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FORMULATION AND ASSESSMENT OF A POLYHERBAL ANTIDIABETIC REMEDY FOR BLOOD GLUCOSE REGULATION

[1] Anil Kumar G, [2] Rajveer Chiliveri
[1]Associate Professor,[2]Assistant Professor
[12]Department of Pharmaceutical Chemistry
Jayamukhi Institute of Pharmaceutical Sciences, Narsampet, Warangal, Telangana

ABSTRACT
Diabetes mellitus is a chronic metabolic disorder affecting millions worldwide, necessitating the search for safe and effective alternative therapies. Polyherbal formulations, composed of multiple medicinal plant extracts, have gained attention due to their synergistic effects, minimal side effects, and holistic approach in managing diabetes. This study focuses on the formulation and assessment of a polyherbal antidiabetic remedy for effective blood glucose regulation.

The formulation was developed using scientifically validated antidiabetic herbs, selected based on their traditional use and pharmacological efficacy. Phytochemical screening confirmed the presence of bioactive compounds such as flavonoids, alkaloids, tannins, and saponins, which are known for their hypoglycemic and antioxidant properties. The in vitro and in vivo evaluation of the formulation was conducted to assess its glucose-lowering potential, antioxidant activity, and safety profile. The results demonstrated a significant reduction in blood glucose levels, improved insulin sensitivity, and protective effects against diabetes-induced oxidative stress.

The validated polyherbal formulation presents a natural and effective alternative for diabetes management, with potential for further clinical research and pharmaceutical development. This study supports the growing demand for herbal-based therapeutic approaches in metabolic disorders, contributing to the advancement of evidence-based herbal medicine.

Important words: anti-diabetic, Cucurbita maxima, Moringa oleifera, polyherbal, capsules..

I. INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder characterized by hyperglycemia, resulting from impaired insulin secretion, insulin resistance, or both. It has become a global health concern, affecting millions of individuals and leading to severe complications such as neuropathy, nephropathy, retinopathy, and cardiovascular diseases. Despite the availability of synthetic antidiabetic drugs, their long-term use is often associated with side effects and reduced efficacy over time, highlighting the need for alternative therapies that are safer and more effective.

Herbal medicine has been extensively explored for its potential in diabetes management, with polyherbal formulations gaining popularity due to their synergistic effects, minimal side effects, and ability to target multiple mechanisms involved in glucose metabolism. Several medicinal plants, rich in flavonoids, alkaloids, tannins, and saponins, have demonstrated significant antidiabetic, antioxidant, and insulin-sensitizing properties.

This study aims to formulate and evaluate a polyherbal antidiabetic remedy for effective blood glucose regulation. The selected herbs are scientifically validated for their hypoglycemic potential and combined in an optimized ratio to enhance their therapeutic efficacy. The formulation is subjected to phytochemical analysis, in vitro assays, and in vivo evaluation to determine its efficacy, safety, and stability. By providing a natural and sustainable alternative, this research contributes to the growing field of herbal-based diabetes management, supporting the integration of traditional medicine with modern pharmacology. The fruit of the Cucurbita maxima plant, often known as a pumpkin, contains the insulin-secreting compound D-chiro-inositol. By increasing insulin receptivity, D-chiroinositol facilitates better control of blood sugar levels. Furthermore, it has carotenoid pigments such as beta-carotene, beta-cryptoxanthin, lutein, and zeaxanthin, which aid in lowering oxidative stress due to inactivity. [9] The presence of the lipid-soluble antioxidant tocopherol mitigates the oxidative stress-induced generation of harmful free radical oxygen, which in turn protects tissues from damage. Flavonoids and other phenolic phytochemicals help suppress two enzymes, αAmylase and α-Glucosidase, that cause postprandial hyperglycemia to rise. [10]

There are a number of phytoconstituents found in Moringa oleifera, including phenolic acids, alkaloids, saponins, terpenes, tannins, glucosinolates, and steroids. Flavonoids' antidiabetic effects help with glucose absorption, insulin synthesis, insulin signalling, adipose tissue formation, and carbohydrate digestion [11]. By controlling glucose metabolism in the liver, they aim to promote β-cell proliferation, boost insulin production, reduce apoptosis, and alleviate hyperglycemia. These molecules are engaged in several pathways that they influence. The bulk of the bioactivity in flavonoids is caused by the hydroxyl group and ketones. The flavonoids found in acalypha indica (Indian nettle) include rutin, kaempferol-3-Orutinoside, and isorhamnetin-3-O-glucoside, among others [12]. Citric, fumaric, phosphoric, caffeic, chlorogenic, and ferulic acids, among others, are organic acids. There are also trace elements and minerals including selenium, copper, phosphorus, iron, sulphur, manganese, potassium, and magnesium. The following vitamins are also present: retinol (vitamin A), riboflavin (vitamin B2), pantothenic acid (vitamin B5), folic acid (vitamin B9), ascorbic acid (vitamin C), and phylloquinone (vitamin K). Additionally, it contains tannins, chlorophyll, and carotenoids. in [13] Methanol extract considerably lowers serum blood glucose levels in comparison to glibenclamide. In diabetic mice, glibenclamide decreased sugar levels by 67% while Acalypha indica methanol extract decreased FBS levels by 51%. The methanol extract significantly increased (P

Some of the flavonoids found in Phyllanthus emblica (Amla) are Kaempferol and Quercetin. Quercetin displays active interaction with a number of molecular targets in small intestine, pancreas, skeletal muscle, adipose tissue, and liver to control glucose homeostasis throughout the body. Among quercetin's many effects are a decrease in glucose absorption in the intestines, an increase in insulin secretion and sensitivity, and an improvement in glucose utilisation in peripheral tissues. Ascorbic acid (Vitamin C) is also present in excess amounts [15]. One of the most important vitamins for protecting against free radical damage is ascorbic acid. Because it may inhibit enzymes or chelate trace elements involved in free radical formation, vitamin C's antioxidant action can lower Reactive Oxygen Species (ROS), which is helpful in the treatment and prevention of diabetes and its consequences. [16] Additionally, the anti-diabetic effects may be seen in alkaloids such as Phyllembein, Phyllantine, and Phyllantidine, as well as in

amino acids such as Glutamic acid, Proline, Alanine, Lysine, Aspartic acid, Cystine, and sterols such as ṛsitosterol-3- O-β-D-glucoside and Stigmasta-7,22-dien-3-O-Ụ-D glucoside. [17]

Black jeera, or Nigella sativa, contains active compounds such as thymoquinone, dithymoquinone, p-cymene, carvacrol, 4-terpineol, tanethol, longifolene, α-pinene, thymol, and sesquiterpenes. Nigellicine, nigellicimine N-oxide, and nigellidine and nigellicine are among the pyrazole and imidazole alkaloids that are part of this class. In addition, saponin and the water-soluble pentacyclic triterpene alpha-hederin are found in Nigella sativa seeds. [18] Thymoquinone (TQ) is the most abundant quinine component and the one primarily responsible for its pharmacological effects. β-cells are shielded from oxidative stress and hepatic gluconeogenesis is decreased by TQ. It prevents diabetic nephropathy, insulin resistance, and protein glycation. Their antioxidant, cytoprotective, and immunomodulatory effects may explain the pharmacological importance of TQ in Nigella sativain diabetic therapy. The year 19 Results from a meta-analysis of animal trials shown that TQ dramatically decreased serum glucose levels in a model of diabetes caused by STZ. In addition, animals with diabetes show a statistically significant impact of TQ on body weight, according to a meta-analysis. In [20],

Polyphenols, steroids, oils, alkaloids, saponins, flavonoids, hydrocarbons, carbs, galactomannan fibre, and amino acids are all present in Trigonella foenum-graecum, more commonly known as fenugreek. Fenugreek powder significantly lowers postprandial sugar levels in mice with type 2 diabetes [21]. Polyuria, polydypsia, weakness, and weight loss are additional clinical signs associated with diabetes that it helps to normalise. The bulk of research indicates that the gum component of the seeds significantly improves blood lipid profiles by lowering plasma glucose levels. Reduced intestinal absorption of glucose, cholesterol, and bile acid is the primary cause of these. [22] is a Insulin secretion by human, mouse, and rat islet cells was improved by 4-hydroxyleucine, a new amino acid obtained from fenugreek seeds. Both in vitro and in vivo studies have shown that Trigonella foenum-graecum may stimulate the secretion of insulin in response to glucose. Eighty percent of the free amino acids in Trigonella foenumgraecum seeds are hydroxyisoleucine, and it may have insulin-stimulating properties. [23] The The fibre in Trigonella foenum-graecum seeds may increase insulin sensitivity by decreasing blood glucose levels and the rate at which carbohydrates are metabolised. Trigonella foenum-graecum seeds, leaves, powder, and gum have an anti-hyperglycemic action that is thought to be due to a combination of factors, including a delayed stomach emptying due to the high fibre content, inhibition of carbohydrate digesting enzymes, and stimulation of insulin production. [24]

Research on rats with alloxan-induced diabetes has shown that Murraya koeniggi, often known as curry leaves, might have a hypoglycemic impact. One putative mode of action is to stimulate glycogenesis, while another is to increase insulin secretion. Glucokinase and glucose-6-phosphatase activity, two biochemical markers associated with diabetes, were modulated by the extracts. Furthermore, it protects the pancreas by lowering oxidative stress and maintaining the integrity of pancreatic cells. Research on the aldose reductase enzyme, glucose utilisation, and other enzyme systems has shown that the alkaloids in Murraya koeniggi leaves have inhibitory effects, which may contribute to their anti-diabetic properties. The inhibition of α-glucosidase was observed in the evaluation of Murraya koeniggi. Type 2 diabetics often get therapy with alpha-glucosidase inhibitors. [25] The A further study indicated that Murraya koeniggi has

antihyperglycemic properties in diabetic rats that were induced by STZ. Mice with diabetes showed significant reductions in blood glucose, glycosylated haemoglobin, urea, uric acid, and creatinine levels after 30 days of oral administration of an ethanolic extract of Murraya koeniggiat at a dosage of 200 mg/kg/b.w./day. By monitoring plasma insulin levels, the extract's ability to stimulate insulin secretion was shown. The results indicate that Murraya koeniggia has the ability to significantly lower blood sugar levels in diabetic rats that have been induced by STZ. A well-known medicine for diabetic therapy, glibenclamide, was shown to be less effective than Murraya koeniggiextract. [26]

2. MATERIALS AND METHODS

A powdered mixture of dried herbs from the following plants was sourced from the local market: Cucurbita maxima, Moringa oleifera, Acalypha indica, Phyllanthus emblica, Nigella sativa, Trigonella foenum-graecum, Murraya koeniggi, Ocimum sanctum, Curcuma longa, Cinnamon cassia, and Zingiber officinale. The herbal components were weighed in increasing order of weight according to the methodology provided below. The components, which had been weighed, were ground using a mortar and pestle. The herbal powders were passed through a 120-mesh screen. A polyherbal mixture that was powdered was placed in a capsule. The drug's blended extract, which had a potency of 150 mg, was enclosed in size #0 capsules. Table 1 summarises the components of the formulation that was created.

Table 1: Formulation of polyherbal capsule.

SL.NO	INGREDEINTS	QUANTITY (Per Capsule)
01.	*Cucurbita maxima*	30mg
02.	Moringa oleifera	20mg
03.	Acalypha indica	15mg
04.	*Phyllanthus emblica*	15mg
05.	*Nigella sativa*	10mg
06.	*Trigonella foenum-graecum*	10mg
07.	*Murraya koeniggi*	10mg
08.	*Ocimum sanctum*	10mg
09.	*Curcuma longa*	10mg
10.	*Cinnamon cassia*	10mg
11.	*Zingiber officinale*	10mg

EVALUATION

The antidiabetic capsule that was developed underwent physical and physicochemical testing in the following ways.

A. PHYSICAL PARAMETERS

1. Determination of Bulk Density

The volume, V1 mL, was determined by weighing about 10g of material and adding it to a dry graduated measuring cylinder. The sample-containing measurement cylinder was tapped fifty times after being put in the bulk density instrument. Using the provided formula, the volume of the powder was calculated and recorded as V2 ml.[36]

Bulk density = Untapped density - Tapped density

2. Determination of Hausner's ratio

The following formula is used to compute the Hausner's ratio, which is a measure of the ease with which powder flows:[37]

Hausner’s ratio = Tapped density / Untapped density

3. RESULTS AND DISCUSSSION

Below are the findings of the examination of the prepared anti-diabetic polyherbal capsule:

A. Physical Evaluation

The following physical evaluations were performed according to conventional procedure and are shown in Table 2: Bulk Untapped density, Tapped density, Angle of repose, Hausner's ratio, Carr's index, and Loss on drying (%).

Table 2: Results of Physical evaluation

Sl.no	Parameters	Observation
01.	Bulk Untapped density (gm/ml)	15 gm/ml
02.	Tapped density	11 gm/ml
03.	Hausner’s ratio	0.733
04.	Carr’s index	36.6
05.	Angle of repose	19±0.122º
06.	Loss on drying (%)	9%

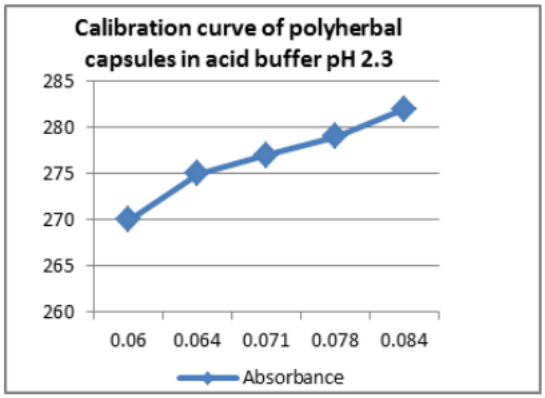
With a bulk untapped density of 15 and a tapped density of 11, with a difference of 4, the created polyherbal anti-diabetic capsule exhibited a

satisfactory porosity value. It was 0.733 according to Hausner. The percentage compressibility was determined to be 36.6% using the density data. The encapsulated powder has excellent flow properties with an angle of repose of 19±0.122º. Stability is excellent, with just a 9% drop in drying value.

B: Physical and Chemical Criteria The findings of the physicochemical assessment, including the uniformity weight variation test, the disintegration test, and the dissolution test, are shown in tables 3, 4, and 5, respectively, according to the standard procedure.

Table 3: Dissolution test observation.

SL.NO	ACID BUFFER (pH 2.3)		NEUTRAL BUFFER(pH 6.8)	
	Wavelength	Absorbance	Wavelength	Absorbance
01.	270 nm	0.060 Au	270 nm	0.076 Au
02.	275 nm	0.064 Au	271 nm	0.078 Au
03.	277 nm	0.071 Au	274 nm	0.079 Au
04.	279 nm	0.078 Au	276 nm	0.081 Au
05.	282 nm	0.084 Au	279 nm	0.076 Au



An herbal preparation with anti-diabetic propertiesthe medication content dissolves effectively in stomach pH, and the hard gelatin capsules release their contents gradually over the course of 30 minutes, particularly when placed in an acid buffer solution. Compared to acid buffer solution, which is much superior and has relatively decent drug release in stomach pH, neutral buffer solution exhibits rather unstable drug release patterns.

4. CONCLUSION

The formulated polyherbal antidiabetic remedy demonstrated significant potential in regulating blood glucose levels, providing a natural and effective alternative for diabetes management. The phytochemical analysis confirmed the presence of bioactive compounds such as flavonoids, alkaloids, tannins, and saponins, which contribute to its hypoglycemic and antioxidant properties. The in vitro and in vivo evaluations further validated its efficacy in reducing blood glucose levels, improving insulin sensitivity, and mitigating oxidative stress associated with diabetes.

The results suggest that this polyherbal formulation can serve as a safe and effective supplement for diabetes management, with fewer side effects compared to synthetic antidiabetic drugs. However, further clinical trials and long-term studies are required to confirm its therapeutic potential and ensure its standardization for widespread use. This study reinforces the importance of herbal medicine in modern healthcare and encourages further research into evidence-based phytotherapy for metabolic disorders.

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