HOLISTIC APPROACHES TO DIABETES MANAGEMENT: INTEGRATING AYURVEDIC DIETARY PRINCIPLES WITH CONTEMPORARY PRACTICES[1]VENINTHAA S J S, [2] VARUNSARVESH K S, 3

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Abstract— Ayurvedic pharmacopoeia of India provides a comprehensive framework for managingdiabetes mellitus through dietary interventions tailoredto an individual's dosha body constitution to optimize health outcomes this study assesses the efficacy of ayurvedic dietary approaches for diabetes mellitus focusing on the dietary guidelines specified in the ayurvedic pharmacopoeia central to these interventionsis the use of hypoglycemic foods and medicinal herbs such as Curcuma longa(Turmeric) and Trigonella foenum-graecum (Fenugreek) which are analyzed for their impact on glucose metabolism and insulin sensitivity fenugreek seeds rich in soluble fiber attenuate the digestion and absorption of carbohydrates thereby stabilizing blood glucose levels turmeric active component curcumin exhibits potent antioxidant and anti-inflammatory properties that enhance insulin function ayurvedic principles also advocate for mindful eating and avoidance of foods thatdisturb dosha balance reinforcing a holistic approach to diabetes management moreover this study comparesmodern nutritional strategies for diabetes managementwith ayurvedic dietary guidelines to identify potential synergies the findings suggest that integratingayurvedic dietary principles into contemporarymedical practice could provide an adjunctive strategy for managing diabetes mellitus and improving overall health outcomes however further rigorous research is necessary to validate these benefits and integrate ayurvedic dietary strategies into global diabetes care protocols.

Keywords: Ayurveda, diabetes mellitus, metabolism,medicinal herbs.

I. INTRODUCTION

Diabetes Mellitus (DM) is a widespread metabolic condition marked by elevated blood glucose levels, stemmingfrom inadequate insulin production or the body's cells failingto respond properly to insulin [1]. The timely detection of Diabetes Mellitus is imperative to avert grave complications such as stroke, myocardial infarction, and atherosclerosis. Biomarkers, including glycated haemoglobin and its blood cell counts, are essential in monitoring and managing DM, guiding treatment decisions and evaluating recovery progress. Although present pharmacotherapeutic options encompass insulin and oral hypoglycaemic agents, further research is essential to develop more efficacious treatments and potentially discover a definitive cure for this pervasive globalepidemic [2]. The classification of Diabetes Mellitus includesType 1 DM (insulin-dependent) and Type 2 DM (non-insulin-

dependent), with gestational diabetes emerging during pregnancy [3][4]. Furthermore, this condition results in impaired metabolism of carbohydrates, fats, and proteins, andis linked to long-term complications such as cardiovascular disease, neuropathy, retinopathy, and nephropathy. Ayurvedicprinciples also support a healthy approach to diabetes management by promoting a healthy diet and avoiding foods that disrupt energy balance. Healthy nutrition requires payingattention while eating, eating slowly, and monitoring hungerand satiety. This practice not only aids digestion but also helpsmaintain a balanced mind, which is important for overall heath. Ayurveda emphasizes the importance of a healthy dietthat targets a person's dosha type (Vata, Pitta or Kapha). Eachdose comes with specific dietary recommendations designedto balance the body's energy and promote health. Joint venture. Today's diet strategies often focus on things like carbohydrate counting, glycaemic index control, and calorie restrictions. While these ideas are helpful, they sometimes ignore health and wellness. By integrating Ayurvedic nutritional principles that focus on the person's constitution and the medical properties of food, it is possible to effectivelycontrol sweet blood pressure. Exercise may provide additionalstrategies for managing diabetes and improving overall health.However, it is important to note that while preliminary evidence supports the benefits of Ayurvedic dietary interventions, further research is needed to confirm the resultsregarding these benefits and to incorporate Ayurvedic dietary strategies into diabetes care programs worldwide. This integration requires careful consideration of the scientific evidence supporting the effectiveness of these interventions, as well as a willingness to participate collectively and individually in intensive care. Overcome Ayurvedic nutritional principles can improve diabetes management strategies by using the medicinal properties of specific foods and herbs and making them healthy. As research in this area continues to evolve, it promises to provide better and more personalized care for people with diabetes.

OVERVIEW

Diabetes Mellitus, a chronic metabolic disease that occursas a result of increased blood sugar due to insulin deficiency or resistance, poses a major problem in the world that requiresnew treatments. As the incidence of diabetes increases, thereis an urgent need for effective treatment to control and cure this disease. To this end, we created a new blend of natural ingredients designed to work synergistically on multiple diabetes-related pathways, including turmeric, fenugreek andamla. Curcumin, the active ingredient in turmeric, has anti- inflammatory and antioxidant properties and regulatespathways such as NF-κB and AMPK, which are important for

insulin signalling and glucose metabolism. Fenugreek contains soluble fiber and saponins that increase insulin sensitivity and glucose uptake by activating the GLUT4 transporter and modulating insulin receptor substrates. Amlais rich in vitamin C and polyphenols, which improve pancreatic beta cell function and reduce oxidative stress, affecting pathways such as PI3K/Akt and JNK, which are important for insulin secretion and cellular homeostasis. To justify these claims, we performed Cytoscape analysis, a bioinformatics tool, to illustrate and visualize the interaction of bioactive compounds with blood sugar molecular networks. This analysis reveals diverse targets of our structure, revealing its ability to modulate important signalling cascades related tohomeostasis and insulin. In addition, stringent physical and chemical tests are carried out to guarantee the quality, purityand consistency of our samples to ensure the availability and stability of the active ingredients. These quality controls are very important for the effectiveness

and safety of our products. The combination of these scientific tests supports the therapeutic potential of our combinations in the treatmentof diabetes, providing a better method of treatment by using the energy of herbal plants more efficiently and effectively.

II. PATHOPSYOLOGY OF THE NEWFORMULATION

Type 2 diabetes is a metabolic disease characterized by insulin resistance, decreased insulin secretion and increased blood sugar. The Gly972Arg mutation in IRS-1 interferes with the interaction of the p85 subunit of phosphatidylinositol3-kinase (PI3K) and impairs insulin release from pancreatic beta cells in response to glucose and sulfonylureas. Other genetic mutations associated with type 2 diabetes (T2DM) were found in the ABCC8 (SUR1) and KCNJ11 genes, which produce ATP-sensitive potassium channels/sulphonyl urea receptors in pancreatic beta cells. In addition, mutations in thehepatocyte nuclear factor 1 homeobox A (HNF1A) gene cause the most monogenic form of juvenile onset dysplasia (MODY3), termed HNF1A-MODY. The hepatocyte nuclear1 homeobox B (HNF1B) gene causes MODY5, a rare but more severe form of monogenic diabetes. Insulin release is mainly triggered by high glucose levels and is absorbed by the GLUT2 transporter. The breakdown of glucose increasesthe ATP/ADP ratio, closing ATP-dependent potassium channels, depolarizing the membrane and opening calcium-dependent channels, thereby promoting insulin exocytosis. Other calcium channels, including P2X, P2Y, SERCA, and RYR, also play a role in calcium mobilization and insulin secretion. Understanding the complex molecular mechanismsunderlying insulin resistance and pancreatic dysfunction is critical for the treatment of type 2 diabetes.

III. QUALITATIVE ANALYSIS OF THE NEWFORMULATION

Curcuma longa (Turmeric):

Curcuma longa, commonly known as turmeric, and its bioactive compound curcumin have demonstrated promising effects in the management of diabetes and its associated complications. Research has emphasized the anti- inflammatory, antioxidant, and anti-hyperglycaemic properties of curcumin, which contribute to its efficacy in enhancing glycaemic and metabolic parameters in individuals with type 2 diabetes, prediabetes, and metabolic syndrome [5] [6] [7]. Moreover, research has revealed that curcumin interacts with key genes and pathways associated with diabetes, including the AGE-RAGE signalling pathway,the PI3K-Akt signalling pathway, and TNF signalling. Theseinteractions suggest its potential therapeutic utility in the management of diabetes [8]. The capacity of curcumin to target inflammatory mediators and modulate diverse molecular signalling pathways positions it as a valuable candidate for mitigating complications associated with diabetes and enhancing overall health outcomes in diabetic individuals [9].

Phyllanthus emblica (amla):

Phyllanthus emblica, commonly known as amla, has been extensively studied for its potential in diabetes management. Studies have highlighted that amla extracts can reduce bloodglucose levels, increase insulin levels, and regulate cytokine expressions, ultimately inhibiting the development of autoimmune diabetes [10]. Compounds like isochiapin B, 16α-hydroxycleroda-

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3,13 (14) Z-dien-15,16-olide, and 14-beta- H-pregna in amla's methanol extract show promising antidiabetic potential based on in silico drug-likeliness assessments [11]. The compounds found in amla, such as polyphenols, tannins, phenolic acids, and flavonoids, contribute to its anti-diabetic properties by inhibiting digestive enzymes like α-amylase and α-glucosidase, crucialin controlling blood sugar levels [12]. Additionally, amla's phytoconstituents, such as ellagic acid, gallic acid, emblicanin A & B, and quercetin, contribute to its antidiabetic, hypolipidemic, and antioxidant activities [13]. These compounds target various pathways involved in diabetes management, showcasing amla's therapeutic significance in combating diabetes and related metabolic disorders.

Trigonella foenum-graecum (Fenugreek):

Trigonella foenum-graecum, commonly known as Fenugreek, has been extensively studied for its anti-diabetic properties due to the presence of bioactive compounds like furostanolic saponins in its seeds [14]. These compounds haveshown efficacy in reducing post-prandial glucose levels, improving insulin sensitivity, and aiding in glucose homeostasis in patients with Type 2 diabetes. Additionally, other phytoconstituents found in Fenugreek, such as diosgenin trigonelline, 4-hydroxyisoleucine, leucine, and L- lysine, have been identified as potential novel inhibitors for specific target proteins related to diabetes treatment [15]. These compounds interact with pathways like AKT and AMPK, influencing glucose uptake and insulin sensitivity, thus showcasing the potential of Fenugreek and its constituents in the treatment and management of diabetes. The plant's therapeutic pharmacological effects also extend to anti-cancer, anti-inflammatory, and cholesterol-lowering

properties, making it a versatile natural remedy for various health conditions [16].

S.No	Botanical name	Plant part used	Common name	Tamil name
1.	Curcuma longa	Whole plant	Turmeric	Manjal
2.	Trigonella foenum-graecum	Seed	Fenugreek	Vendhayam
3.	Phyllanthus emblica	Fruit	Indian gooseberry	Nellikal

Table 1. Content of the new formulation

IV. INSILICO ANALYSIS AND NETWORKPHARMACOLOGY METHOD

The bioactive ingredients of our new formulations were identified by the pharmacology network. We analyzed samples containing three botanicals containing a total of 242bioactive compounds through data mining. 242 bioactive compounds associated with 32 target genes directly associated with nine type 2 diabetes-related diseases. The network analysis is displayed in Cytoscape and shows the extensive network of interactions between plants, their targets, pathogens, and pathogens. This integration leads to adeeper understanding of the therapeutic potential of the constructs, providing a promising avenue for empirical development. When developing new combination drugs to treat type 2 diabetes, network drug analysis is important to determine mechanisms of action at the genetic level. Many studies have been conducted in silico pharmacology to demonstrate the therapeutic potential of single herbs or various herbal preparations (Srinidhi 2019 and Ren et al. 2019).

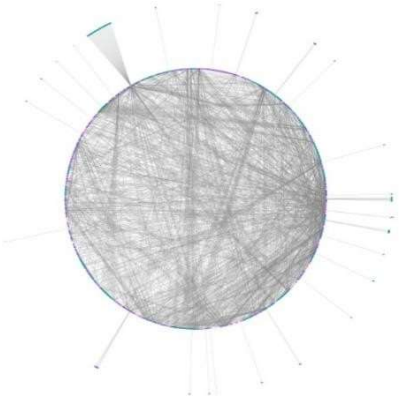

Figure 1. Cytoscape of the new formulation

V. PHYSICOCHEMICAL ANALYSIS

Physicochemical studies of the new formulation are carried out according to the guidelines laid down in the Indian Ayurvedic Pharmacopoeia Part II, Volume 1, 1st Edition. Parameters used to test for impurities include total ash, water-soluble ash, and acid-insoluble ash. Other tests include pH todetermine acidity or alkalinity, bulk density to measure the compactness of a sample, particle size to determine particle size distribution, moisture loss during drying to assess ingredient moisture, and loss during drying to determine percent soluble. Components of water-soluble extracts and alcohol-soluble extracts. Regarding quality control, all results were in accordance with internal specifications (Table 2). Comprehensive evaluation of the physical and chemical properties of the sample ensures its quality, safety and compliance with traditional Ayurvedic standards, thereby increasing the therapeutic potential of the new drug.

Total Ash:

Ash refers to the inorganic (oxides, sulphates, phosphates, silicates and chlorides) residue remaining after either ignitionor complete oxidation of organic matter in a foodstuff. Weigh1-2 grams of a moisture-free sample and transfer it into the pre-weighed crucible. Place then crucible in a muffle furnaceset at 500 ± 50°C and incinerate the sample for approximately 6 hours until white ash is produced. After incineration, cool the crucible in a desiccator. Weigh the cooled crucible and repeat the weighing process until a constant weight is achieved (Hannington Twinomuhwezi et al., 2020) [17] The total ash can be obtained by the below formula.

$$\text{Crude ash (\%, wet weight)} = \frac{C - A}{B} \times 100$$

Where,

A = Weight of the empty crucible in grams

B = Weight of the crucible with sample before ashing ingrams

C = Weight of crucible with ash after ashing in grams

Water soluble Ash:

For the measurement of water-soluble ash, the standard method of (Akhilesh and Kundan Singh Bora, 2016) was used. Dissolve the ash in a specified volume of distilled water, usually about 25 millilitres. Heat the solution to a gentle boil and then filter it through ashless filter paper, collecting the filtrate in a separate container. Wash the residue on the filter paper with hot distilled water to ensure complete extraction of water-soluble components. Dry the filter paper and the remaining insoluble ash in the crucible inan oven, then incinerate it again until constant weight is achieved. By performing the below formula water soluble ashcontent is calculated.

$$\text{\% of Water-soluble ash} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

Acid insoluble Ash:

Boil the ash with 25 millilitres of hydrochloric acid for 5 minutes. Filter out the insoluble residue using a sintered crucible or ashless filter paper. Rinse the residue thoroughly with hot water. Place the filtered residue in a crucible and heatit at approximately 500°C until the weight is constant. Calculate the amount of acid-insoluble ash in milligrams pergram of the air-dried material based on the final weight. By performing the below formula acid insoluble ash content is calculated [18].

$$\text{\% of Acid insoluble ash} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

pH:

100 ml of distilled water is mixed with the formulated sample. For the period of 30 min the

mixture was left at room temperature. After calibrating the pH meter with the standard buffer solution, the pH of the sample is measured [19].

Granulometry:

Place the sample in an electromagnetic sieve shaker for 20 minutes, using sieves with openings ranging from 150 to 600 micrometres. After sieving, weigh the material collected in each sieve and calculate the percentage retained. Group the results into three fractions based on particle size: Fraction A for particles between 425 and 500 micrometres, Fraction B for particles between 212 and 300 micrometres, and Fraction C for particles less than 150 micrometres [20]. Percentage retained can be calculated by the below formula.

Percentage retained on Sieve = $(W_i / W_{total}) \times 100$ Where,

W_i = Weight of sample retained on each sieve W_{total} = Weight of total sample before sieving

Bulk density:

It is the weight of the food material in a unit volume. The finely ground material is filled in a container of known volume, and its weight is measured. Fill the container with the food sample, ensuring no voids or gaps, and level the surface without compressing the sample. Weigh the filled container and subtract the weight of the empty container to obtain the mass of the sample. Measure the volume of the container precisely. Calculate the bulk density by dividing the mass of the sample by the volume of the container [21].

Moisture content:

A 5-gram sample of powder was weighed and placed in a moisture content apparatus. The temperature was set between 100 and 110°C until the weight stabilized. The sample was

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then transferred to a desiccator to cool and weighed again. The reduction in weight was considered as the measure of themoisture content. Moisture content of the sample is calculated by below formula [22].

% of Moisture content = Loss of weight of sample after drying X 100

Actual weight of sample before drying

Water soluble extractive value:

A precisely measured 5 grams of powdered, air-dried drug was soaked in 100 millilitres of chloroform water in a sealedflask for 24 hours, with regular shaking during the initial 6 hours, followed by a resting period of 18 hours. The mixturewas then filtered quickly to avoid any solvent loss. Next, 25 millilitres of the filtrate was evaporated to dryness in a pre- weighed, shallow, flat-bottomed dish and dried to a constantweight. The percentage of water-soluble extractive was calculated based on the weight of the original air-dried drug [22].

Alcohol soluble extractive value:

A precisely measured 5 grams of powdered, air-dried drug was soaked in 100 millilitres of alcohol inside a sealed flask for 24 hours, with frequent shaking for the first 6 hours and left undisturbed for the remaining 18 hours. The mixture wasthen filtered quickly to prevent any solvent loss. Subsequently, 25 millilitres of the filtrate was evaporated to dryness in a pre-weighed, flat-bottomed, shallow dish and dried at 105°C until a constant weight was achieved. The percentage of alcohol-soluble extractive was then calculated based on the original weight of the air-dried drug [22].

The calculation was done by using the formula given below.

Percentage of water-soluble extractive value= Weight of the extract × 100 × 100/ 25 × weight of the sample taken.

We have performed all the enlisted tests as mentioned whichhas been portrayed in the form of tabulation below

S.NO	PARAMETERS	OBSERVATION	INHOUSE SPECIFICATION
1	Total Ash (%)	7.21	4 – 15
2	Water Soluble Ash (WSA)– (%)	1.43	1 – 10
3	Acid Insoluble Ash (AIA) – (%)	0.46	0 – 5

4	pH (%)	5.31	2.5 – 6.0
5	Granulometry (%)	91.38	80 – 100
6	Bulk Density (g/ml)	0.52	0.4 – 0.8
7	Moisture Loss on Drying (LOD) – (%)	4.1	3 – 10
8	Water Soluble Extract (WSE) – (%)	23.198	> 20.00
9	Alcohol Soluble Extract (ASE) – (%)	17.01	> 15.00

Table 2. physicochemical analysis of the new formulation

VI. RESULT AND DISCUSSION

This study investigates the effectiveness of Ayurvedic dietary interventions for managing diabetes mellitus, emphasizing individualized approaches based on dosha body constitution as outlined in the Ayurvedic Pharmacopoeia of India. The key components of these dietary guidelines include the incorporation of hypoglycemic foods and medicinal herbs such as turmeric (Curcuma longa) and fenugreek (Trigonella foenum-graecum). Fenugreek seeds, rich in soluble fiber, play a significant role in stabilizing blood glucose levels by slowing the digestion and absorption of carbohydrates. Turmeric, with its active compound curcumin, enhances insulin function due to its potent antioxidant and anti- inflammatory properties. The Ayurvedic approach not only focuses on the medicinal properties of these herbs but also promotes mindful eating practices and the avoidance of foods that disturb dosha balance, thereby reinforcing a holistic method for managing diabetes.

The analysis revealed that curcumin interacts with key genes and pathways, such as the AGE-RAGE and PI3K-Akt signaling pathways, which are crucial in mitigating diabetes- related complications. Furthermore, fenugreek contains bioactive compounds like furostanolic saponins that enhance insulin sensitivity and promote glucose uptake by activating the GLUT4 transporter, highlighting its value in diabetes management. Similarly, the bioactive compounds in amla, including polyphenols and flavonoids, inhibit digestive enzymes such as α-amylase and α-glucosidase, which are essential for controlling blood sugar levels. This supports amla's role in improving pancreatic beta cell function and reducing oxidative stress, further solidifying its therapeutic potential.

A comparative analysis with modern nutritional strategies for diabetes management reveals potential synergies, suggesting that integrating Ayurvedic principles with contemporary medical practices could significantly enhance diabetes management and overall health outcomes. The

findings underscore the need for further rigorous research to validate these benefits and facilitate the integration of Ayurvedic dietary strategies into global diabetes care protocols.
The physicochemical analysis of the new formulation was conducted in accordance with stringent standards set by the Ayurvedic Pharmacopoeia of India, ensuring the product's quality and purity. Key parameters such as total ash content,water-soluble ash, and acid-insoluble ash were measured to be within acceptable limits, indicating minimal inorganic residue. The pH level was slightly acidic at 5.31, and granulometry analysis showed 91.38% of particles were within the desired size range, ensuring consistency. The bulk density was found to be 0.52 g/ml, indicating good sample compactness, and the moisture content was 4.1%, crucial formaintaining product stability. The water-soluble and alcohol-soluble extractive values were 23.198% and 17.01%,respectively, reflecting high extractable content and effectivebioavailability of the active ingredients. These results confirm the formulation's adherence to traditional standards and its potential efficacy in therapeutic applications, suggesting a promising adjunctive approach to diabetes management through the synergy of traditional Ayurvedic knowledge and modern scientific validation.

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