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Validation of therapeutic efficacy of polyherbal formulations using computational approach for type II Diabetes Mellitus

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***Abstract*— Type 2 diabetes mellitus presents a significant health concern, often exacerbated by misconceptions and the prevalence of self-medication practices. Addressing this issue, our study introduces a novel polyherbal formulation for type 2 diabetes mellitus, comprising Trigonella foenum-graecum, Zingiber officinale, Allium sativum, Curcuma longa, Azadirachta indica, and Cinnamomum verum. Informed by an exhaustive literature review, these components were selected based on their recognized therapeutic properties. Leveraging in silico analyses and physicochemical assessments, we substantiate the efficacy and safety of our formulation. Furthermore, we have developed proprietary software to authenticate the formulation, providing a safeguard against the risks associated with uninformed self-medication. To expand the scope of our investigation, we conducted comparative analyses with established market products, adhering to the standards outlined by the Ayurvedic Pharmacopoeia of India (API). Our research contributes to the advancement of evidence-based treatments for type 2 diabetes mellitus, offering a promising alternative grounded in scientific rigor and adherence to regulatory guidelines.**

Keywords: Type 2 diabetes mellitus, polyherbal formulation, literature review, in silico analysis, physicochemical assessment, product authentication, comparative analysis, Ayurvedic Pharmacopoeia of India (API).

I. INTRODUCTION

This is an innovative attempt to unite traditional Ayurvedic knowledge with contemporary science. Our research clarifies the complex mechanisms behind the advancement of Type 2 Diabetes Mellitus (T2DM) and suggests new treatment strategies by drawing on a thorough understanding of the disease's pathophysiology. In light of the increasing inclination towards choornams and other natural remedies, often prompted by compelling marketing endeavors, concerns have arisen regarding potential long-term adverse effects. In response, we propose an innovative methodology utilizing Python programming to scrutinize the physicochemical attributes of these products in accordance with the standards delineated in the Ayurvedic Pharmacopoeia of India (API).Our approach facilitates a rigorous quality control assessment, furnishing a structured mechanism to gauge the safety and effectiveness of such remedies. Moreover, we introduce a groundbreaking ingredient meticulously tailored for the management of Type 2 Diabetes Mellitus, subjected to exhaustive physicochemical scrutiny to ensure its compliance with established quality control criteria. Ayurvedic principles and contemporary scientific research were interpreted through literature reviews, which helped inform the choice of herbs and chemicals for the treatment of diabetes. The assessment of molecular interactions and the prediction of the effectiveness of particular components against diabetes pathways such as Akt/mTOR and PPAR-gamma activation were made easier by in-silico research. This methodology facilitated the development of an innovative treatment by utilizing both conventional wisdom and modern understanding. We verified the efficacy and safety of our formulation by combining computational predictions with findings from the literature. This opens the door to a holistic treatment strategy for diabetes that combines cutting-edge research with time-honored customs.By utilizing substances such as quercetin, curcumin, bisdemethoxycurcumin, demethoxycurcumin, and ß-sitosterol from Curcuma longa and Azadirachta indica, we aim to improve insulin sensitivity, control glucose metabolism, and lessen the negative effects of type 2 diabetes by targeting important pathways like PPAR-gamma activation, Akt/mTOR, and AMPK. Both HNF1A and HNF1B genes encode nuclear transcription factors required for the development and function of pancreatic islets [1]. Extensive physicochemical analyses meet strict quality control criteria and guarantee the safety, effectiveness, and quality of our New Formulation.In addition, we conducted a thorough market research of the current products using our novel formulation, comparing these traditional therapies with contemporary pharmaceutical interventions for Type 2 Diabetes Mellitus and the findings are reported in the paper.

By utilizing Python algorithms and artificial intelligence, we examine and refine formulation factors to guarantee effectiveness and security. Formulation creation and optimization are aided by the intuitive display of physicochemical data made possible by Live Gap software. This holistic approach not only establishes a robust framework for safeguarding the quality and safety of natural remedies but also furnishes valuable insights into their comparative efficacy of conventional treatments, thereby enriching informed decision-making within healthcare paradigms. This innovative endeavor also represents a potentially effective Ayurvedic remedy for type 2 diabetes by integrating conventional wisdom with modern scientific techniques. With its ability to address T2DM, our New Formulation offers hope for better management and treatment of this common chronic illness.

II. OVERVIEW OF THE NEW FORMULATION

Type 2 diabetes mellitus (DM) is a long-term metabolic disorder with an increasing global prevalence. This study aims to establish a new interdisciplinary paradigm by combining biotechnology and machine learning algorithms to create an advanced polyherbal formulation for treating Type 2 Diabetes Mellitus (T2DM). The widespread condition has piqued interest in traditional medicinal systems, prompting an investigation into Ayurveda's potential treatments. The exact formulation includes botanicals such as Trigonella foenum-graecum, Zingiber officinale, Allium sativum, Curcuma longa, Azadirachta indica, and Cinnamomum verum. This initiative takes a holistic approach, beginning with a thorough examination of historical Ayurvedic knowledge and current research on Type 2 Diabetes Mellitus. Bioactive components from these botanicals are rigorously isolated and processed using biotechnological technologies optimizing synergistic effects is critical for T2DM control. The formulation's efficacy is systematically assessed utilizing in-silico tests, with an emphasis on altering insulin sensitivity and managing blood glucose levels. Furthermore, the combination of pre-processing and feature extraction methods, as well as machine learning-based Python programming language identification and DM diagnosis, guarantees that the polyherbal powder is manufactured intelligently. Automation-based software guided by machine learning principles, such as the use of Python programming language for Authentication of obtained Physicochemical Parameters with features customised to characteristics such as total ash, particle size, detection methods, moisture, granularity, bulk density, and pH measurement, with In House specification based on the collaboration between the Ayurvedic Pharmacopoeia of India (API) and Live Gap software which uses graphs to represent data outputs, ensuring accurate and consistent production and improving scalability and allows full data visualization. This collaboration not only highlights the medicinal potential of the herbal combination, but it also demonstrates the significance of merging biotechnology and machine learning algorithms for improved pharmaceutical development. Furthermore, the blend's contents are compared to similar treatments on the market, confirming its potential as a promising new treatment for type 2 diabetic mellitus (T2DM), addressing critical areas of blood sugar control and oxidative stress. This collaborative effort demonstrates how interdisciplinary research might help enhance precision medicine for metabolic illnesses.

Pathophysiology of the New formulation:

Type 2 diabetes is a metabolic condition characterised by insulin resistance, decreased insulin production, and hyperglycemia. The Gly972Arg substitution in IRS-1 disrupts the interaction of the p85 subunit of phosphatidylinositol 3-kinase (PI3K). This defect in pancreatic β-cells reduces insulin release when exposed to glucose and sulfonylureas. Additional genetic variants linked to Type 2 Diabetes Mellitus (T2DM) have been discovered in the ABCC8 (also known as SUR1) and KCNJ11 genes. These genes help create the ATP-sensitive potassium channel/sulfonylurea receptor in pancreatic β-cells.Furthermore, mutations in the hepatocyte nuclear factor-1 homeobox A (HNF1A) gene result in the most prevalent monogenic variant of Maturity Onset Diabetes of the Young (MODY3), known as HNF1A-MODY. Another gene, hepatocyte nuclear factor-1 homeobox B (HNF1B), causes a less common but more severe monogenic form of diabetes known as MODY5. Insulin is largely released in reaction to high glucose levels, which are primarily absorbed via the GLUT2 transporter. Glucose breakdown raises the ATP/ADP ratio, which closes ATP-dependent potassium channels, depolarizes the membrane, and opens voltage-dependent calcium channels. This increase in Ca2+ promotes insulin exocytosis. Other calcium channels, such as P2X, P2Y, SERCA, and RYR, contribute in calcium mobilisation and insulin secretion [2]. Understanding the complex molecular processes of insulin resistance and pancreatic dysfunction is critical for treating Type 2 Diabetes Mellitus.

III. QUALITATIVE ANALYSIS OF THE NEW FORMULATION

1. Trigonella foenum-graecum:

Fenugreek may help manage Type 2 Diabetes Mellitus by increasing insulin sensitivity and decreasing blood sugar levels. Trigonella seeds' putative antidiabetic properties are linked to steroid saponins, alkaloids, and fibre. HPLC was used to identify and measure five bioactive compounds: trigonelline, isoorientin, orientin, vitexin, and isovitexin [3]. Trigonelline reduces diabetic nephropathy and insulin resistance in T2DM via PPAR-γ [4].Isoorientin, by inhibiting the PI3K-AKT-TSC2-mTOR pathway, can reduce TSC2 S939 over-phosphorylation and promote autophagy under high glucose (HG) circumstances. Isoorientnin is expected to bind to the SH2 domain of PI3Kp85β, which is crucial for PI3K recruitment and activation [5]. Orientin has substantial potential in raising the mRNA expression of Ampk and Cpt1, which are key components of a critical process involved in insulin-independent glucose control [6]. Vitexin also improved insulin signalling by boosting the expression of insulin receptor substrate-1 (IRS-1) and its downstream effector AKT[7] .

2. Curcuma longa:

Curcuma longa, also known as turmeric, may help treat Type 2 Diabetes Mellitus by enhancing insulin sensitivity, decreasing inflammation, and managing blood sugar levels. Curcumin and other bioactive chemicals contained in turmeric are thought to give protection against type 2 diabetes (T2D) via a variety of methods. These include boosting insulin production, increasing insulin sensitivity, and decreasing cellular glucose uptake. Dietary curcumin increases PPAR-γ expression in the liver, which leads to

increased expression of AMPK and decreased expression of NF-κB (p65). These effects are considered favourable for reducing T2D problems [8]. Turmeric's PPAR-g active chemicals, curcumin (1), demethoxycurcumin (2), bisdemethoxycurcumin (3), and ar-turmerone (4), are thought to improve insulin resistance and alleviate type 2 diabetes by the same biological mechanism as thiazolidinedione derivatives [9].

3. Azadirachta indica:

The use of Azairachta indica leaf extract corrected abnormal levels of blood glucose, serum insulin, lipid profile, and insulin signalling molecules. It also improved poor glucose tolerance and insulin signalling, including insulin receptor, insulin receptor substrate-1, phospho-IRS-1Tyr632, phospho-IRS-1Ser636, phospho-AktSer473, and GLUT4 proteins, as well as glycogen concentration and glucose oxidation [10] .Azadirachtin prevents amyloid production, disassembles fibrils, and protects pancreatic β-cells from the negative effects of human islet amyloid polypeptide/amylin [11] .In skeletal muscles, quercetin activates AMPK. As a result, this activation stimulates the GLUT4 receptors and Akt (protein kinase B) on the cell membrane. As a result, glucose can enter cells via the GLUT4 transporter, regulating blood sugar levels[12] . Ascorbic acid supplements can modulate fasting blood glucose (FBG), glycosylated haemoglobin (HbA1c), and reduce insulin resistance [13] .

4. Cinnamomum verum:

Cinnamon's major mode of action is based on the concept that it can elicit an insulin-mimetic-like effect by regulating insulin signalling pathways, enhancing glucose uptake in muscle and adipose tissue via glucose transporter (GLUT) 4 synthesis and GLUT 4 translocation. Furthermore, by boosting glycogen synthesis in the liver, thus inhibiting glycogen synthase kinase 3β and lowering gene expression of two regulators of gluconeogenesis in the liver, the phosphoenolpyruvate carboxykinase (PEPCK) and the glucose-6-phosphatase [14].The administration of p-Coumaric Acid considerably lowers the blood glucose level, gluconeogenic enzymes such as glucose-6-phosphatase and fructose-1,6-bisphosphatase, while raising the activities of hexokinase, glucose-6 phosphate dehydrogenase, and GSH via increasing the level of insulin [15].

5. Allium sativum:

Garlic was found to lower fasting blood glucose and HbA1C.Organosulfur compounds generated from garlic, diallyl sulphide, S-methylcysteine, S-allylcysteine, and N Acetylcysteine, are known to protect LDL from oxidation and glycation, and this could be a plausible mechanism by which garlic protects against cardiovascular disease (Ou et al., 2003) [16] .Organosulfur compounds generated from garlic, diallyl sulphide, S-methylcysteine, S-allylcysteine, and N-acetylcysteine are known to protect LDL from oxidation and glycation [17] . Allicin has been shown to efficiently lower blood glucose levels, regulate intestinal flora, reduce lipid and body weight buildup, and decrease systemic inflammation. Allicin can improve serum insulin by successfully interacting with chemicals like cysteine, sparing insulin from SH group interactions, which are a primary source of insulin inactivation [18]. Allyl Propyl disulfide reduces insulin production, and impaired insulin sensitivity (insulin resistance) is involved in the pathophysiology [19].

6. Zingiber officinale roscoe:

The phenolic compounds are predominantly gingerols, shogaols, and paradols, which account for the diverse bioactivities of ginger10. Ginger active components, including 6-, 8-, 10-paradols, 6-, 8-, 10-shogaols, 6-, 8-, 10-gingerols, and zingerone, and their anti-hyperglycemic activity were examined. Among the substances studied, 6-paradol and 6-shogaol were highly effective in increasing glucose utilisation by 3T3-L1 adipocytes and C2C12 myotubes. The effects were linked to increased 5′ adenosine monophosphate-activated protein kinase (AMPK) phosphorylation in 3T3-L1 adipocytes. In an in vivo study, 6-paradol, the primary metabolite of 6-shogaol, was found to drastically reduce blood glucose, cholesterol, and body weight.Gingerols greatly improved glucose absorption in adipocytes [20] and skeletal muscle cells [21] through the increase in GLUT4 expression on the cell membrane [22] and activation of the AMP-activated protein kinase (AMPK) pathway [23]. Ginger non-volatile pungent components promote medium glucose consumption by 3T3-L1. Gingerols also showed anti-hyperglycaemic and anti-hyperlipidaemic effects in type 2 diabetes mellitus [24]. The novel medicine was produced using the formulations of Chaturbeeja Churnam (Bhava prakasha, Hareetakyadi Varga) and Sathakuppa Churnam (Bhojana Kutuhalam, Twelfth Chapter), as well as the rest of the botanicals chosen based on their therapeutic benefits based on the Literature review (Table 2). It is a precise combination of Allium sativum, Azadirachta indica, Curcuma longa, Cinnamomum zeylanicum, Trigonella foenum-graecum, and Zingiber officinale Roscoe, based on ancient Ayurvedic principles, with the goal of creating an efficient and safe therapy for Type 2 Diabetes Mellitus.

S.NO	BOTANICAL NAME	PLANT PARTS USED:	COMMON NAME	TAMIL NAME
A	*Allium sativum*	Bulb	Garlic	Poondu
B	*Azadirachta indica*	Leaf	Neem	Veppilai
C	*Curcuma longa*	Whole plant	Turmeric	Manjal
D	*Cinnamomum zeylanicum*	Bark	Cinnamon	Izh Lavanga pattai
E	*Trigonella foenum-graecum*	Seed	Fenugreek	Vendhayam
F	*Zingiber officinale Roscoe*	Seed	Ginger	Innji

Table 1 : Raw materials of New Formulation

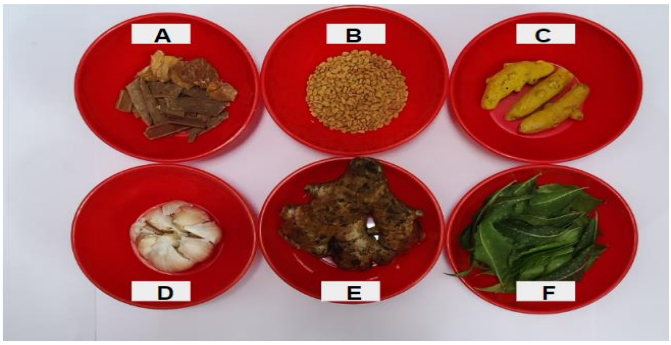


Image 1 : Raw Materials of the New Formulation : A-Cinnamomum verum ; B - Trigonella foenum - Graecum ; C-Curcuma longa ; D- Allium sativum;E- Zingiber officale ; F - Azadirachta indica.

Image 2 : Powdered Raw Materials of the New Formulation : A-Cinnamomum verum ; B - Trigonella foenum - Graecum ; C- Curcuma longa ; D- Allium sativum;E-Zingiber officale ; F - Azadirachta indica.

IV. INSILICO ANALYSIS: NETWORK PHARMACOLOGY

The bioactive components for our new formulation were found utilising network pharmacology (Figure 1). Database mining for a formulation comprising six botanicals containing 423 bioactive components. 423 bioactive chemicals interact with 71 target genes, which directly treat 40 disorders associated with Type 2 diabetes mellitus. Network analysis is represented as a frame of image in Cytoscape (Figure 2). A consolidated Network encompassing all these seven botanicals and their interaction targets, gene codes, associated to disease and disease class were developed for understanding the therapeutic potential, providing an intense technique for evidence-based formulation. When developing a new polyherbal formulation for Type 2 Diabetes Mellitus, network pharmacology analysis is critical for identifying the gene-level mechanism of action. Several studies used in-silico network pharmacology to better understand the therapeutic potential of uni (or) polyherbal formulations (Srinidhi 2019 and Ren et al., 2019).

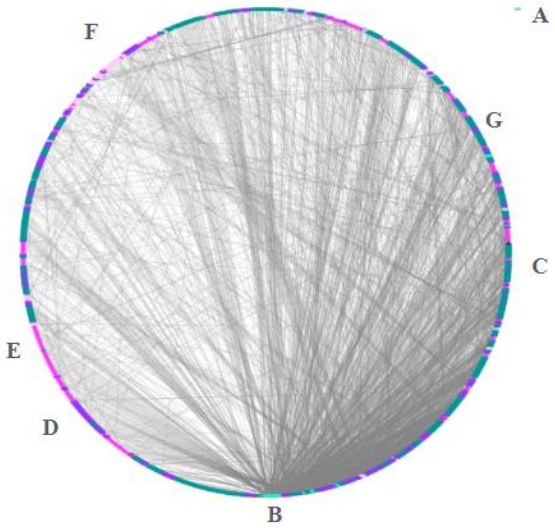


Image 3 : Cytoscape of the New formulation

(A - New Drug Formulation E:Gene Code-52
B-Botanical -6 F:Disease-40
C:Bioactive Compound-423 G:Disease Class-16
D:Target name - 71)

V. PHYSIOCHEMICAL ANALYSIS:

The physicochemical investigation for the new drug formulation was carried out in accordance with the instructions of The Ayurvedic Pharmacopoeia of India, Part II, Volume I, First Edition. Total Ash, Water Soluble Ash, and Acid Insoluble Ash are the parameters used to test for the presence of inorganic impurities. pH to determine acidity/alkalinity, Bulk Density to measure sample compactness, Granulometry to analyse particle size distribution, Moisture - Loss on Drying to evaluate moisture content, and finally Water-Soluble Extract and Alcohol Soluble Extract to determine the percentage of soluble components present.In terms of Quality Control Analysis, all of the acquired results met the requirements of the In-house Specification (Table 2). It is possible to evaluate the medicine's physical and chemical qualities, assuring quality, safety, and conformity to traditional Ayurvedic prescriptions, thereby increasing the therapeutic potential of the new drug formulation.

S.NO	PARAMETERS	OBSERVATION	INHOUSE SPECIFICATION
1	**Total Ash(%)**	7.11	4 – 15
2	**Water Soluble Ash (WSA) – (%)**	1.58	1 – 10
3	**Acid Insoluble Ash (AIA) – (%)**	0.39	0 – 5
4	**pH (%)**	5.67	2.5 – 6.0
5	**Bulk Density (g/ml)**	0.68	0.4 – 0.8
6	**Granulometry (%)**	91.21	80 – 100
7	**Moisture Loss on Drying (LOD) – (%)**	3.4	3 – 10
8	**Water Soluble Extract (WSE) – (%)**	23.148	> 20.00
9	**Alcohol Soluble Extract (ASE) – (%)**	16.67	> 15.00

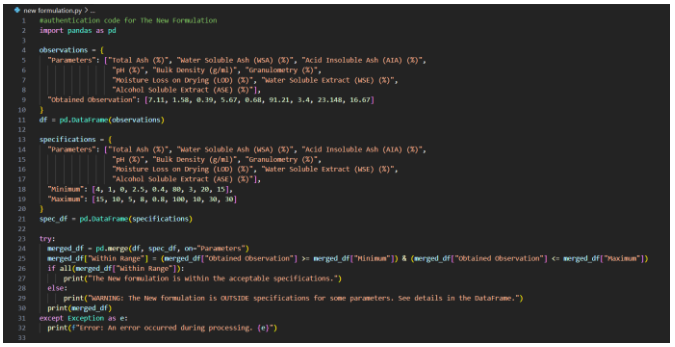
Table 2: Physicochemical analysis of the New formulation

VII. SOFTWARE ARCHITECTURE

The key innovation of our project work is the software that we utilised to identify the authentication of the new formulation in contrast to the API (Ayurvedic Pharmacopoeia of India) restrictions. Here, we used the Python programming language to create our own software in which the physicochemical parameters are provided as inputs, and the algorithm checks the authentication of the new formulation against the API limits and returns whether or not the new formulation is authenticated. To support this software, we used the Live gap open software tool to generate a graphical representation of the new formulation's physicochemical parameters.

Working principle of Software:

A Python program is created to evaluate the physicochemical findings of the project "Bio-electrical Fusion for Advanced Polyherbal Formula for Type 2 Diabetes". It evaluates input data such as total ash, particle size, moisture, granularity, bulk density, and pH, validating it for expected forms and values. Algorithms evaluate data by comparing it to standards, discovering trends, and creating summary reports. Visualisation enhances understanding, while storage and retrieval features monitor outcomes over time. Reports include details on deviations, trends, and correlations, as well as recommendations for next steps. This comprehensive solution provides effective analysis and informed decision-making during the project's physicochemical evaluation.



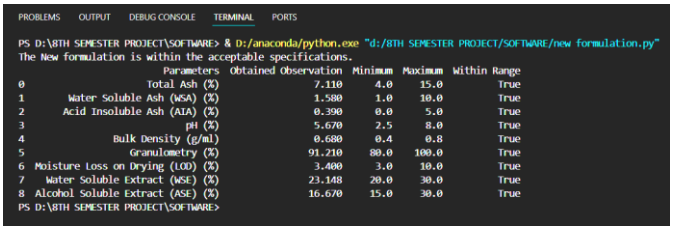
```
# authentication code for The New Formulation
import pandas as pd

observations = {
    "Parameters": ["Total Ash (%)", "Water Soluble Ash (WSA) (%)", "Acid Insoluble Ash (AIA) (%)",
                   "pH (%)", "Bulk Density (g/ml)", "Granulometry (%)",
                   "Moisture Loss on Drying (LOD) (%)", "Water Soluble Extract (WSE) (%)",
                   "Alcohol Soluble Extract (ASE) (%)"],
    "Obtained Observation": [7.11, 1.58, 0.39, 5.67, 0.68, 91.21, 3.4, 23.148, 16.67]
}
df = pd.DataFrame(observations)

specifications = {
    "Parameters": ["Total Ash (%)", "Water Soluble Ash (WSA) (%)", "Acid Insoluble Ash (AIA) (%)",
                   "pH (%)", "Bulk Density (g/ml)", "Granulometry (%)",
                   "Moisture Loss on Drying (LOD) (%)", "Water Soluble Extract (WSE) (%)",
                   "Alcohol Soluble Extract (ASE) (%)"],
    "Minimum": [4, 1, 0, 2.5, 0.4, 80, 3, 20, 15],
    "Maximum": [15, 10, 5, 8, 0.8, 100, 10, 30, 30]
}
spec_df = pd.DataFrame(specifications)

try:
    merged_df = pd.merge(df, spec_df, on="Parameters")
    merged_df["Within Range"] = (merged_df["Obtained Observation"] >= merged_df["Minimum"]) & (merged_df["Obtained Observation"] <= merged_df["Maximum"])
    if all(merged_df["Within Range"]):
        print("The New formulation is within the acceptable specifications.")
    else:
        print("WARNING: The New formulation is OUTSIDE specifications for some parameters. See details in the Dataframe.")
    print(merged_df)
except Exception as e:
    print(f"Error: An error occurred during processing. {e}")
```

Image 11: Input of the Python coding for the New formulation



```
PROBLEMS  OUTPUT  DEBUG CONSOLE  TERMINAL  PORTS

PS D:\8TH SEMESTER PROJECT\SOFTWARE> & D:/anaconda/python.exe "d:/8TH SEMESTER PROJECT/SOFTWARE/new formulation.py"
The New formulation is within the acceptable specifications.
                    Parameters  Obtained Observation  Minimum  Maximum  Within Range
0                  Total Ash (%)                7.110      4.0     15.0          True
1          Water Soluble Ash (WSA) (%)          1.580      1.0     10.0          True
2        Acid Insoluble Ash (AIA) (%)           0.390      0.0      5.0          True
3                           pH (%)              5.670      2.5      8.0          True
4                Bulk Density (g/ml)            0.680      0.4      0.8          True
5                  Granulometry (%)            91.210     80.0    100.0          True
6  Moisture Loss on Drying (LOD) (%)            3.400      3.0     10.0          True
7    Water Soluble Extract (WSE) (%)           23.148     20.0     30.0          True
8   Alcohol Soluble Extract (ASE) (%)          16.670     15.0     30.0          True
PS D:\8TH SEMESTER PROJECT\SOFTWARE>
```

Image 12: Output of the Python coding for the New formulation

Live Gap :

Live Gap software allows us to graphically exhibit physicochemical data from our Bioelectronic fusion for improved polyherbal formulations that target type 2 diabetic Mellitus. Bar charts are used to graphically represent parameters such as total ash, particle size, moisture content, grain size, bulk density, and pH. Mean values are depicted by bars, while error bars reflect variance. Interactive features allow for tweaking to improve clarity. This visual depiction helps with quick comparisons, trend spotting, and decision-making. We use Live Gap's skills to effectively communicate data, allowing for formulation optimization for type 2 diabetic medication.

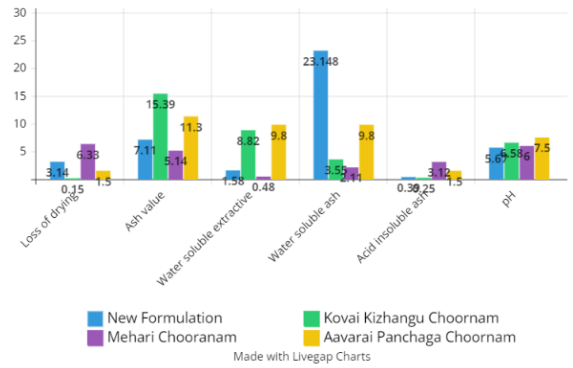


Image 13: Graph of Physicochemical analysis of the combined comparison with the market product with our New formulation

VII. COMPARISON WITH MARKET PRODUCTS

1. Kovai Kizhangu Choornum:

The plant contains a variety of chemicals, including ascorbic acid, glutamic acid, asparagine, tyrosine, histidine, phenylalanine, threonine, serine, hydroxyproline, arginine, and valine amino acids, as well as nicotinic and aspartic acids. The aerial parts include cephalandrol, tritriacontane, β-sitosterol, and two unidentified alkaloids called cephalandrine A and cephalandrine B [25]. The roots contain a chemical with hypoglycemic effects. Fruits contain fatty acids, taraxerone, taxerol, β-amyrin, lupeol, and a bitter glycoside with cucurbitin B. Seeds contain fatty acids. Fresh juice derived from the tuberous root, stem, and leaves is

given either alone or in combination with certain metals formulations for early-stage diabetes, intermittent glycosuria, swollen glands, and skin disorders like pityriasis [26].

S.No	Parameters	Results
1.	Loss of drying at 105°C (%)	0.15
2.	Ash value at 550°C (%)	15.39
3.	Water soluble, (%)	8.82
4.	Alkalinity as $CaCO_3$ in water soluble ash, (%)	3.55
5.	Acid insoluble ash, (%)	0.25
6.	pH at 10% aqueous solution	6.58

Table 3: Physicochemical analysis of Kovai Kizhangu Choornum

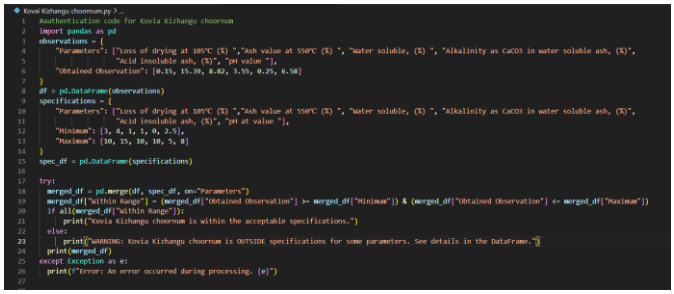


Image 5: Input of the Python coding for Kovai Kizhangu choornum

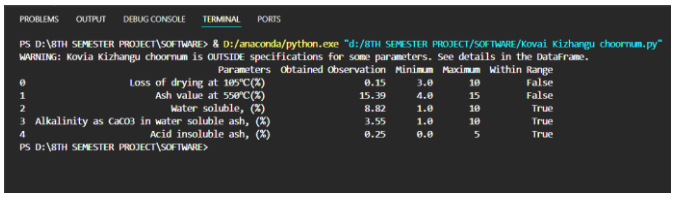


Image 6: Output of the Python coding for Kovai Kizhangu choornum

2. Mehari Choornum:

Mehari Choornum has the following ingredients: Asansal, amalaki, kade chirayat, karali, khair sal, gulwel, jambhul beej, daru haladi, manjishta, halad, methi, and haritaki. Arkashala introduced Mehari Choornum in 1995 after conducting significant research on Ayurvedic treatments with anti-diabetic potential. It can be used on its own or in conjunction with allopathic treatments. Consistent use of Mehari Choornum helps reduce the dosage of hypoglycemic drugs [27].

S.No	Parameters	Results
1.	Total Ash	5.14 ∓ 0.014
2.	Acid-insoluble Ash	3.12 ∓ 0.012
3.	Water-soluble Ash	2.11 ∓ 0.015
4.	Moisture content/ Loss on drying	6.33 ∓ 0.116
5.	Bulk Density	0.48 ∓ 0.01
6.	Determination of pH of the sample	6

Table 4: Physicochemical analysis of Mehari choornum

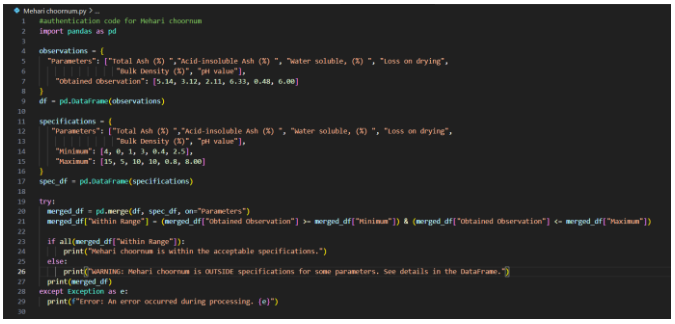


Image 7: Input of the Python coding for Mehari choornum

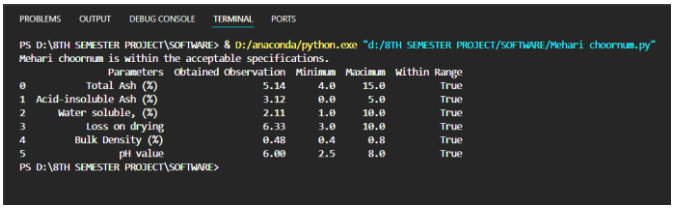


Image 8: Output of the Python coding for Mehari choornum

3. Aavarai panchaga Choornum:

The Aavarai plant has five parts: leaf, flower, young fruit, stem bark, and root, all of which are used to treat a variety of diseases including diabetes, leucorrhoea, body heat, wound ulcers, bacillary dysentery, bone fever, and polydipsia. The seeds are used to cure ophthalmia, diabetes, and diarrhoea, as well as chronic purulent conjunctivitis. Diabetes mellitus is treated with an entire plant decoction delivered three times a day in a one-ounce (30ml) dose. Flowers are used to treat nocturnal emissions, urine discharges, diabetes, and throat problems, whereas extracts from both flowers and seeds are more useful in managing diabetes and urinary disorders. Overall, Aavarai is used extensively in treating illnesses such as diabetes, genitourinary tract infections, and bacillary dysentery, and thirst [28].

S.No	Parameters	Results
1.	Loss of drying at 110°C	1.50 ∓ 0.100 1.5%
2.	Ash Value	
	A. Total ash	11.3 ∓ 0.210 11%
	B. Acid insoluble ash	1.50 ∓ 0.110 1.5%
	C. Water soluble	9.80 ∓ 0.100 9.8%
3.	Water soluble extractive	9.80 ∓ 0.100 9.8%
4.	Colour, pH value	Brown, 7.50

Table 5: Physicochemical analysis of Aavarai panchaga Choornum

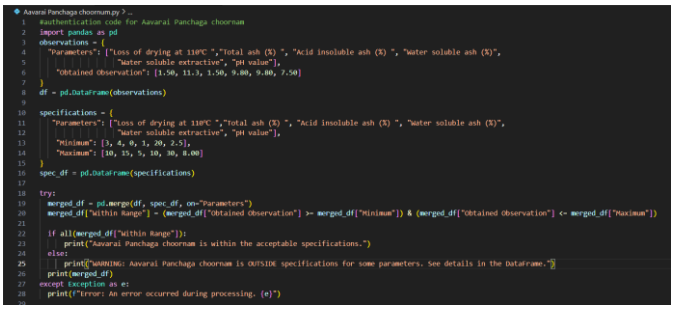


Image 9: Input of the Python coding for Aavarai panchaga choornum

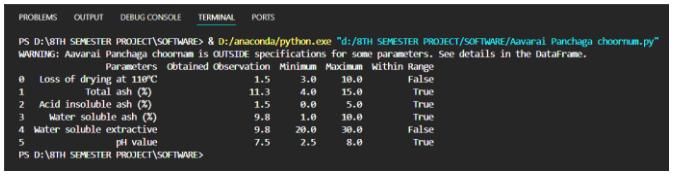


Image 10: Output of the Python coding for Aavarai panchaga choornum

VIII. RESULTS & DISCUSSION

Understanding the pathophysiology of Type 2 Diabetes Mellitus allowed us to appreciate the intricate balance between targets and the regulatory mechanisms involved to suppress the disease .This knowledge served as a foundation for our in-depth evaluation of New Formulation. Allicin triggers the adenosine monophosphate-activated protein kinase (AMPK) pathway, thereby enhancing insulin sensitivity. S-allyl cysteine (SAC) enhances insulin sensitivity in key organs such as the liver and skeletal muscle while also augmenting insulin secretion by pancreatic beta cells. Diallyl disulfide (DADS) activates the nuclear factor erythroid 2-related factor 2 (Nrf2) pathway, leading to increased production of antioxidant enzymes and improved insulin sensitivity. S-allyl mercaptocysteine (SAMC) maintains pancreatic beta cell health and enhances insulin sensitivity by mitigating oxidative stress and inflammation. Furthermore, SAMC reduces the generation of reactive oxygen species (ROS) and pro-inflammatory cytokines by inhibiting the nuclear factor-kappa B (NF-κB) pathway.Trigonelline, through its action on the insulin signalling system, enhances insulin sensitivity and refines glucose metabolism. Hydroxyisoleucine augments insulin secretion and promotes glucose absorption by influencing the insulin secretion pathway. Diosgenin improves glucose tolerance and insulin sensitivity via the insulin sensitivity pathway. Galactomannan regulates glucose metabolism and stabilises blood sugar levels by retarding carbohydrate absorption. Additionally, flavonoids bolster insulin sensitivity and protect pancreatic beta cells through their antioxidant properties.Zingiber officinale, or ginger, is a plant that contains a variety of bioactive substances, including gingerol, gingerone, shogaol, gingerdiones, shojaol, and ginger paradols. These substances work in different ways to inhibit and treat type 2 diabetes mellitus. While gingerone increases insulin sensitivity and facilitates glucose absorption through the insulin signalling pathway, gingerol, which is present in ginger, improves insulin sensitivity and glucose absorption via the AMPK pathway. Gingerdiones reduce type 2 diabetes by improving glucose absorption and boosting GLUT4 translocation, whereas sobogaol enhances glucose metabolism by activating the PPARγ pathway. Ginger paradols improve glucose metabolism by regulating insulin sensitivity through the PPARγ pathway, while shojaol enhances glucose absorption and insulin signalling via the PI3K/Akt pathway. Azadirachtin, an active component of neem, improves insulin sensitivity and increases glucose absorption by activating the AMPK pathway, showing potential benefits in the treatment of type 2 diabetes mellitus. Similarly, another neem-derived chemical called nimbin stimulates the insulin signalling system to improve insulin sensitivity and enable glucose uptake. By interfering with the PPARγ pathway, gedunin improves glucose metabolism and insulin sensitivity. Neem contains nimbolide, which increases glucose absorption by GLUT4 translocation. Furthermore, via the PI3K/Akt pathway, nimbidin increases glucose absorption and insulin signalling. Moreover, neem's component quercetin acts on the PPARγ pathway to improve insulin sensitivity and promote glucose metabolism.Cinnamaldehyde increases insulin sensitivity and causes glucose uptake by activating the insulin signalling pathway; Cinnamic Acid increases insulin sensitivity and refines it through the AMPK pathway; Coumarin makes GLUT4 translocation easier, which increases glucose uptake; Eugenol acts on the PPARγ pathway to modulate insulin sensitivity and improve glucose metabolism; Cinnamyl Alcohol increases insulin signalling and improves glucose uptake through the PI3K/Akt pathway; and Procyanidins, which are found in cinnamon, control insulin sensitivity and refine glucose metabolism by modulating the PPARγ pathway.Turmeric's curcumin improves insulin sensitivity and glucose uptake by stimulating the AMPK pathway; demethoxycurcumin, on the other hand, increases insulin sensitivity and glucose uptake by stimulating the insulin signalling system. By influencing the PPARγ pathway, bisdemethoxycurcumin improves glucose metabolism and interferes with insulin sensitivity. While Ar-turmerone promotes insulin signalling and glucose absorption via the PI3K/Akt pathway, Turmerone accelerates GLUT4 translocation, which increases glucose uptake. Furthermore, via modifying the PPARγ pathway, curcumenol improves insulin sensitivity and promotes glucose metabolism.Through the results obtained it was demonstrated that Quercetin found in Azadirachta indica prevents type 2 diabetes by inhibiting the Akt/mTOR pathway, which reduces insulin resistance. It interacts with PPARγ receptors to increase glucose and adiponectin levels while modulating AMPK activation, which improves insulin sensitivity and reduces gluconeogenesis, effectively regulating blood glucose. Quercetin stimulates cellular glucose uptake and decreases hyperglycaemia regulates key signalling pathways involved in glucose metabolism. Reduces oxidative stress and improves insulin resistance. Act as a promising agent against the pathophysiological complications of diabetes [29]. Curcumin intake (1,000 mg per day) for 3 months could contribute to decreasing serum non-high-density lipoprotein cholesterol (non-HDL-C) and lipoprotein A levels in patients with T2D [30]. Demethoxycurcumin and bisdemethoxycurcumin found in Curcuma longa prevent type 2 diabetes by activating the AMPK pathway, which increases insulin sensitivity. This improves glucose absorption and regulation, ultimately alleviating diabetic complications through anti-inflammatory and antioxidant effects. These results indicate that turmeric is a promising ingredient of functional food for the prevention and/or amelioration of type 2 diabetes and that demethoxycurcumin, bisdemethoxycurcumin, and ar-turmerone mainly contribute to the effects via PPAR-gamma activation [31]. ß-sitosterol found in Azadirachta indica is the most effective compound for type 2 diabetes because it can improve insulin sensitivity and lower blood sugar.β-Sitosterol (SIT) up regulates mRNA expression of insulin receptor (IR) in adipose tissue, that it enhanced the insulin receptor mRNA levels [32]. Our literature survey revealed the complexity of Type 2 Diabetes Mellitus, with various compounds and receptors influencing Type 2 Diabetes Mellitus.

Compounds like Quercetin, Curcumin, Demethoxycurcumi n and bisdemethoxycurcumin, β-Sitosterol showcased diverse pathways and mechanisms that contribute to their potential in addressing Type 2 Diabetes Mellitus. The physicochemical analysis delved into critical aspects such as solubility, stability, and particle size distribution, ensuring that New Formulation met rigorous quality control specifications. The physicochemical characteristics of New Formulation, including total ash content, water-soluble ash, acid-insoluble ash, pH, bulk density, granulometry, moisture content, and water-soluble and acid-soluble extractives, all met in-house specifications, ensuring the highest quality control standards were maintained throughout the formulation process.

Artificial intelligence (AI) has just begun to facilitate its application in various sectors of society, the pharmaceutical industry being the first [33,34] . In order to study and comprehend the intricate biological networks that underlie the therapeutic actions of our polyherbal formulation for type 2 diabetes mellitus, we utilized Cytoscape, a potent network visualization program. With Cytoscape, it was possible to clarify the complex relationships that exist between the chosen herbal ingredients and their molecular targets, which gave important new information on how effective the treatments were. As a result, our study emphasizes how critical it is to use cutting-edge software tools in the creation and assessment of new treatment approaches for type 2 diabetes. A key component of our research is the use of unique software designed, using Python Programming language, specifically for authentication, providing an essential means of guaranteeing the safety and validity of the prepared polyherbal cure which also facilitated the creation of computational algorithms for data processing and in silico analysis. With the help of this software, people can make educated healthcare decisions in addition to reducing the hazards connected with ignorant self-medication. Our reliance on in silico analyses further highlights the importance of computational methods as they enable effective candidate compound screening and physicochemical property prediction. The performed physicochemical analyses of our polyherbal formulation was analyzed using Python, which expedited the quality control assessment and improved the effectiveness and precision of our formulation. Through the incorporation of these software tools into our research framework, we have developed a strong approach to assess and validate new treatment interventions. In the future, there is great potential for improving the safety and effectiveness of healthcare interventions through the continued development and application of such software platforms. This will ultimately help patients and healthcare professionals manage complex health conditions like type 2 diabetes mellitus. Live Gap software provides an intuitive platform for visual presentation of physicochemical results related to formulation development with features tailored to parameters such as total ash, particle size, detection methods, moisture, granularity, bulk density, and pH determination. The data obtained were tabulated and also represented in the form of Bar graphs for comprehensive data visualisation.

In essence, this project represents a pioneering effort to develop a potent Ayurvedic solution for Type 2 Diabetes Mellitus by harmoniously combining ancient wisdom and cutting-edge science. This New Formulation has shown promise in its bioactive composition and physicochemical attributes.

This endeavour underscores the potential for Ayurveda to contribute significantly to modern healthcare solutions [35]. Further in vitro and in vivo analyses will be carried out in the laboratory paving an open pathway towards fostering innovation and significant discoveries.

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