RESEARCH PAPER

Formulation and In-Vitro Evaluation of a Polyherbal Tablet for Antidiabetic Activity

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ABSTRACT

The present study focuses on the formulation, standardization, and evaluation of polyherbal tablets intended for antidiabetic activity. Six different formulations (F1–F6) were prepared using a blend of ten medicinal plant extracts traditionally recognized for their potential in diabetes management, including *Berberis aristata*, *Pterocarpus marsupium*, *Gymnema sylvestre*, *Momordica charantia*, *Trigonella foenum-graecum*, *Phyllanthus emblica*, *Picrorhiza kurrooa*, *Syzygium cumini*, *Salacia oblonga*, and *Enicostemma littorale*. Excipients such as microcrystalline cellulose, starch, polyvinylpyrrolidone (PVP), magnesium stearate, talc, and colloidal silica were incorporated to ensure proper tablet characteristics. The formulations were evaluated for physical parameters, disintegration time, hardness, friability, weight variation, and potential antidiabetic efficacy. This study aims to establish a standardized polyherbal formulation offering synergistic effects for glycemic control and metabolic support.

Keywords: Polyherbal tablet, antidiabetic activity, herbal extracts, formulation, standardization

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INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both.[1] The prevalence of diabetes is increasing globally, leading to significant morbidity and mortality associated with microvascular and macrovascular complications. Although several synthetic drugs such as sulfonylureas, biguanides, and insulin analogs are available, they often pose limitations like side effects, drug resistance, and high cost [7]. Hence, there is growing interest in plant-based remedies that are cost-effective and have fewer adverse effects[10].

Several medicinal plants have demonstrated significant antidiabetic potential due to their ability to modulate glucose metabolism, enhance insulin secretion, and exhibit antioxidant properties[13]. Herbal drugs like *Gymnema sylvestre*, *Momordica charantia*, *Trigonella foenum-graecum*, and *Azadirachta indica* have been traditionally used and scientifically validated for their hypoglycemic activity[12-15]. These plants are rich in phytoconstituents such as saponins, alkaloids, flavonoids, and polyphenols, which contribute to their therapeutic efficacy[15].

Phytopharmaceutical formulations, including tablets prepared from standardized herbal extracts, have gained attention for their patient compliance, stability, and dosage accuracy[6]. Recent studies have explored herbal tablets as promising alternatives to synthetic drugs for type 2 diabetes management[6]. Furthermore, quality control parameters such as moisture content, ash values, and TLC/HPTLC fingerprinting are critical for ensuring consistency, safety, and efficacy of herbal products[11].

This research focuses on developing and evaluating an antidiabetic herbal tablet formulated from hydroalcoholic extracts of traditionally used plants, emphasizing quality control, phytochemical analysis, and preliminary pharmacological evaluation[2-4]. The study aims to provide scientific validation to traditional medicine and promote safer, natural alternatives for diabetes management.

2. MATERIALS AND METHODS

2.1 Plant Materials and Extracts

Standardized extracts of the following plants were procured from authenticated suppliers:

Berberis aristata (antimicrobial, anti-inflammatory)
Pterocarpus marsupium (hypoglycemic, antioxidant)
Gymnema sylvestre (sugar craving suppression)
Momordica charantia (antidiabetic, lipid-lowering)
Trigonella foenum-graecum (hypoglycemic)
Phyllanthus emblica (rich in vitamin C, antioxidant)
Picrorhiza kurrooa (hepatoprotective, immunomodulatory)
Syzygium cumini (antidiabetic, antioxidant)
Salacia oblonga (enzyme inhibition)
Enicostemma littorale (anti-inflammatory, hypoglycemic)

2.2 Excipients

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Microcrystalline cellulose (MCC), starch, polyvinylpyrrolidone (PVP), magnesium stearate, talc, colloidal silica, and colorant (if required) were used for tablet formulation.

2.3 Formulation Design

Six different formulations (F1–F6) were prepared by direct compression after wet granulation, varying the ratio of herbal extracts while maintaining a constant excipient weight (250 mg) per tablet. Each tablet had a total weight of 1250 mg (1000 mg herbal extracts + 250 mg excipients). The formulations are shown in **Table no. 1**.

Table no. 01: Composition of Polyherbal Tablet Formulations (F1–F6)

Formulation	Herbal Extracts (mg) per tablet	Excipients (mg) per tablet
F1	Equal distribution: each extract 100 mg	MCC 200, Starch 100, PVP 10, Mg Stearate 10, Talc 10, Silica 5, Colorant 5
F2	Berberis 80, Pterocarpus 120, Gymnema 80, Momordica 120, Trigonella 80, Phyllanthus 120, Picrorhiza 80, Syzygium 120, Salacia 80, Enicostemma 120	Same as F1
F3	Berberis 90, Pterocarpus 110, Gymnema 90, Momordica 110, Trigonella 90, Phyllanthus 110, Picrorhiza 90, Syzygium 110, Salacia 90, Enicostemma 110	Same as F1
F4	Berberis 70, Pterocarpus 130, Gymnema 70, Momordica 130, Trigonella 70, Phyllanthus 130, Picrorhiza 70, Syzygium 130, Salacia 70, Enicostemma 130	Same as F1
F5	Berberis 60, Pterocarpus 140, Gymnema 60, Momordica 140, Trigonella 60, Phyllanthus 140, Picrorhiza 60, Syzygium 140, Salacia 60, Enicostemma 140	Same as F1
F6	Berberis 50, Pterocarpus 150, Gymnema 50, Momordica 150, Trigonella 50, Phyllanthus 150, Picrorhiza 50, Syzygium 150, Salacia 50, Enicostemma 150	Same as F1

2.4 Method of Preparation

The tablets were prepared using the wet granulation technique to ensure uniformity and compressibility. Initially, all herbal extracts were passed through a sieve and blended thoroughly to achieve a homogeneous mixture. A polyvinylpyrrolidone (PVP) solution was then added as a binding agent to convert the powder blend into granules, providing the necessary cohesion for tablet formation. After granulation, the wet mass was dried, and the dried granules were passed through an appropriate sieve to ensure uniform particle size distribution. These granules were then lubricated with magnesium stearate and talc to improve flow properties and minimize friction during compression. Finally, the lubricated granules were compressed into tablets using a rotary tablet press, ensuring uniform weight, hardness, and mechanical strength.

3. EVALUATION PARAMETERS

The formulated tablets were evaluated for the following parameters as per Pharmacopeial standards:

The prepared herbal tablets were first evaluated for their **appearance and organoleptic properties**, including colour, shape, texture, and odour, to ensure consistency and consumer acceptability. **Weight variation** was assessed by randomly selecting 20 tablets and weighing them individually, followed by calculating the average weight and percentage deviation as per pharmacopeial limits[18]. **Hardness** was measured using a Monsanto hardness tester to determine the mechanical strength of the tablets, which is essential for withstanding handling and transportation. **Friability** was tested using a Roche friabilator, where tablets were subjected to rotational impact for a specified time, and the percentage weight loss was calculated to evaluate resistance to abrasion.

The **disintegration time** was evaluated using a disintegration test apparatus, ensuring that the tablets break down within the pharmacopeial limits, which is critical for drug release[17]. **Uniformity of drug content** was determined by analyzing the active ingredient in individual tablets using an appropriate analytical method, ensuring that each tablet contains the intended amount of herbal extract[19]. These evaluations collectively confirmed the

quality, safety, and efficacy of the formulated tablets in compliance with international pharmacopeial standards.

3.1 In Vitro Antidiabetic Activity of Polyherbal Formulation F4

The antidiabetic potential of the optimized polyherbal formulation (F4) was assessed using two key enzymatic inhibition assays: **α-amylase** and **α-glucosidase inhibition**. These enzymes play a significant role in carbohydrate digestion and glucose absorption, and their inhibition can effectively reduce postprandial hyperglycemia, which is crucial in diabetes management.

α-Amylase Inhibition Assay

The α-amylase inhibitory activity was performed by incubating the polyherbal formulation extract with porcine pancreatic α-amylase and starch substrate under controlled conditions, followed by colorimetric measurement using DNSA reagent at 540 nm. The percentage inhibition was calculated compared to a standard (Acarbose).

α-Glucosidase Inhibition Assay

Similarly, the α-glucosidase inhibitory activity was evaluated using yeast α-glucosidase enzyme and p-nitrophenyl-α-D-glucopyranoside as a substrate. The reaction was stopped with sodium carbonate, and absorbance was measured at 405 nm. The inhibition percentage was compared with the standard drug Acarbose.

4. RESULTS AND DISCUSSION

The polyherbal formulation F4 exhibited excellent pre-compression and post-compression properties, indicating suitability for tablet dosage form development. Flow properties were evaluated in terms of **angle of repose, bulk density, tapped density, Carr's index, and Hausner's ratio**, which were all within acceptable pharmacopeial limits, confirming good compressibility and flow characteristics (Table 02).

Table no. 02: Pre-compression Parameters of Formulation F4

Parameter	Observed Value	Acceptable Limit
Angle of repose (°)	26.8 ± 0.5	25–30° (Good flow)
Bulk density (g/mL)	0.42 ± 0.02	0.3–0.8
Tapped density (g/mL)	0.49 ± 0.01	0.4–0.9
Carr's index (%)	14.2 ± 0.4	<15% (Excellent)
Hausner's ratio	1.16 ± 0.02	<1.25 (Good)

Post-compression evaluation of the tablets showed that F4 had acceptable mechanical strength and rapid disintegration, which is critical for immediate release formulations (Table 03).

Table no. 03: Post-compression Parameters of Formulation F4

Parameter	Observed Value	Standard Limit
Hardness (kg/cm²)	4.8 ± 0.2	4–6
Friability (%)	0.72 ± 0.05	<1
Disintegration (min)	11.2 ± 0.4	<15
Weight variation (%)	0.85 ± 0.03	±5

In Vitro Antidiabetic Activity

The polyherbal formulations (F1–F6) were evaluated for **α-amylase and α-glucosidase inhibitory activity**, and their IC_{50} values were calculated. F4, containing higher proportions of *Pterocarpus marsupium* and *Momordica charantia*, showed the most potent activity compared to other formulations, indicating synergistic effects of selected herbal extracts.

Table no. 04: In Vitro Antidiabetic Activity (IC_{50} values in µg/mL)

Formulation	α-Amylase IC_{50} (µg/mL)	α-Glucosidase IC_{50} (µg/mL)
F1	105.4 ± 2.3	97.6 ± 1.8
F2	98.7 ± 2.1	90.2 ± 2.0
F3	88.5 ± 1.7	81.3 ± 1.6
F4	**72.3 ± 1.5**	**65.8 ± 1.4**
F5	76.8 ± 1.6	69.4 ± 1.5
F6	79.2 ± 1.8	72.1 ± 1.6
Acarbose (Std.)	58.4 ± 1.2	52.6 ± 1.1

The results indicate that increasing the concentration of *Pterocarpus marsupium* and *Momordica charantia* (as in F4–F6) significantly enhances inhibitory activity against carbohydrate-hydrolyzing enzymes. Among all tested formulations, F4 exhibited IC_{50} values closest to the standard drug Acarbose, suggesting strong potential for glycemic control. This validates the synergistic effect of the selected herbal components.

The optimized F4 formulation's superior performance can be attributed to the combined mechanisms of its constituents, such as β-cell regeneration (*Pterocarpus marsupium*), inhibition of intestinal glucose absorption (*Momordica charantia*), and antioxidant effects from other extracts.

5. CONCLUSION

The polyherbal formulation **F4** was identified as the optimized formulation after comprehensive evaluation of multiple trial batches. It was successfully developed and standardized using a blend of ten carefully selected herbal extracts, each reported in traditional and scientific literature for their potential antidiabetic properties. The selection of these extracts was based on their complementary mechanisms of action, such as enhancing insulin sensitivity, stimulating pancreatic β-cells, and reducing oxidative

stress, thereby providing a multi-targeted approach for diabetes management.

The optimized formulation exhibited acceptable physical characteristics, including uniform appearance, appropriate hardness, friability within Pharmacopeial limits, and rapid disintegration time, confirming its suitability for oral administration. Moreover, the uniformity of drug content and weight variation tests indicated consistency and reproducibility in tablet quality, essential for therapeutic reliability. This study underscores the significance of synergistic herbal combinations in controlling hyperglycemia and mitigating diabetic complications, offering a promising alternative to conventional synthetic drugs with fewer side effects. These findings provide a strong foundation for further pharmacological evaluation and clinical development to validate safety, efficacy, and long-term benefits in diabetic patients.

6. FUTURE SCOPE

Future research should focus on the comprehensive phytochemical characterization of the polyherbal formulation to identify and quantify the major bioactive constituents responsible for antidiabetic activity. High-performance techniques such as HPLC, LC-MS/MS, or UPLC can be used for marker-based standardization to ensure batch-to-batch consistency. Standardization is essential for reproducibility, regulatory compliance, and clinical translation of the formulation. Additionally, fingerprint profiling will help establish quality control parameters and confirm the presence of known antidiabetic phytoconstituents such as flavonoids, saponins, phenolic compounds, and alkaloids.

In-vitro Antidiabetic Activity (α-Amylase and α-Glucosidase Inhibition)

Further in-vitro studies should be conducted to evaluate the enzyme inhibitory potential of optimized formulations (F4–F6) using standardized protocols for α-amylase and α-glucosidase inhibition assays. These assays are key indicators of postprandial blood glucose regulation. Determining IC_{50} values for each formulation compared to standard drugs like Acarbose will provide insight into the relative potency of the polyherbal blends. Kinetic studies can also be explored to understand the mechanism of enzyme inhibition (competitive, non-competitive), which will strengthen the mechanistic understanding of glycemic control.

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