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Formulation and Characterization of Novel Medicated Jelly from *Momordica cymbalaria* Hook F- A Promising Natural Approach for Diabetes Management

K. Devaki Devi[1], C. Pavan Kumar[1], Mukta Dixit[2], H. S. Aishwarya[2], Savithri Bhat[2], B. Mahonara Reddy[1], P. Akbar Basha[1] and E. Sreedevi[1*]

[1]Department of Botany, Government College (A), Ananthapuramu, A.P., India
[2]Department of Biotechnology, BMS College of Engineering (A), Bengaluru, Karnataka, India

**Corresponding author*

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A B S T R A C T

This study investigates the latent capacities related to the antidiabetic properties of *Momordica cymbalaria*, a traditional medicinal plant which is native to India and Southeast Asia, characterized by its rich phytochemical profile, which includes charantin, saponins, flavonoids, and phenolics. There is a growing interest in natural, plant-based therapeutic alternatives as there is increasing global prevalence of diabetes mellitus (DM) and the limitations of conventional synthetic drugs that show adverse effects and long-term toxicity. *M. cymbalaria* has historically been used in traditional medicine to manage diabetes due to its hypoglycemic and antioxidant properties. This research focuses on developing a medicated jelly formulation incorporating *M. cymbalaria* extracts to enhance bioavailability, improve patient compliance, and facilitate ease of administration, particularly in pediatric and geriatric populations. The jelly matrix provides a palatable, fast-dissolving delivery system that effectively delivers bioactive compounds. The formulation is characterized by its physicochemical properties, stability, and bioactivity, aiming to establish a safe, sustainable, and natural approach to diabetes management. Overall, this work highlights *M. cymbalaria's* potential as a promising natural antidiabetic agent and demonstrates the feasibility of delivering plant-based therapeutics via innovative dosage forms, such as medicated jellies. This integrative approach combines traditional knowledge with modern pharmaceutical technology to address unmet needs in diabetes therapy.

Introduction

Type 1 diabetes (T1D) incidence in adolescents varies widely, but has increased globally in recent years. This study reports T1D burden among adolescents and young adults aged 10–24 years at the global, regional, and national levels (Boshen Gong *et al.,* 2025). It is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from defects in insulin secretion, insulin action, or both. It has emerged as one of the most

pressing global health issues due to its increasing prevalence, associated complications, and economic burden. According to the International Diabetes Federation (IDF), approximately 425 million people were affected by diabetes in 2017, with projections estimating a rise to 629 million by 2045. India, being home to one of the largest diabetic populations, accounts for one in every seven diabetics globally (Miao *et al.,* 2024).

Current treatment strategies for diabetes involve insulin injections and various oral hypoglycaemic agents such as sulfonylureas, biguanides, thiazolidinediones, and DPP-4 inhibitors.

Despite their effectiveness in managing blood glucose levels, these synthetic drugs have side effects such as hypoglycemia, gastrointestinal discomfort, weight gain, and long-term organ toxicity. As a result, there is a growing interest in identifying safer and more sustainable alternatives derived from natural sources (Pathak *et al.,* 2024).

Role of Medicinal Plants in Diabetes Management

In traditional medical systems, including Ayurveda, Unani, and Traditional Chinese Medicine (TCM), Medicinal plants have been utilized for centuries to manage various diseases, such as diabetes. The diverse range of bioactive compounds, including flavonoids, alkaloids, saponins, tannins, glycosides, and phenolics, in these plants contributes to their therapeutic effects.

Over 800 plant species in India alone have been reported to possess antidiabetic activity. These natural remedies often exhibit fewer side effects and provide additional benefits due to their antioxidant, anti-inflammatory, and lipid-lowering properties (Afrisham *et al.,* 2015).

Momordica cymbalaria Hook. F. (Family: Cucurbitaceae) is a lesser-known yet highly promising plant with a history of use in traditional Indian medicine for managing diabetes and related metabolic disorders. Commonly referred to as Karchikai (Kannada), Athalakkai (Tamil), or Kasarakayee (Telugu), this plant is native to the tropical regions of India and Southeast Asia. Phytochemical investigations have revealed that *M. cymbalaria* is rich in charantin, saponins, flavonoids, and other compounds known for their hypoglycemic and antioxidant effects (Tomoyuki *et al.,* 2017; Matsuda *et al.,* 2002).

Botanical Classification and Morphology of *Momordica cymbalaria*

Momordica cymbalaria Hook. f. belongs to the family Cucurbitaceae. It is a herbaceous climbing plant found in the tropical regions of India and Southeast Asia. The plant is a trailing vine with tuberous roots and small, ovate leaves. This plant is an evergreen herbaceous climber that trails on the ground and climbs on supports with the aid of its stem (Prashanth *et al.,* 2003). It produces yellow flowers and small spiny fruits that resemble miniature bitter gourds. The plant is also referred to by synonyms such as *Luffa tuberosa* and *Momordica tuberosa* in some traditional texts. *M. cymbalaria* Hook F (Fig 1). It is commonly known as Karchikai (Kannada), Athalakkai (Tamil), Kasarakayee (Andhra Pradesh), and Kakrol (India). Athalakkai has been used in various Asian traditional medicine systems for a long time (Joseph *et al.,* 2008).

Traditional uses

Different parts of *M. cymbalaria* have traditionally been used to treat various ailments. The fruits are utilized as a stimulant, tonic, laxative, and stomachic. They are used for treating gout, rheumatism, spleen, and liver diseases. The plant is used in local folk medicine to treat diabetes mellitus. The juice of fruits and tea leaves of *M. cymbalaria* is used to treat diabetes, malaria, colic sores, wounds, and infections. The juice is also used against worms and parasites. They are also helpful as an emmenagogue for measles, hepatitis, and fever. The roots of *M. cymbalaria* possess abortifacient and aphrodisiac activities. The roots are also utilized to treat constipation, indigestion, diabetes, diarrhea, and rheumatism. The juice of the fruits, leaves, and seeds of *M. cymbalaria* possesses antihelmintic properties (Mahantesh *et al.,* 2016).

Nutritional Profile

The nutrient contents of *M. cymbalaria are* summarized and correlated with the nutritional value of *Momordica charantia* in Table 1. *Momordica charantia,* commonly known as bitter gourd or bitter melon, is a highly regarded plant in the Ayurvedic system of medicine for treating hyperglycemic conditions. It contains carbohydrates, protein, Calcium, potassium, sodium, iron, copper, manganese, zinc, phosphorus, vitamin C, and β-carotenes. It also maintains normal cardiac rhythm, blood coagulation, muscle contraction, and nerve

responses. *Momordica cymbalaria* contains a higher amount of Calcium than *M. charantia*. The iron content in both vegetables is almost the same. Potassium, sodium, copper, manganese, and zinc contents are also high in *M. cymbalaria,* whereas *β*-carotenes content in *M. cymbalaria* is very low. The fruits of *M. cymbalaria* were reported to contain citric acid, malic acid, and vitamin C (Parvathi *et al.,* 2016).

Phytochemical Constituents

Phytochemical screening has revealed the presence of several biologically active compounds in *Momordica* plant parts, characterized by a wide diversity of bioactive compounds, including phenolic acids, flavonoids, carotenoids, cucurbitane triterpenoids, and phytosterols (Koneri *et al.,* 2014). Many therapeutically active substances are present in *M. cymbalaria*, i.e., tannins, alkaloids, amino acids, vitamin C, carbohydrates, and β-carotenes.

The fruits of *M. cymbalaria* contain citric acid, maleic acid, and vitamin C (Gopu *et al.,* 2022). The fixed oil present in the fruits of *M. cymbalaria* also contains palmitic acid, oleic acid, stearic acid, α-eleostearic acid, and γ-linolenic acid (Parvathi *et al.,* 2002; Mohammed *et al.,* 2024). These compounds distributed in the fruits, seeds, roots, and leaves, with the highest concentration of antidiabetic agents found in the fruit and roots.

Medicated Jelly

Jellies are semisolid dosage forms; they are transparent and non-greasy and can be used internally. Today, jelly candies are readily accepted by all patients due to the use of flavoring fruit juices and extracts, such as mango, lemon, orange, and strawberry, which can make them appealing in terms of taste and chewing ability. Compared to conventional dosage forms, the patient-compliance form is particularly advantageous in pediatrics and geriatrics. The unique feature of oral jelly is that it can be easily chewed, dissolves in saliva, and doesn't require water. Overall, oral medications have the potential to revolutionize the way drugs are administered. The review's objective is to provide a concise explanation of its advantages, disadvantages, and method for preparation. The oral medicated jelly is composed of gelling agents, preservatives, and flavoring agents. As a result, patients are more likely to be drawn to and accept it, contributing to poor patient compliance (Howard C. Ansell *et al.,* 2015).

Traditional medications can often have a bitter or unpleasant taste, but oral jellies are usually flavored, making the medication more enjoyable to take. This is particularly helpful in pediatric and geriatric care, where patient compliance can be a challenge. Flavor masking in these jellies helps ensure that patients complete their prescribed course of treatment without a version (Vasoya *et al.,* 2012). Medicated oral jelly is a unique pharmaceutical formulation used to deliver medications in a more convenient, palatable, and easy-to-administer format. They are generally administered in the oral cavity to dissolve in the mouth or pharynx (Sarojini *et al.,* 2018). It is typically a semisolid form of medication, often flavored, making it more appealing for patients, especially those who may have difficulty swallowing tablets or capsules, such as children, the elderly, and those with limited access to water (Patel *et al.,* 2020).

Medicated oral jellies are often packed in sachets or tubes, making them portable and easy to use on the go. The packaging also enhances the product's stability, protecting it from environmental factors such as moisture and air, which could degrade the active ingredient. Currently, medicated oral jellies are the only quick-dissolving dosage form recognized by the FDA and listed in approved drug products with therapeutic equivalence evaluations. Additionally, the 17th edition of the Japanese Pharmacopoeia defines jellies as non-flowable, gelatinous compositions of specific size and shape intended for oral administration (Joan Vijetha *et al.,* 2024).

Benefits of Oral Medicated Jellies

Enhanced Bioavailability: The unique properties of medicated oral jellies can improve the bioavailability of certain drugs, leading to increased therapeutic efficacy.

Reduced Side Effects: By providing controlled release, medicated oral jellies can help to reduce the occurrence of side effects associated with rapid drug absorption.

Improved Patient Quality of Life: Medicated oral jellies can enhance patient quality of life by reducing the inconvenience and discomfort associated with traditional drug delivery methods.

Potential for New Therapeutic Applications: The versatility of medicated oral jellies presents opportunities for developing new drug delivery systems for a wide range of therapeutic indications (Paradowska-Stolarz *et al.,* 2021).

Application of Oral Medicated Jellies

Medicated oral jellies have the potential to be used for a variety of therapeutic applications, including Pediatrics, for children who struggle with swallowing tablets or capsules. Geriatrics: For elderly patients with swallowing difficulties or impaired cognitive function. Oral Health: For treating mouth ulcers, gingivitis, or periodontal disease. Systemic Drug Delivery: For controlled release of certain medications, such as antihypertensives, antidiabetic agents, or anti-inflammatory drugs. Targeted Drug Delivery: For delivering drugs to specific sites within the gastrointestinal tract, such as the small intestine or colon (Sajilata *et al.,* 2005). Thus, in this study, the Development of a medicated jelly formulation for practical therapeutic application in diabetes management has been undertaken for the benefit of human well-being.

Materials and Methods

Collection and Preparation of Plant Material

Fresh *Momordica cymbalaria* plants were collected as whole plants from Raketla village, Uravakonda (M), Anantapur District. Andhra Pradesh, India. The collected plant parts (fruits and roots) were thoroughly washed with distilled water to remove dirt and debris, shade-dried for 10–15 days, and then ground into a fine powder using a mechanical grinder. The powdered samples were stored in airtight containers for extraction analysis and further use.

Development of Medicated Jelly

Oral administration remains the most preferred route for delivering therapeutic agents. However, conventional dosage forms, such as tablets or capsules, may not be suitable for pediatric or geriatric patients. A medicated jelly offers an attractive alternative due to its palatability, ease of swallowing, and rapid disintegration.

Ingredients Used

The formulation included:

Momordica cymbalaria (1 g): Used uniformly across all trials as the active herbal component. It is known for its antidiabetic, antioxidant, and anti-inflammatory properties.

Steviose Sugar (60–65 g): Serves as a sweetening agent and also contributes to the gel network formation with pectin.35 mL of water was heated to 80°C using a magnetic stirrer with controlled heating.65 g of sugar was gradually added to the heated water, which was stirred continuously. The mixture was stirred for 30–40 minutes to ensure complete dissolution of the sugar.

Pectin (1–10 g): A plant-based polysaccharide that forms a gel in the presence of acid and sugar was used.

Gelatin (2–5 g): A protein-based gelling agent, effective in forming thermo-reversible gels, was used. 5.5 g of gelatin was dispersed in 25 mL of water and allowed to hydrate (bloom) for 5–10 minutes to facilitate water absorption and swelling (Jordan-Lloyd *et al.,* 2025).

Sodium Alginate (0.1 g): Used as a stabilizer and viscosity enhancer to maintain homogeneity and improve mouthfeel.

Citric Acid (0.5 g): Acts as a pH adjuster and preservative. Also activates pectin gelling in acidic media.

Water (50 ml): Solvent medium for dissolving and dispersing ingredients.

Total Volume adjusted to 100 ml in each trial.

Gel Incorporation

The temperature of the sugar solution was reduced to 60°C. The pre-hydrated gelatin was added to the warm sugar solution and stirred for 5 minutes until it was fully dissolved, ensuring uniform gel formation (Sruthi *et al.,* 2020).

Incorporation of *Momordica cymbalaria* Powder

1 g of *Momordica cymbalaria* powder was introduced into the Gelatin-sugar mixture. The solution was stirred continuously until the extract was uniformly dispersed.

Preservative Addition and Sample Division

The prepared solution was equally divided into two portions. Sodium alginate, a natural stabilizing and preservative agent, was incorporated into one portion, while the other was left untreated as a control sample for comparative analysis.

Stability Evaluation

Both formulations were subjected to stability studies under different storage conditions (ambient temperature, refrigeration, and accelerated stability conditions). Key parameters, including gel consistency, color, odor, microbial growth, and phase separation, were systematically monitored over time.

Test for Gel formation

Take a small spoonful of the solution and place it on a chilled plate. Let it sit for 30 seconds. Tilt the plate and observe if the mixture does not flow; it is ready to form a gel. If a gel network forms, it indicates the presence of thermosensitive gelation properties.

Solubility Testing of Medicated Jelly

The solubility behavior of the optimized Momordica cymbalaria-based medicated jelly (Trial 8) was assessed in two solvents: distilled water and ethanol (95%). Approximately 500 mg of jelly was added to 10 mL of each solvent in separate test tubes.

The mixtures were vortexed for 2 minutes and allowed to stand at room temperature (25 ± 2°C). Observations were recorded after 5 and 30 minutes to assess dispersion, clarity, and residue formation.

Viscosity Evaluation

The viscosity of the optimized *Momordica cymbalaria* medicated jelly (Trial 8) was evaluated to assess the rheological behaviour and gel consistency. The measurement was performed using a Brookfield digital viscometer (Model: DV2T), equipped with an appropriate spindle (Spindle No. 6), at a rotation speed of 10 rpm under controlled room temperature (25 ± 1°C). The sample was allowed to equilibrate before the reading was recorded to ensure accuracy and repeatability.

Settling of jelly

Once the solution reached the gelation point, it was poured into silicone molds and allowed to cool to room temperature, approximately 25 °C. Then refrigerate it at 4°C for at least 2 hours. The formulated jellies are ready (Mayur M. More *et al.,* 2024).

Results and Discussion

Medicated Jelly Formulation: Method of Preparation

A measured quantity of gelatin was soaked in water and allowed to swell. The mixture was heated gently until the gelatin dissolved completely. The extract powder was added with continuous stirring. Citric acid and a sweetener were added for taste and pH adjustment. The solution was poured into molds and allowed to set at 4°C. The final jelly was stored in sterile containers under refrigeration. Finally, the Jelly evaluation parameters have been determined by studying Physical Appearance and Organoleptic Properties, pH Measurement, Solubility Testing, Viscosity and Stability Studies (Kasparaviciene *et al.,* 2024).

Physical Appearance and Organoleptic Properties

The physical properties of the *Momordica cymbalaria* Powder showed a smooth, uniform consistency. It was visually appealing, with a pleasant taste and aroma. The fine green powder reflects proper drying and pulverization of plant material, retaining chlorophyll content. Slight pungency and bitterness are typical of cucurbitaceae alkaloids and glycosides. Poor to fair flow suggests the need for flow enhancers (e.g., talc, colloidal silica) if used in dry formulations. Being hygroscopic, it should be stored in airtight containers to prevent clumping and loss of stability, and is mentioned in Table 2. (Mohammed *et al.,* 2024)

Gelatin and pectin-based *Momordica cymbalaria* jelly formulations

Jelly formulations using gelatin and pectin as gelling agents, incorporating Momordica cymbalaria fruit extract, have been developed and require further evaluation for potential nutraceutical or antidiabetic applications. Various trials were conducted to achieve a stable and uniform jelly, and the results are presented in Table 3, showing the observed outcome of jelly formation using different concentrations of pectin and gelatin across trials.

Pectin-only formulations (Trials 1–5) were unable to form a stable jelly, even at higher concentrations (10 g), likely due to inadequate acidity, improper sugar-to-pectin

ratio, or insufficient gel network. Gelatin-based formulations (Trials 6–8) demonstrated phase separation and crystallization at lower levels (2–3 g). Trial 8, containing 5 g gelatin, produced the only stable and uniform jelly, indicating optimal gelation at this concentration for 100 g formulations. The presence of *Momordica cymbalaria* did not inhibit gelation, but further analysis may be required to assess its stability and phytochemical integrity.

The results indicate that pectin alone is insufficient for jelly formation in this herbal matrix, even at a concentration of 10 g. Gelatin at a concentration of ≥5 g is effective, resulting in a stable and uniform jelly. Sucrose concentration was slightly increased in gelatin-based trials (65 g vs. 60 g), which may have contributed to a better gel structure. Maintaining constant levels of sodium alginate and citric acid helped to ensure formulation consistency and pH control throughout, as illustrated in Fig. 2. (Rani *et al.,* 2021)

(Trials 1–2**)** Liquid**;** (Trials 3–4) Thickened; (Trials 6–7) Phase Separation; (Trial 8) Proper Jelly Formation

Physical properties of Medicated jelly of *M. cymbalaria*

The soft, jelly-like texture indicates successful gel formation, likely due to the optimal gelatin content. The green color is characteristic of phytoconstituents in *Momordica cymbalaria*, especially chlorophylls and flavonoids. The slightly pungent odour may be attributed to volatile bitter principles naturally present in the extract. Readily soluble nature ensures rapid disintegration and bioavailability in the oral cavity or digestive tract and shown in Table 4 (Nasir NAHA *et al.,* 2023).

pH Evaluation of the Medicated Jelly Formulation

The pH of the optimized medicated jelly containing *Momordica cymbalaria* (Trial 8) was found to be approximately 6.93, indicating a near-neutral pH suitable for oral administration, and is compared in Table 5.

This value is ideal for oral administration, as it falls within the physiological pH range of saliva (6.5–7.5), ensuring minimal mucosal irritation and good patient compliance.

A neutral pH also contributes to the stability of herbal bioactives, particularly in formulations containing sensitive phytoconstituents, such as saponins, flavonoids, and glycosides. Moreover, maintaining a near-neutral pH is beneficial for preserving organoleptic properties (taste, odor) and limiting acid-induced degradation during storage. Given its physicochemical profile and stable pH, the final jelly is suitable for routine oral consumption in therapeutic applications. Since pH can affect both the gelling process and the interaction between ingredients, the stability of the jelly may also be compromised. The precise effect, however, may vary depending on the jelly's specific formula and ingredients (Surywanshi *et al.,* 2024).

Solubility Testing

The jelly's readily soluble behaviour in water is highly favourable for oral administration, where dissolution in gastric fluids is crucial for bioavailability. Its solubility in ethanol, although slightly delayed, suggests that the formulation may also be compatible with semi-polar phytoconstituents, such as flavonoids and alkaloids, present in *Momordica cymbalaria*. This amphiphilic solubility profile enhances the potential for broad-spectrum phytochemical delivery, supporting its therapeutic application in managing metabolic disorders, such as diabetes. The optimized jelly formulation exhibits excellent solubility in water and good solubility in ethanol, rendering it pharmaceutically acceptable for oral use and increasing the chances of systemic absorption of the herbal actives, as compared in Table 6 (Elshafeey *et al.,* 2022).

Viscosity Evaluation

The viscosity was recorded at 57,100 centipoise (cP), indicating a highly viscous and stable gel network. This viscosity range is considered ideal for oral jelly formulations, offering several formulation and functional benefits. The high viscosity value confirms that the final jelly formulation possesses the desirable textural and mechanical characteristics expected of an oral gel-based system. This consistency ensures efficient administration, improved mouthfeel, and dosage accuracy, making it a pharmaceutically acceptable delivery form for *Momordica cymbalaria*. Jellies made using gelatin and *M. cymbalaria* fruit extract on an individual basis revealed much higher viscosities, which is consistent with the results of (Akansha Rawat *et al.,* 2022).

Table.1 Nutritional values comparison between the two taxons *M. cymbalaria* & *M. charantia* (Behera *et al.,* 2011; Ghorbani *et al.,* 2017; Jeyadevi *et al.,* 2012)

Composition	*M. cymbalaria*	*M. charantia*
Moisture %	84.30	83.20
Fiber %	6.42	1.70
Beta Carotene %	0.01	126.00
Protein %	2.15	2.10
Carbohydrate %	12.60	10.60
Energy kcal/100 g	3.00	60.00
Calcium mg/100 g	72.00	23.00
Sodium mg/100 g	40.00	2.40
Potassium mg/100 g	500.00	171.00
Iron mg/100 g	1.70	2.00
Zinc mg/100 g	2.82	0.46
Manganese mg/100 g	0.32	0.08
Copper mg/100 g	0.18	0.19
Phosphorus mg/100 g	0.46	38.00
Vitamin C mg/100 g	290.00	96.00

Table.2 Organoleptic properties of *Momordica cymbalaria* Powder

Character	Property
Appearance	**Fine powder**
Color	**Green**
Odour	**Slightly pungent**
Taste	**Bitter**
Flow Properties	**Poor to fair**
Nature	**Hygroscopic**

Table.3 Gelatin and pectin-based *Momordica cymbalaria* jelly formulations

Trial	Gelling Agent(s)	Result
1–2	Low pectin (1-1.5 g)	Solution remained liquid
3–4	Moderate pectin (3-5 g)	The solution was thicker, but no jelly formation
5	High pectin (10 g)	Thickened further, but jelly not properly formed
6–7	Gelatin (2–3 g)	Phase separation, crystallization, and sedimentation observed
8	Gelatin (5 g)	Proper jelly formation observed

Table.4 Physical properties of Medicated jelly of *M. cymbalaria*

Character	Property
Appearance	**soft jelly**
Color	**Green**
Odor	**Slightly pungent**
Taste	**sweet**
Weight	**8-9gms**
Solubility	**Readily soluble**

Table.5 pH Comparison Across Jelly Formulations

Trial No.	Gelling Agent	Concentration (g)	pH Value	Observation	Suitability
Trial 1–5	Pectin	1–10	~6.2–6.6	Remained liquid or partially viscous	Not suitable for jelly
Trial 6–7	Gelatin	2–3	~6.8–6.9	Phase separation, unstable texture	Not ideal
Trial 8	**Gelatin**	**5.0**	**6.93**	Proper jelly formation	Ideal for oral delivery

Table.6 Solubility Testing of Medicated Jelly

Solvent	Observation After 5 min	Observation After 30 min	Solubility
Water	Fully dispersed, no residue	Clear solution maintained	Readily soluble
Ethanol (95%)	Partial dispersion initially	Fullydispersed, slight haze	Soluble

Figure.1 *Momordica cymbalaria* Fruits

Figure.2 Bar chart **showing the concentration of** pectin and gelatin in the trials**, and the** outcome **of jelly formation**

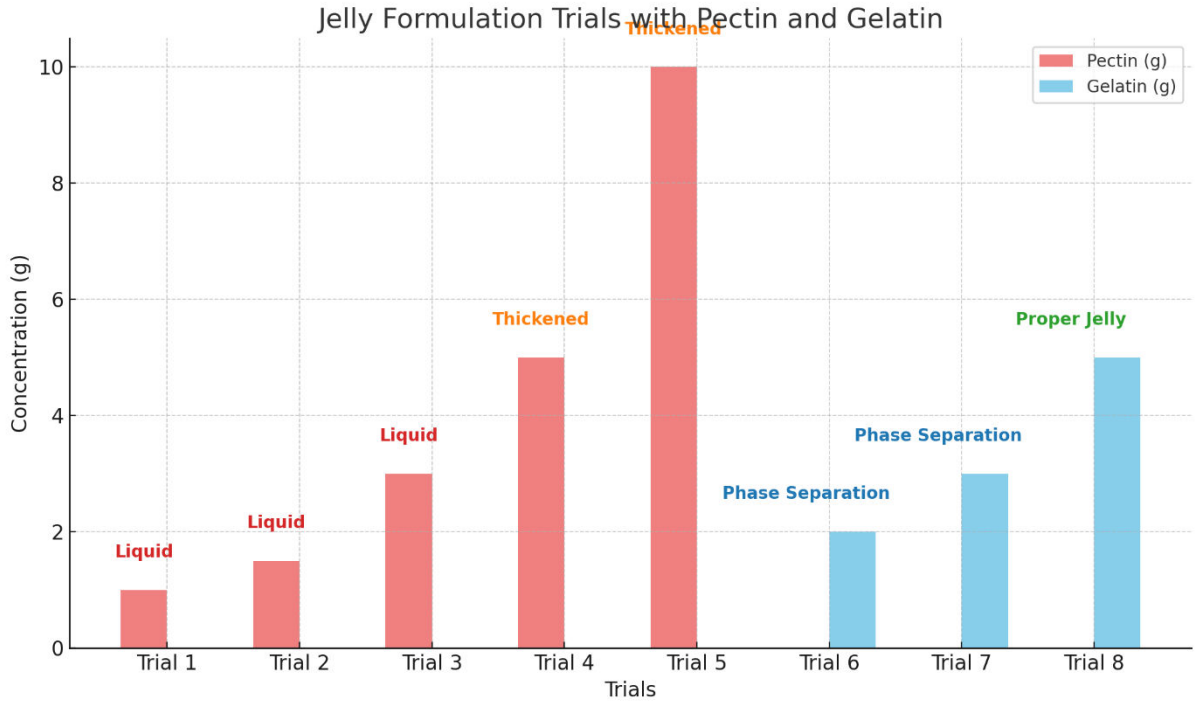

Figure.3 ***A total of 13 jellies were formulated for a 100-gram solution. The weight of each jelly is 9 grams.***

Stability Studies

Jellies are evaluated for 6 months at room temperature and under refrigeration. No significant changes are observed in texture, color, and odour. Jellies retained form and showed no microbial growth under refrigerated storage. Suitable taste, color, and texture made them potentially acceptable for diabetic patients Fig. 3. Thus, medicated jelly is more organoleptically accepted, particularly by patients with disability in the ingestion of food and drink, in other words, those having difficulty in mastication and swallowing (Jaykumar *et al.,* 2024).

Gelatin-based jellies containing *Momordica cymbalaria* offer a promising route for the **oral delivery** of plant bioactives. Gelatin provides thermo-reversible gels, ideal for a soft texture, while pectin offers plant-based, vegan alternatives with enhanced gelling properties under acidic conditions.

Author Contributions

K. Devakidevi: Investigation, formal analysis, writing—original draft. C. Pavan Kumar: Validation, methodology, writing—reviewing. Mukta Dixit:—

Formal analysis, writing—review and editing. H. S. Aishwarya: Investigation, writing—reviewing. Savithri Bhat: Resources, investigation writing—reviewing. B. Mahonara Reddy: Validation, formal analysis, writing—reviewing. E. Sreedevi: Conceptualization, methodology, data curation, supervision, writing—reviewing the final version of the manuscript.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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