperine inhibits the activity of cytochrome P450 enzymes, which are responsible for metabolizing drugs and compounds in the liver and intestines. This inhibition prevents the premature breakdown of substances, allowing them to remain active in the body for longer and enhancing their overall bioavailability[16].

[4] Ajwain:

Fig. 5: Ajwain

- **Synonym:** Bishop's Weed, Onva, Yamini
- **Biological source:** It is fresh seeds of the plant Trachyspermum ammi L.
- **Family:** Apiaceae[17]
- **Category:** Anti-flatulent
- **Chemical Constituents:** Ajwain include fibre (11.9%), carbohydrates (24.6%), tannins, glycosides, moisture (8.9%), protein (17.1%), fat (21.1%), saponins, flavones, and other components (7.1%) involving calcium, phosphorous, iron, cobalt, copper, iodine, manganese, thiamine, riboflavin, and nicotinic acid (6-8%)[18].
- **Pharmacological Activity:**
  Ajwain seeds contain active compounds like thymol and carvacrol which helps in relieving gas formation, bloating and abdominal discomfort by promoting digestion and easing the movement of gas in the intestines[19].

[5] Flaxseed:

Fig. 6: Flaxseed

- **Synonym:** Alsi, linseed
- **Biological source:** It the dried, ripe seed of Linum usitatissimum Linn.
- **Family:** Linaceae
- **Category:** Bulk forming agent

- **Chemical Constituents:** Polyunsaturated fatty acids (PUFA) omega-3 family, soluble dietary fibres, lignans, proteins and carbohydrates[20].
- **Pharmacological Activity:**
  Flaxseeds are rich in soluble and insoluble dietary fibers, primarily mucilage gums and cellulose which absorb water in the gut, swell up and increase stool volume[21].

[6] Cardamom:

Fig. 7: Cardamom

- **Synonym:** Elaichi
- **Biological source:** It is dried fruit found on perennial herbaceous plant, Elettaria cardamomum Maton.
- **Family:** Zingiberaceae[22]
- **Category:** Cooling agent
- **Chemical Constituents:** Cardamom contains 2.8–6.2% volatile oil, 10% protein, 1–10% fixed oil and up to 50% starch. The aroma and flavor of cardamom are obtained from the essential oils which is composed of mainly α-terpinyl acetate (20–55%) and 1,8-cineole (20–60%) which are responsible for specific flavor to the cardamom[23].
- **Pharmacological Activity:**
  Cardamom contains essential oils like cineole, terpinyl acetate and limonene which produce a mild cooling and refreshing sensation in the gastrointestinal tract, reducing the feeling of heat and acidity[24].

[7] Black Salt:

Fig. 8: Black Salt

- **Synonym:** Kala namak
- **Biological source:** It is derived from halite (rock salt), a naturally occurring mineral form of sodium chloride (NaCl), which is mined from salt deposits.
- **Category:** Mineral enhancer
- **Chemical Constituents:** Besides the presence of sodium chloride in larger amounts, this salt also possesses impurities of sodium sulphate, sodium bisulphate, sodium bisulphite, sodium sulphide, iron sulphide and hydrogen sulphide in traceable amounts[25].
- **Pharmacological Activity:**

  Black salt provides essential minerals like sodium, potassium, magnesium, calcium and iron which supports overall digestive health.

Method of Preparation:

Prosopis cineraria pods were collected.

↓

The pods were cleaned and washed with distilled water to remove impurities.

↓

The cleaned pods were shade dried for 7-10 days to retain bioactive compounds.

↓

The dried pods were coarsely crushed and then finely powdered using a mechanical mixer.

↓

The powder was passed through sieve no. 80-100 for uniform particle size.

↓

Other herbal ingredients were separately dried, powdered and mixed with the Prosopis cineraria powder in appropriate ratios[26].

Formulation of Digestive Powder:

Table 1: Formulation of Digestive Powder

Sr. No.	Ingredients	Quantity	Category
1.	Prosopis cineraria pods powder	10g	Prebiotic
2.	Ginger powder	2g	Carminative
3.	Black Pepper powder	1.5g	Bioavailability enhancer
4.	Ajwain powder	2g	Anti-flatulent
5.	Flaxseed powder	2g	Bulk forming agent
6.	Cardamom powder	1.5g	Cooling agent
7.	Black salt	1g	Mineral enhancer

Fig. 9: Formulated Digestive Powder

Evaluation of Digestive Powder:

I. Phytochemical Screening:

Phytochemical screening identifies the presence of major phytochemical constituents in Prosopis cineraria pods.

The extracts of Prosopis cineraria prepared in aqueous, methanolic, ethanolic and chloroform solution.

Table 2: Tests for Phytochemical Screening

Sr. No.	Phytochemicals	Test	Procedure	Observation
1.	Alkaloids	Dragendorff's Test	2 ml extract + 1 ml Dragendorff's reagent	Orange red precipitate
2.	Tannins	Ferric Chloride Test	1 ml extract + 2 ml of 5% ferric chloride solution	Dark blue colour
3.	Carbohydrates	Fehling's Test	2 ml extract + an equal volume of Fehling's solution A and B. Heat for 5 mins.	Dark red Presipitate
4.	Flavonoids	Shinoda Test	1 ml extract + 10 drops of dil. HCl and a piece of magnesium	Deep pink colour
5.	Proteins	Biuret Test	1 ml extract + 2 drops of 3% copper sulphate and few drops of 10% sodium hydroxide solution	Violet or red colour[27]

II. Organoleptic Evaluation:

The prepared digestive powder was evaluated for various organoleptic parameters such as color, odour, taste and texture.

III. Physicochemical Evaluation:

The prepared digestive powder was evaluated for various physicochemical parameters such as pH, moisture content, loss on drying and ash value.

i. **pH:** Take 1gm of powder and dissolve in 100 ml distilled water. Stir well for about 15-20 minutes and filter if required. Calibrate the pH meter using standard buffer solutions and then insert the electrode into the solution and record the pH once it stabilizes.

ii. **Moisture content:** Weigh empty dish (w_1). Add 2gm of powder and weigh again (w_2). Put the dish in hot air oven at 105°C for 3-4 hours. Cool it in a desiccator and weigh again (w_3).

$$\% \text{ Moisture content} = (w_2\text{-}w_3/w_2\text{-}w_1)100$$

iii. **Ash value:** Weigh empty crucible(w_1). Add 2gm of powder and weigh again (w_2). Heat gently over flame and place in a muffle furnace at 500-600°C (about 4-6 hours). Cool in desiccator and weigh(w_3)[28].

$$\text{Ash}\% = (w_3\text{-}w_1/w_2\text{-}w_1)100$$

IV. Physical Evaluation:

i. **Bulk density:** Fill the powder into the measuring cylinder and note the volume filled (Bulk volume).

$$\text{Bulk density} = \text{Weight of powder(gm)/Bulk volume(ml)}$$

ii. **Tapped density:** Fill the powder into the measuring cylinder and tapped 100 times. Note the volume (Tapped volume).

$$\text{Tapped density} = \text{Weight of powder(gm)/Tapped volume(ml)}$$

iii. **Carr's Index:**

$$\text{Carr's Index} = (\text{Tapped density} - \text{Bulk density}/\text{ Tapped density})$$

iv. **Hausner ratio:**

$$\text{Hausner ratio} = \text{Tapped density/Bulk density}$$

v. **Angle of repose:** Fill the funnel with powder. Allow powder to fall onto the flat surface, forming a cone. Measure the height(h) of the cone from base to tip. Measure the radius(r) of the cone′s base[29].

$$\text{Angle of repose} = \tan^{-1}(h/r)$$

Where, h = Height of the cone from base to tip.

r = Radius of the cone′s base.

Result:

I. Phytochemical Screening:

The phytochemical screening of Prosopis cineraria pods extracts showed the presence of important phytochemicals. Aqueous, methanolic and ethanolic extracts tested positive for alkaloids, tannins, carbohydrates, flavonoids and proteins. The chloroform did not show significant presence of these compounds, indicating that most of the active ingredients are water or alcohol soluble.

Table 3: Phytochemical Screening

Sr. No.	Phytochemical	Aqueous	Methanolic	Ethanolic	Chloroform
1.	Alkaloids	+	+	+	-
2.	Tannins	+	+	+	-
3.	Carbohydrates	+	+	+	-
4.	Flavonoids	+	+	+	-
5.	Protein	+	+	-	-

II. Organoleptic Evaluation:

The formulated digestive powder was light brown in color, characteristic in odour and astringent in taste with fine and smooth texture.

Table 4: Organoleptic Evaluation

Sr. No.	Parameter	Observation
1.	Color	Light brown
2.	Odour	Characteristic
3.	Taste	Astringent
4.	Texture	Fine and smooth

III. Physicochemical Evaluation:

The pH of formulated digestive powder was found to be 6.92, which indicates that the formulation is slightly acidic and suitable for oral consumption. The moisture content was 7.5%, which indicates the powder is dry and stable. The ash value was within normal range, indicating low impurity level.

Table 5: Physicochemical Evaluation

Sr. No.	Parameter	Observation
1.	pH	6.92
2.	Moisture content	7.5%
3.	Ash value	6.8%

IV. Physical Evaluation:

The formulated digestive powder was tested for flow properties. The Carr's index and Hausner ratio indicates good flow and angle of repose indicates fair flow.

Table 6: Physical Evaluation

Sr. No.	Parameter	Observation
1.	Bulk density	0.45g/ml
2.	Tapped density	0.52g/ml
3.	Carr's index	13.5%
4.	Hausner ratio	1.15
5.	Angle of repose	40.6°

Discussion:

Prosopis cineraria, also known as the 'Desert Thorn' is known for its medicinal and nutritional value. The pods of this plant are rich in bioactive compounds which have several health benefits, making them ideal for use in a digestive powder.

Phytochemical screening of the dried pods powder confirmed the presence of bioactive compounds such as alkaloids, tannins, carbohydrates, flavonoids and proteins which are essential for digestive health. Tannins have astringent properties which controls diarrhoea, while flavonoids have strong antioxidant and anti-inflammatory effects. Alkaloids support blood sugar regulation. The high fiber content of the pods supports bowel movement and gut motility, while the presence of antioxidants provides protection against oxidative stress-induced gastric discomfort. The formulation was developed using P. cineraria pod powder as the primary ingredient, with ginger, black pepper, ajwain, flaxseed, cardamom and black salt. These ingredients were selected based on their synergistic effects on digestion.

The physicochemical evaluation of the powder indicates acceptable moisture content(7.5%) and ash value(6.8%) which confirms that the digestive powder is stable, dry and free from impurities. The pH of digestive powder was found to be 6.92 which is slightly acidic and suitable for oral administration. The organoleptic properties such as color, odour, taste and texture were pleasant and consistent with expectations for the herbal formulation.

The flow properties of the powder were found suitable with a Carr's index 13.5% and Hausner's ratio 1.15, which indicates that the powder can be easily handled and packed into capsules or sachets, ensuring convenience for consumers. The angle of repose 40.6° indicates that the powder flows well and is not too compacted.

The combination of antioxidant, anti-inflammatory and digestive health promoting properties makes the digestive powder from Prosopis cineraria pods a valuable nutraceutical product. The formulation of a digestive powder using Prosopis cineraria pods demonstrates promising nutraceutical potential. Future research may focus

on clinical evaluation to confirm therapeutic efficacy, development of advanced dosage forms for improved patient compliance and detailed stability and toxicity studies to ensure product safety and shelf life.

Conclusion:

This research demonstrates the promising nutraceutical potential of Prosopis cineraria pods through the successful formulation and evaluation of digestive powder. The phytochemical composition of the pods, including high fiber content, phenolic compounds and trace minerals supports their traditional use in digestive and antidiabetic therapies. The formulated digestive powder, incorporating the powdered pods with other complementary natural ingredients, demonstrated favourable organoleptic properties, good flowability, moisture stability, and pH within acceptable ranges for oral administration. The study successfully formulated a stable, effective, and natural digestive powder using Prosopis cineraria pods, contributing valuable insight to the field of nutraceutical science and supporting the integration of traditional knowledge with contemporary health solutions.

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