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DEVELOPMENT OF SUGAR-FREE POLYHERBAL GUMMIES AS A NOVEL NUTRACEUTICAL APPROACH FOR GLYCEMIC CONTROL

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ABSTRACT:
Diabetes mellitus is a long-term metabolic condition marked by consistently high blood sugar levels, which can happen due to issues with insulin production, its effectiveness, or a combination of both. With the rising global impact of diabetes, there's a pressing need for safe, effective, and patient-friendly treatment options. Herbal remedies have become increasingly popular because of their antioxidant, anti-inflammatory, and blood sugar-lowering benefits. The current study dives into creating and assessing sugar-free polyherbal gummies that are packed with standardized extracts from a variety of plants, including turmeric (Curcuma longa), amla (Emblica officinalis), moringa (Moringa oleifera), guava leaves (Psidium guajava), fenugreek (Trigonella foenum-graecum),neem (Azadirachta indica), bay leaf (Laurus nobilis), cinnamon (Cinnamomum verum), and curry leaves (Murrayakoenigii). The formulation was crafted using a natural gelling agent, steering clear of added sucrose, and was assessed for its physicochemical properties, stability, phytochemical content, and potential to help with glycemic control. The resulting gummies showed good taste, solid stability, and encouraging antioxidant activity. This sugar-free nutraceutical formulation could be a helpful dietary supplement for managing glycemic levels.

Keywords: Diabetes mellitus, Polyherbal formulation, Sugar-free gummies, Nutraceuticals, Glycemic control, Antioxidant activity

1. INTRODUCTION

Diabetes mellitus is a long-lasting metabolic condition characterized by high blood sugar levels and a range of complications that can impact various organs. This condition is divided into several types: Type 1, Type 2, Gestational, and a few others. Notably, Type 2 diabetes makes up about 90–95% of all cases worldwide. When blood sugar remains elevated over time, it can lead to serious issues like retinopathy, nephropathy, and neuropathy, as well as larger problems such as heart disease and stroke[1]. Even though we have oral hypoglycemic agents and insulin therapy at our disposal, relying on these medications for the long haul can lead to some unwanted side effects, an increased risk of hypoglycemia, and issues with patient adherence. That's where herbal medicines and nutraceuticals come into play as promising, safer alternatives. Many medicinal plants have shown impressive benefits, including lowering blood sugar levels, fighting oxidative

stress, reducing inflammation, and managing lipid levels[2]. Using a combination of these herbs can boost their effectiveness thanks to the way their natural compounds work together. Gummy dosage forms are a great way to help patients stick to their treatment plans, particularly for older adults and those who struggle with swallowing pills. That's why this research is focused on creating sugar-free polyherbal gummies as an innovative way to deliver nutrients that can help manage blood sugar levels[3].

2. HERBAL POWDERS:

Turmeric (Curcuma longa)

Curcumin exhibits strong antioxidant, anti-inflammatory, and antidiabetic effects. It improves insulin sensitivity and reduces oxidative stress[4].

Amla (Emblica officinalis)

Rich in Vitamin C and polyphenols, amla reduces blood glucose, cholesterol, and improves pancreatic beta-cell function[5].

Moringa (Moringa oleifera)

Contains essential amino acids and antioxidants; improves glucose tolerance and lipid metabolism[6].

Guava Leaves (Psidium guajava)

Exhibit alpha-glucosidase inhibitory activity and improve postprandial glucose control[7].

Fenugreek (Trigonella foenum-graecum)

Rich in soluble fiber and 4-hydroxyisoleucine; enhances insulin secretion and glucose uptake[8].

Neem (Azadirachta indica)

Possesses hypoglycemic and antioxidant properties[9].

Cinnamon (Cinnamomum verum)

Improves insulin receptor function and reduces fasting blood glucose[10].

Bay Leaf (Laurus nobilis)

Contains bioactive compounds that improve glucose metabolism[11].

Curry Leaves (Murrayakoenigii)

Enhances pancreatic function and reduces oxidative stress.

Literature supports the combined use of these herbs for synergistic glycemic regulation[12].

Collection and Preparation of Herbal leaves

The selected herbal leaves was procured from a reliable source and authenticated. The crude drug leaves material was cleaned to remove foreign matter such as dust and impurities. It was then shade dried to remove moisture content while preserving phytoconstituents. The dried material was coarsely powdered using a mechanical grinder. The powder was passed through a suitable sieve (e.g., sieve no. 40) to obtain uniform particle size and stored in an airtight container until further use.

Procedure:

* 20 g of powdered drug was placed in a thimble made of filter paper.
* The thimble was placed inside the Soxhlet extractor.
* 100 ml of distilled water was added to a round-bottom flask.
* The apparatus was assembled and heated using a heating mantle.
* Extraction was carried out for 6–8 hours until the solvent in the siphon tube became colorless.

Fig1:EXCIPIENTS USED IN HERBAL GUMMIES FORMULATION

1.Stevia (Natural Sweetener)

Stevia is a natural, non-caloric sweetener obtained from the leaves of *Stevia rebaudiana*. It contains steviol glycosides, which provide intense sweetness without contributing to caloric load or raising blood glucose levels. Due to its high sweetness potency (approximately 200–300 times sweeter than sucrose), stevia is widely used in sugar-free and diabetic-friendly formulations.

2.Agar-Agar (Gelling Agent)

Agar-agar is a natural polysaccharide extracted from red algae (*Gelidium* and *Gracilaria* species). It is widely used as a gelling, thickening, and stabilizing agent in pharmaceutical and food formulations. Agar-agar forms a firm gel at low concentrations and remains stable over a wide range of temperatures and pH conditions.

3. Water (Solvent and Processing Medium)

Purified water acts as a solvent, dispersion medium, and processing vehicle in gummy formulation.It facilitates the dissolution of agar-agar, stevia, citric acid, and herbal extracts, enabling uniform mixing and gel formation.

4.Citric Acid (Acidulant and Flavor Enhancer)

Citric acid is a weak organic acid commonly used as a flavor enhancer, acidifying agent, and preservative in pharmaceutical and food formulations.

Concentration of Extract

The obtained extract was filtered using muslin cloth or Whatman filter paper to remove insoluble particles.

The filtrate was concentrated by:

* Heating on a water bath at controlled temperature (below 60°C)

*The final concentrated extract obtained was approximately 50 ml.

*The concentrated extract was stored in a refrigerator until formulation.

Preparation of Agar Solution

Agar (0.8 g) was dispersed in 10–15 ml distilled water.

The mixture was heated at 85–95°C with continuous stirring until a clear solution wasobtained.

Agar requires high temperature for proper dissolution and forms gel upon cooling below 40°C.

Incorporation of Herbal Extract

The concentrated herbal extract (50 ml) was slowly added to the hot agar solution with continuous stirring.

Sweetener (stevia) and citric acid were added to improve taste and stability.

The mixture was stirred gently to avoid air bubble formation.

Molding and Setting

The hot gummy mixture was immediately poured into pre-lubricated silicone molds.

The molds were kept undisturbed at room temperature for 30–45 minutes to allow gel formation.

After complete setting, gummies were carefully removed from molds.

Drying and Storage

The prepared gummies were:

* Air-dried for few hours to remove surface moisture

* Stored in airtight containers

* Kept in a cool and dry place

This test is performed to evaluate the physical appearance and surface quality of the gummies. Samples are placed on a clean white surface and observed under proper lighting to check color uniformity, clarity, shape consistency, and surface smoothness. The presence of cracks, air bubbles, sugar crystallization, or stickiness is carefully noted. Uniform color and absence of visible defects indicate good manufacturing quality and proper formulation stability**.**

Fig2: Formulation of Gummies

Role of phytochemicals in decreasing diabetes:

Flavonoids, polyphenols, tannins, saponins, and alkaloids are fascinating bioactive compounds found in plants that play a crucial role in preventing and managing diabetes mellitus through various complementary mechanisms. These compounds help improve insulin sensitivity by boosting insulin signaling pathways and encouraging glucose uptake in peripheral tissues like muscle and fat, which ultimately lowers blood glucose levels. Additionally, they help regulate carbohydrate digestion and absorption by inhibiting important intestinal enzymes such as α-amylase and α-glucosidase, which helps reduce post-meal spikes in blood sugar. The powerful antioxidant properties of these compounds help shield pancreatic β-cells from damage caused by oxidative stress, which in turn helps maintain insulin secretion. On top of that, their anti-inflammatory benefits work to lessen chronic inflammation linked to insulin resistance. They also play a role in improving lipid metabolism by reducing LDL cholesterol and triglycerides while boosting HDL cholesterol, which helps lower insulin resistance and the chances of cardiovascular issues. All in all, regularly including foods rich in these phytochemicals in your diet can greatly aid in achieving better glycemic control and managing diabetes mellitus effectively.

Pharmacology :

Diabetes mellitus is a long-term metabolic condition marked by consistently high blood sugar levels, which can happen due to either insufficient insulin production, insulin resistance, or a combination of both. Interestingly, plant-based bioactive compounds like flavonoids, polyphenols, tannins, and saponins are crucial in managing this condition. These compounds help boost insulin sensitivity in various tissues by improving insulin receptor signaling and facilitating the movement of GLUT-4, which leads to better glucose absorption and lower blood sugar levels. They work by blocking important enzymes that break down carbohydrates, such as α-amylase and α-glucosidase. This action helps slow down the absorption of glucose, which in turn reduces spikes in blood sugar after meals. Plus, their antioxidant qualities help protect the insulin-producing β-cells in the pancreas from oxidative damage, supporting healthy insulin release. On top of that, they have anti-inflammatory properties that help lower the inflammatory substances linked to insulin resistance. They also play a role in managing how the liver processes glucose by decreasing gluconeogenesis and boosting glycogen production. Additionally, they enhance fat metabolism by lowering triglycerides and LDL cholesterol while raising HDL cholesterol. All these effects work together to improve blood sugar control and lower the chances of complications related to diabetes.

3. AIM AND OBJECTIVES

Aim :

To develop and evaluate sugar-free polyherbal gummies for glycemic control.

Objectives :

- To prepare polyherbal extract using Soxhlet extraction method
- To formulate sugar-free gummies using natural gelling agents
- To evaluate physicochemical parameters
- To assess antioxidant potential
- To study stability of formulation

4. MATERIALS AND METHODS

4.1 Materials

- Dried herbal powders
- Natural gelling agent (pectin/agar)
- Stevia (natural sweetener)

- Citric acid
- Purified water

4.2 Extraction Method

Each herbal powder (2 g each) was subjected to Soxhlet extraction using ethanol-water mixture (70:30) at 60–70°C for 6–8 hours. Extracts were concentrated using rotary evaporator and dried.

4.3 Formulation of Gummies

1. Dissolve gelling agent in warm water
2. Add concentrated polyherbal extract
3. Add stevia and citric acid
4. Heat at 80–90°C until uniform mixture forms
5. Pour into molds
6. Allow to set and dry

4.4 Evaluation Parameters

- ✓ Organoleptic properties
- ✓ pH
- ✓ Weight variation
- ✓ Moisture content
- ✓ Stability studies
- ✓ Phytochemical screening
- ✓ Antioxidant activity (DPPH method)

5. RESULTS

The formulated gummies were:

Dark greenish-brown in color

Pleasant herbal aroma

Uniform in weight

pH between 5.5–6.5

Stable under accelerated conditions

Showed significant antioxidant activity

6. DISCUSSION

The polyherbal formulation combines multiple antidiabetic herbs providing synergistic effects. Curcumin reduces inflammation, fenugreek enhances insulin secretion, cinnamon improves insulin sensitivity, and amla provides antioxidant protection. The sugar-free formulation avoids sucrose-induced glycemic spikes, making it suitable for diabetic individuals. The gummy dosage form enhances compliance compared to tablets or capsules.

7. ADVANTAGES OF SUGAR-FREE POLYHERBAL GUMMIES

Improved patient compliance

No added sugar

Synergistic herbal action

Antioxidant support

Suitable for prediabetic individuals

Convenient nutraceutical form

8. LIMITATIONS

Lack of large-scale clinical trials

Stability challenges in humid conditions

Standardization of herbal extracts required

9. FUTURE PROSPECTS

Clinical trials for glycemic index evaluation

Bioavailability studies

Development of different flavors

Commercial scale production

10. CONCLUSION

The present study successfully developed a sugar-free polyherbal gummy formulation with potential benefits for glycemic control. The combination of antidiabetic medicinal plants in an innovative nutraceutical dosage form offers a promising complementary strategy for diabetes management. Further pharmacological and clinical investigations are required to validate therapeutic efficacy and safety.

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