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Original Article

Functional Beverage for Pre-Diabetic Patients

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ABSTRACT

This review explores the formulation of a functional beverage aimed at supporting the health of pre-diabetic individuals using indigenous antidiabetic plant-based ingredients. The primary active pharmaceutical ingredient (API) in the formulation is Fenugreek (Trigonella foenum-graecum),widely known for its ability to regulate blood glucose levels through mechanisms such as delayed gastric emptying and improved insulin sensitivity. Complementary excipients used in the beverage include stevia, a natural, non-caloric sweetener; citric acid for flavor enhancement and pH regulation; guar gum as a thickening agent and fiber source; natural lemon flavor for taste masking and consumer acceptability; ascorbic acid (vitamin C) for its antioxidant stability; and purified water as the solvent base. The methodology involves optimizing ingredient ratios to maintain palatability, stability, and therapeutic efficacy. Preliminary results from various studies indicate that such formulations can improve glycemic control, provide antioxidant benefits, and offer are freshing, low-calorie alternative to sugary drinks. This review concludes that fenugreek-based functional beverages, when properly formulated with suitable excipients, hold potential as safe and effective dietary interventions for pre-diabetic individuals.

Keywords: Functional beverage, Fenugreek, Pre-diabetes, Blood glucose control, Indigenous plant therapy

INTRODUCTION

Diabetes mellitus is characterized by high blood glucose and changed fat metabolism brought on by inadequate insulin secretion and function. [1] The Egyptians were the first to record diabetes, which is distinguished by polyuria and weight reduction. The term diabetes mellitus (DM), however, was invented by the Greek doctor Aertaeus. Diabetes is the Greek word for "to pass through," and mellitus is the The term for honey in Latin, which alludes to its sweetness. With about one death every 10 seconds, diabetes causes more fatalities each year than HIV/AIDS and is a major contributor to chronic illness and premature death. Diabetes has emerged as a global epidemic as a result of the advent of industrialization and the dramatic increase in obesity. The standard and methods of data collecting differ greatly, making it hard to determine the prevalence of two major causes. In different regions of the globe, recent surveys anticipate that the percentage of adults with diabetes will rise from 4% in 1995 to 6.4% by 2025.

1. It is also predicted that it will evolve quickly, with a 170% growth in developing nations and a 42% rise from 51 to 72 million in industrialized nations. in the developing world, from 84 to 228 million. The number of adults with diabetes worldwide will increase from 194 million in 2003 to about 380 million in 2025. India, China, and the United States will be the nations most impacted by this epidemic in 2025.

2. Another cause for concern is that a sizable percentage of patients—close to 50%—remain undiagnosed even now. The shift in lifestyle The amazing increase in the prevalence of diabetes mellitus is partially attributable to expectancy and the failure to improve healthcare. Consequently, there is a rising rate of diabetes incidence, particularly in cities. As a result, the strain will increase significantly in nations all over the world. for health care, since people with diabetes are more susceptible to early mortality as well as short- and long-term consequences. [2] Diabetes Mellitus is more likely to occur in those who are older, physically inactive, obese, hypertensive, dyslipidemic, or have had gestational Diabetes Mellitus in the past.

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Furthermore, certain racial and ethnic groups have a significant genetic predisposition. The pathogenic process that results in Diabetes Mellitus is used as the basis for its classification. to hyperglycemia. There are two main forms of DM: Type 1 and Type 2. Both of these forms of diabetes are preceded by a period. The pathogenic mechanism is described by the category of aberrant glucose homeostasis. The remaining categories are based on etiology, such as gestational diabetes. Hyperglycemia and diabetes caused by drugs, which are linked to a wide range of causes. [3]

Types of Diabetes:

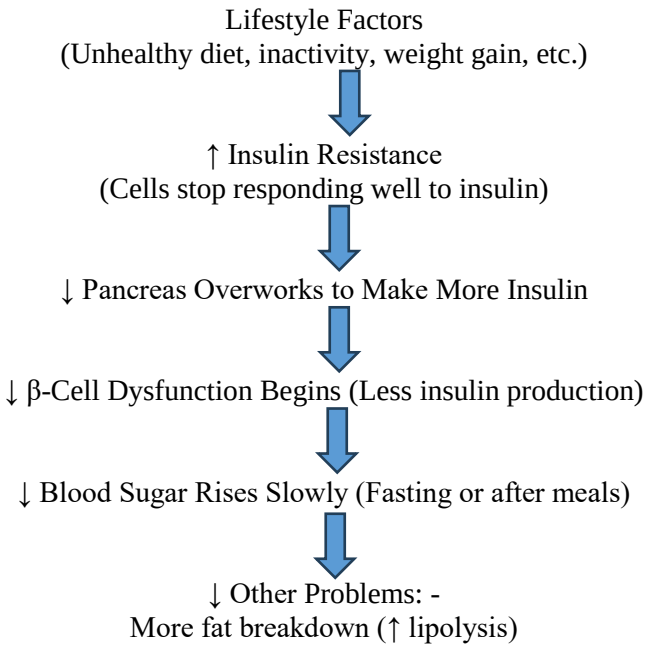
Table 1: Types of diabetes

Type of Diabetes	Description	Causes
Type 1 Diabetes	The body makes little or no insulin because the immune system destroys the cells that produce it	Body's defence system attacks insulin-making cells
Type 2 Diabetes	The body cannot use insulin properly or does not make enough of it	Unhealthy habits, family history, overweight
Gestational Diabetes	Diabetes that's starts during pregnancy	Pregnancy hormones reduce insulin activity
Pre-diabetic	Sugar level is higher than the normal but not yet diabetes	Insulin not working well and poor lifestyle

Prediabetes:

If your blood sugar level is higher than usual but not high enough to be considered diabetes, you have prediabetes. Consider it a warning sign that your body is beginning to struggle with sugar, but that you are not quite diabetic.Despite the fact that prediabetes is frequently asymptomatic, it is not benign. Individuals with prediabetes have an increased chance of developing type 2 diabetes, as well as other health issues such heart disease, nerve damage, kidney problems, and eye problems.Although various health groups, such as the WHO and the ADA, have somewhat different blood sugar ranges for determining prediabetes, the fundamental concept is the same: your between diabetic and healthy sugar levels.The good news is that many individuals can postpone or even avoid type 2 diabetes by making lifestyle adjustments such as improving their diet, increasing their physical activity, and shedding a few pounds. diabetes. Lifestyle is the first and most important action, although some medications, such metformin, are also utilized in individuals at high risk. [5]

Pathophysiology:



- Gut hormone problems (↓ GLP-1)
- Too much glucagon (↑ liver glucose)
- Inflammation (↑ cytokines like TNF-α)

↓ PREDIABETES STAGE (Body can't fully control blood sugar anymore) [6,7,8]

Prediabetes Risk Factors:

People are more prone to getting prediabetes if they have:

I. Weight that is unhealthy, particularly fat around the abdomen
II. Elevated blood pressure
III. Unbalanced cholesterol or triglyceride levels
IV. A sedentary way of life
V. Old age
VI. Employment in the informal sector, which may be related to stress, erratic schedules, or inadequate healthcare access.
VII. Somewhat elevated diastolic blood pressure (80–99 mmHg)
VIII. Elevated triglyceride-glucose (TyG) index, a reliable indicator of prediabetes

If these factors are present, even those without a family history of diabetes can get prediabetes. [9,10]

SYMPTOMS AND INDICATIONS:

There aren't usually any obvious symptoms of prediabetes, but some individuals may experience the following:

i. Experiencing greater thirst than usual
ii. Frequently experiencing fatigue
iii. Frequent need to urinate
iv. Dim sight
v. Wounds that heal slowly
vi. A lot of people don't know they have prediabetes until it's discovered in a blood test. [6,7]

Prediabetes Complications Include:

Although prediabetes is not the same as full-blown diabetes, it can still harm the body over time. People with prediabetes are more likely to experience:

1. Advancing towards type 2 diabetes:

Around 5–10% of people get full diabetes annually. It may affect as many as 70% of people throughout their lives.

2. Issues with the heart and blood vessels (cardiovascular diseases):

Increased risk of high blood pressure, heart attack, stroke, and artery damage Particularly if there is also insulin resistance and high blood pressure, the risk rises.

3. Kidney Ailment:

Higher risk of developing chronic kidney disease

4. Diseases of the Brain and Nervous System:

Increased risk of dementia (including Alzheimer's and vascular dementia) Over time, it may also cause nerve injury (neuropathy).

5. Some Kinds of Cancer:

higher risk of malignancies in the liver, pancreas, breast, and colon.

Prohibiting Prediabetes:

Strategies to stop the development of prediabetes have been investigated, such as:

1. Changes in Lifestyle (Diet and Exercise) Overview: Motivating patients to eat healthily, reduce weight, and engage in more physical activity.

Drawbacks:

i. It calls for sustained discipline and drive.
ii. Maintaining it consistently is challenging for the elderly and those who are employed.

iii. People with a strong genetic predisposition may not be able to overcome it just via lifestyle modifications.

2. Therapeutic Interventions (e.g., Metformin) Overview: The usage of drugs such as metformin to increase insulin sensitivity and lower glucose output from the liver.

Drawbacks:

I. Possible negative consequences include lactic acidosis and gastrointestinal distress.
ii. Not advised for all patients, especially those with liver or renal dysfunction.
iii. If underlying causes are not addressed, long-term dependency may result.

3. Surgery for Obesity Summary: Weight reduction surgery can significantly improve insulin resistance in patients with severe obesity.

Drawbacks:

i. Costly and invasive.
ii. Involves the possibility of surgical dangers and complications.
iii. Not required or practical for the majority of people who are prediabetic.

4. Functional Foods and Nutraceuticals

Summary: Foods or supplements with therapeutic effects, such as cinnamon, fenugreek, or bitter melon.

Disadvantages:

i. Because of inconsistent dosage or bioavailability, efficacy might sometimes vary.
ii. Some may have powerful tastes or unpleasant flavors that make it difficult for patients to follow instructions.
iii. if taken incorrectly, there is a chance of drug interactions. [9,10]

Useful Drinks:

The nutritional worth of people's diets is now better understood. Functional beverages contain bioactive ingredients derived from plants, animals, and microbes, such as phenolic compounds, minerals, vitamins, amino acids, peptides, unsaturated fatty acids, and more.

Kinds:

1. Infused Herbal Drink
2. Decoctions Made With Plants
3. drinks with extra flavor
4. Drinks Containing Probiotics or Prebiotics
5. Drinks Rich in Fiber
6. Fruit & Vegetable Juices with a Low Glycemic Index
7. Functional lemonades or coolers sweetened with stevia
8. Functional Smoothies (with anti-diabetic herbs) [11–13]

Importance:

Importance of herbal beverages In Africa, over 90% of the people consume herbal remedies to enhance their physical health, while in India, 70% of the population does the same. health (Saad & Prochaska, 2020). For more than a century, herbal remedies in the form of tablets, capsules, or liquids have been used as primary care. especially in poor countries with large populations. As a result, herbal beverages have been promoted as one of the options for maintaining good health. herbal remedies innovation. As a result, the use of herbal beverages is widespread, with certain beverages becoming more well-known than others depending on their geographic location. Over 80% of people in Africa and Asia still rely on herbal cures as their primary form of healthcare, according to the World Health Organization. (WHO). In order to stay healthy, certain communities around the world drank herbal beverages as part of their diet. [14]

Role of Herbal Beverage In Prediabetic Management:

The Function of Herbal Drinks in the Treatment of Prediabetes In this situation, herbal drinks provide a positive and patient-friendly solution. They combine the therapeutic advantages of traditional herbs with ease of use and deliciousness. In contrast to synthetic pharmaceuticals, herbal beverages are often tolerated well, inexpensive, and culturally acceptable in many areas. The herbal beverage that this study looked at is made using [list of herbs, such as Gymnema sylvestre, cinnamon, fenugreek, etc.] that are known for their glucose-lowering properties. Effects, enhanced insulin sensitivity, and anti-inflammatory and antioxidant qualities.

Herbal Beverages' Benefits:

I. simple to integrate into everyday life and non-invasive.
II. Fewer adverse effects than pharmacological medications.
III. May address a variety of metabolic processes, not just blood sugar.
IV. Improved patient adherence as a result of taste and cultural acceptability.

As a result, this study examines the efficacy of a specifically created herbal drink as a natural, safe, and efficient method for controlling prediabetes, perhaps surpassing traditional methods. strategies for sustainability and patient satisfaction. [11–13]

Herbs for Diabetic Management:

Table 2: Herbs for Diabetic Management

Common Name	Biological Source	Part Used	Images
Fenugreek	Trigonella foenum-graecum	Fruit	
Neem	Azardirachta indica	Leaves, bark	
Turmeric	Curuma longa	Rhizome	
Amla	Emblica officinalis	Fruit	

Bael	Aegle marmelos	Leaves,fruit	
Cinnamon	Cinnamomum zeylanicum	Bark	
Garlic	Allium sativum	Bulb	
Onion	Alliumcepa	Bulb	
Aloe vera	Aloe barbedadensis	Leaf gel	

Elected Phytoconstituents And Additives for Formulation Development:

For the creation of the formula, we chose certain phytoconstituents and additives. It has been said that around 800 plants have the potential to treat diabetes.

The use of many bioactive chemicals (active principles) derived from plants in the prevention and treatment of diabetes has already been demonstrated in a variety of laboratory settings. research, however, has not shown it to be effective for therapeutic applications.

1. Trigonella foenum graecum, or fenugreek, is a therapeutic plant belonging to the Fabaceae family that is used to treat a variety of ailments, including diabetes, inflammation, cancer, neurodegenerative illnesses, reproductive problems, and hypercholesteremia. Fenugreek seeds have been used for ages as carminative, demulcent, expectorant, laxative, and stomachic remedies. It has its roots in It originated in Eastern Europe, but is now cultivated everywhere. It contains a variety of phytochemicals, including Address correspondence to this author at the India, Uttar Pradesh, Aligarh, Aligarh Muslim University, Faculty of Life Sciences, Department of Zoology, Section of Genetics, Drosophila Transgenic Laboratory, 202002; flavonoids, alkaloids, coumarins, vitamins, carbohydrates (Galactomannan) The pharmacological effects are caused by saponins, trigonelline, diosgenin, and soluble fibers. Its anti-diabetic, anti-sterility, and anti-fertility characteristics have been demonstrated by several clinical and preclinical investigations. Additionally, it governs the creation of enzymes that regulate blood sugar levels and aid in lowering cholesterol. The hypoglycemic effect of fenugreek corresponds to physiological needs and are influenced by the amount of Glucogen-like peptide-1. [15–17]

Fig 1: **Trigonella foenum graecum, or fenugreek**

One of the earliest herbs used for therapeutic purposes in India, fenugreek (Trigonella foenum graceum) has a history that goes back to ancient Egypt. Among the alkaloids found in fenugreek seeds are trigonelline, gentianine, and carpaine compounds. These seeds are a good source of fiber and protein, and the fiber may be broken down further. categorized as neutral detergent fiber and gum (gel fiber). The seeds also include fiber-galcatomannan, fenugreekine, a chemical that may have, and 4-hydroxyisoleucine, a unique amino acid. hypoglycemic effect.9 Although lignin, another kind of crude fiber, is of plant origin and also undigestible, it is not technically a carbohydrate. slows gastric emptying, prevents the quick absorption of glucose in the small intestine, helps diabetic individuals retain blood sugar, and may also be helpful in treating hypercholesteremia. [26]

Fig 2: Stevia rebaudiana

2. The family Asteraceae includes **Stevia rebaudiana**. It is indigenous to northeastern Paraguay. but is grown in other parts of the world, such as Europe, Asia, and North America. Stevia is well-known for its exceptional sweetness, which is 250 to 300 times that of sucrose. Its pleasant flavor is connected to the steviol glycosides, which are widely employed as sugar alternatives and non-caloric sweeteners. The Impact of Stevia on the Glycemic Profile: The majority of research in this area focused on the effects of stevia in diabetes (10–12), and only a small number of clinical trials looked at this topic. Animal models are used for research on the topic. [27]

Fig 3: Citric acid

3.Citric acid, Due to their pH-reducing effect, one group exhibits an antimicrobial activity primarily. This group They function either directly by reducing the pH of the by moving into the cytoplasm of the microorganism via the cell membrane in the undissociated state, or by adding stress to the food and thereby harming the microorganism. they break apart and reduce the cell's internal pH.[28]

Fig 4: Natural galactomannan

4. Natural galactomannan, which is derived from the endosperm of guar seeds, is known as guar gum. Guar belongs to a class of compounds. It is made up of indigestible carbohydrates and has been shown to be effective at lowering blood glucose levels after meals, especially when Guar granules are sprinkled on food (Jenkins et al. 1977). In addition, It has been documented that taking guar gum supplements for 48 weeks can help the lipid profile in those with type 2 diabetes mellitus (T2DM). [29]

Fig 5: Citric acid

5. The flavorings must be organic and originate either entirely or nearly entirely from lemons in order to be considered **"Natural lemon flavoring."** Although the word "almost exclusively" is not defined, the 1988 Commissioner agreed that a level of more than 90% from the named source would be considered to be so. be agreeable to the industry and the commission. This brings up the issue of how to categorize natural flavorings that are not exclusively or nearly exclusively obtained from the specified source. This is a question of the course is a matter for the individual Member States. In the United Kingdom, phrases like "natural lemon flavor flavoring" or "natural flavoring lemon type" have been used. However, the courts have never addressed the question of whether these are permissible. [30]

Fig 6: Ascorbic acid

6. The common reducing agent in all cells is **Ascorbic acid**. It improves nutrient content and inhibits oxidation. It is a nutritional need for humans and a number of other species that have mutations in the gene for l-gulonolactone oxidase. Ascorbic acid preserves particular enzyme activities, especially those of the hydroxylase enzymes that are essential for collagen production and carnitine synthesis. Additionally, it could enhance insulin sensitivity and glucose metabolism.

Preperation Methods of Functional and Nutritional Beverages:

1. Infusion-Based Herbal Beverage Preparation

Fig 7: Infusion-Based Herbal Beverage Preparation

Selection of Herbal Ingredients (e.g., Fenugreek, Cinnamon, Amla)
↓
Cleaning and Drying
↓
Crushing / Grinding to Powder
↓
Hot Water Infusion (80–90°C for 15–30 mins)
↓
Filtration
↓
Addition of Natural Sweeteners (e.g., Stevia
↓
Cooling & Bottling [31]

2. Juice-Based Blending Method

Fig 8: Juice-Based Blending Method

Selection of Fruits / Juicy Plants (e.g., Lemon, Amla, Pineapple)
↓
Extraction of Juice (Cold Press or Mechanical)
↓
Blending with API Extract (e.g., Fenugreek Decoction)
↓
Addition of Sweeteners, Acids, Stabilizers
↓
Pasteurization (60–70°C, 10–15 min)
↓
Cooling → Bottling → Labelling[32]

3. Fermentation-Based Functional Beverage (e.g., Kombucha Style)

Fig 9: Fermentation-Based Functional Beverage

Brew Base Tea (Black/Green) with Herbal Extract (e.g., Fenugreek)
↓
Add Sugar Source (controlled for diabetic-safe level)
↓
Cool to Room Temperature
↓
Inoculate with SCOBY (Symbiotic Culture of Bacteria & Yeast)
↓
Fermentation (7–10 days at 25–30°C)
↓
Filter and Bottle → Chill for Storage [33]

4.Cold Maceration or Soaking Method

Fig10: Cold Maceration or Soaking Method

Selection of Antidiabetic Herbs (e.g., Jamun, Gudmar, Fenugreek)
↓
Drying and Grinding
↓
Soak in Cold Purified Water (6–12 hours)
↓
Filter through Muslin Cloth
↓
Add Citric Acid, Stevia, Lemon Flavor (Optional)
↓

Store in Refrigeration (Consume within 1–2 days) [34]

5. Concentrate-Based Functional Beverage

Fig 11: Concentrate-Based Functional Beverage23

Prepare Herbal Extract Concentrate (using decoction or pressure extraction)

↓

Concentration Under Vacuum or Low Heat

↓

Add Thickening Agents (e.g., Guar Gum)

↓

Adjust TSS and pH (with natural acidulants like lemon juice)

↓

Mix with Diluent Water Before Bottling

↓

Sterilization & Packaging (PET/Glass bottles) [35]

Evaluation Parameter for Beverage Formulation:

Table 3: Evaluation Parameter for Beverage Formulation:

Parameter Category	evaluation Parameter	Purpose
Physical	Colour, Turbidity, Texture	To ensure the beverage look clear, clean, consistent in appearance.
Physical	Temperature	To check heat sensitiveity during processing and storage.
Chemical	Ph,Acidity/Alkalinity,Brix (sugar level) Additives	To balance taste,preserve shelf life,and ensure proper blr Ending of ingredints.
Chemical	Vitamin/nutrient content	Ensures nutritional value meets label
Microbiological	Totalplate,Yeasts,Molds,Pathogens	To check for harmful microogranisms and ensure product is safe.
Sensory(organoleptic)	Taste, Odor, Mouthfeel, Appearance	To taste overall consumer acceptability
Packing Integrity	Leakage,Seal	Ensures no contamination and correct labelling
Shelf lifeand Stability	Sedimentation,Seperation, Color/Fizz retention	Totest how long the product remains fresh, stable, and visually appealing over time
Water Quality	Hardness, Purity, Microbial load, Metal ions	Since water is a major component, its purity directly affects taste and safety
Processing parameters	Pasteurization effectiveness, Homogenization, Mixing uniformity	Ensures pathogens are killed and ingredients are evenly distributed
Regulatory Compliance	Compliance with food safety standards	To meet legal and quality requirements before market approval

Marketed Formulation:

Table 4: Marketed Formulation

Product Name	Main Ingreints	Type	Purpose
Diabliss herbal lemon drink	Fenugreek, amla, turmeric, cinnamon	Functional beverage mix	Blood glucose management
Kapiva dia free juice	Jamun, karela, neem, amla	Herbal juice	Reduce blood sugar, improves insulin
Organic India fenugreek tea	fenugreek, tulsi	Herbal infusion	Improves metabolism, glucose control
Nutriorg methi water	Fenugreek extract	Ready to drink herbal water	Regulates blood sugar

Zevic stevia Refreshing drink	Stevia, lemon extract	Low calorie cooler	Refreshing diabetic safe drink
Himalaya diabecon DS syrup	Herbal extracts	Syrup	Support pancreatic function
Yakult light	Pribiotic drink	Functional beverage	Improves gut health, metabolism

CONCLUSION:

This review emphasizes the potential of herbal-based functional drinks in controlling prediabetes, an important alert period prior to the onset of type 2 diabetes. Employing native anti-diabetic Fenugreek, amla, neem, turmeric, and other herbs provide a healthy, all-natural, and efficient way to help maintain blood sugar levels. The active substances in these herbs contribute to lower cholesterol, reduced inflammation, improved insulin sensitivity, and delayed glucose absorption. The formulation described in this article uses fenugreek as the primary active ingredient, along with supportive additives like stevia, citric acid, guar gum, and ascorbic acid. acid to make a low-calorie, tasty drink. In addition to improving flavor and texture, these components also increase the drink's nutritional advantages. Depending on the intended product type, various preparation techniques, such as infusion, blending, fermentation, and cold maceration, provide flexibility and adaptability. Safety, stability, and acceptability to consumers are guaranteed by proper evaluation using sensory, chemical, physical, and microbiological criteria. In conclusion, herbal functional drinks have great promise as a preventive dietary approach for those at risk of diabetes. They complement current trends toward plant-based and natural health remedies and provide a better option than sugary beverages. Nevertheless, additional clinical studies and standardization are required to guarantee consistent results and long-term safety in bigger groups. Based on the review's conclusions, this continuing effort aims to create a functional drink for prediabetic people utilizing traditional anti-diabetic plants.

CONFLICT OF INTEREST:

The author(s) state that there is no conflict of interest in using native antidiabetic plants for the development and evaluation of functional beverages for prediabetic patients.

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