Formulation and Evaluation of a Natural Anti-Diabetic Nutraceutical Powder

Sunil D.Hilli[1], Abhishek D.Jadhav[2], Ashitosh.S Humbare[3], Nikita.N Ingale[4], Payal R Gharde[5], Poff. Sushma T. Nakhate[6], Principal.Dr Tushar.T. Shelke[7]
[1,2,3,4,5,6,7]*Genba Sopanrao Moze College of Pharmacy, Wagholi-412207*

***Abstract*—Formulation and Evaluation of a Natural Anti-Diabetic Nutraceutical Powder**

Diabetes mellitus remains a significant global health challenge, particularly Type 2 diabetes, which accounts for the vast majority of cases. Conventional pharmaceutical treatments, while effective, often require lifelong adherence and may carry side effects. This research aimed to formulate and evaluate a natural, effective nutraceutical powder dosage form designed to assist in maintaining blood sugar levels and preventing diabetes complications. The term "nutraceutical" refers to products derived from food sources that provide extra health benefits beyond basic nutrition, and this study leverages their potential as a preventive and management strategy.

The formulation was developed following an extensive literature survey to identify herbal ingredients with proven anti-diabetic properties, such as *Moringa oleifera* (Drumstick), *Syzygium cumini* (Jamun), and *Phyllanthus emblica* (Amla). Specifically, the optimized formulation utilized 46.65% Moringa leaves powder, 33.35% Jamun seed powder, and 20% Amla powder. The preparation involved collecting healthy Moringa leaves, which were washed with distilled water, shade-dried to prevent the degradation of active constituents, and milled to a uniform particle size. All herbal materials were passed through a sieve to ensure uniformity and blended using a geometric mixing method to achieve a homogeneous powder.

Evaluation of the formulated powder included organoleptic, physicochemical, and flow property testing. Initial results showed an olive-green powder with a characteristic odor and a slightly bitter, earthy taste. The suspension was found to be acidic with a pH of 2.16. Early assessments of flow properties revealed a "Poor" rating, with an angle of repose of 41.34 and a compressibility index of 37.31. To optimize the formulation for commercial feasibility, a 1% w/w glidant (Talc) was added. This modification significantly improved the flow properties to a "Good" rating, reducing the angle of repose to 33.42 and the compressibility index to 19.4.

The medicinal efficacy of the selected ingredients is supported by their various mechanisms of action, such as stimulating insulin secretion from pancreatic beta cells, enhancing glucose uptake, and inhibiting enzymes like \alpha-amylase. For instance, Moringa leaves provide essential antioxidants and anti-inflammatory properties, while Jamun seeds and Amla contribute to glucose homeostasis and immune support. This research concludes that the developed herbal nutraceutical powder is a stable and promising alternative for diabetes management, offering the benefits of preventive care with minimal side effects. The study successfully meets its objective of creating a standardized herbal formulation that is both palatable and physically stable.

***Index Terms*—Nutraceutical, Diabetes Mellitus (Type 2)**
Anti-diabetic Herbs (e.g., Karela, Jamun, Methi)
Herbal Formulation Moringa oleifera
Amla (Phyllanthus emblica) Phytochemicals a-Amylase Inhibition Physicochemical Evaluation
Antioxidant Preventive Care

I. INTRODUCTION

Nutraceuticals

Nutraceuticals is a term derived from “nutrition” and “pharmaceutics.” The term is applied to products that are isolated from herbal products, dietary supplements (nutrients), specific diets, and processed foods such as cereals, soups, and beverages that other than nutrition are also used as medicine. [1]

The term “nutraceutical” dates back to 1989, when physician Stephen DeFelice, founder and chairman of the Foundation for Innovation in Medicine, coined the term to describe products derived from food sources that offer extra health benefits along with the basic nutritional value of foods. [2]

Nutraceuticals Classification:

1. Functional foods- It provides nutrition. It also contains antioxidants compounds that prevent diabetes, hypertension, Parkinson's disease etc. Examples of functional foods are oat bran fiber, plant sterol and stenols.
2. Carotenoids- They are pigmented compounds like alpha-carotene, beta carotene and beta cryptoxanthin. These compounds have antioxidant and anti-inflammatory properties, used to improve vision, prevent certain cancer and improve the immune system.
3. Collagen hydrolysate – It is essential human protein secreted from skin. It has several medicinal properties like cell proliferation, promote cell migration etc. The source of collagen is fish, meat, eggs etc.
4. Dietary fibers- They are non-starchy poorly digestible vegetable carbohydrates found in vegetables, fruits, wheat bran and oats. It improves digestion and reduces Crohn's disease and ulcerative colitis.
5. Fatty acids- These covers all vegetable oil like olive oil, fish oil, cod liver oil, algal oil etc. They have antioxidant and anti-inflammatory properties.
6. Phytochemicals- These are active compounds that work on balance inside the body and nervous activity, so they decrease the cancer. One of the most important of these compounds is lutein and lycopene.
7. Herbs – They are plants that do not have side effects and having antioxidant properties, for example garlic extract, ginger used for treatment of cholesterol, wound healing and antiulcer.
8. Probiotics- Microbes are considered to have many used in the medicinal field and human health. They are found in milk products and they have antioxidant properties. They work to regulate the growth of gut microbiota.
9. Dietary supplements –Tablets are dietary supplements that are taken from different sources. Dietary supplements are vitamins, amino acid, fish oil etc. [3]

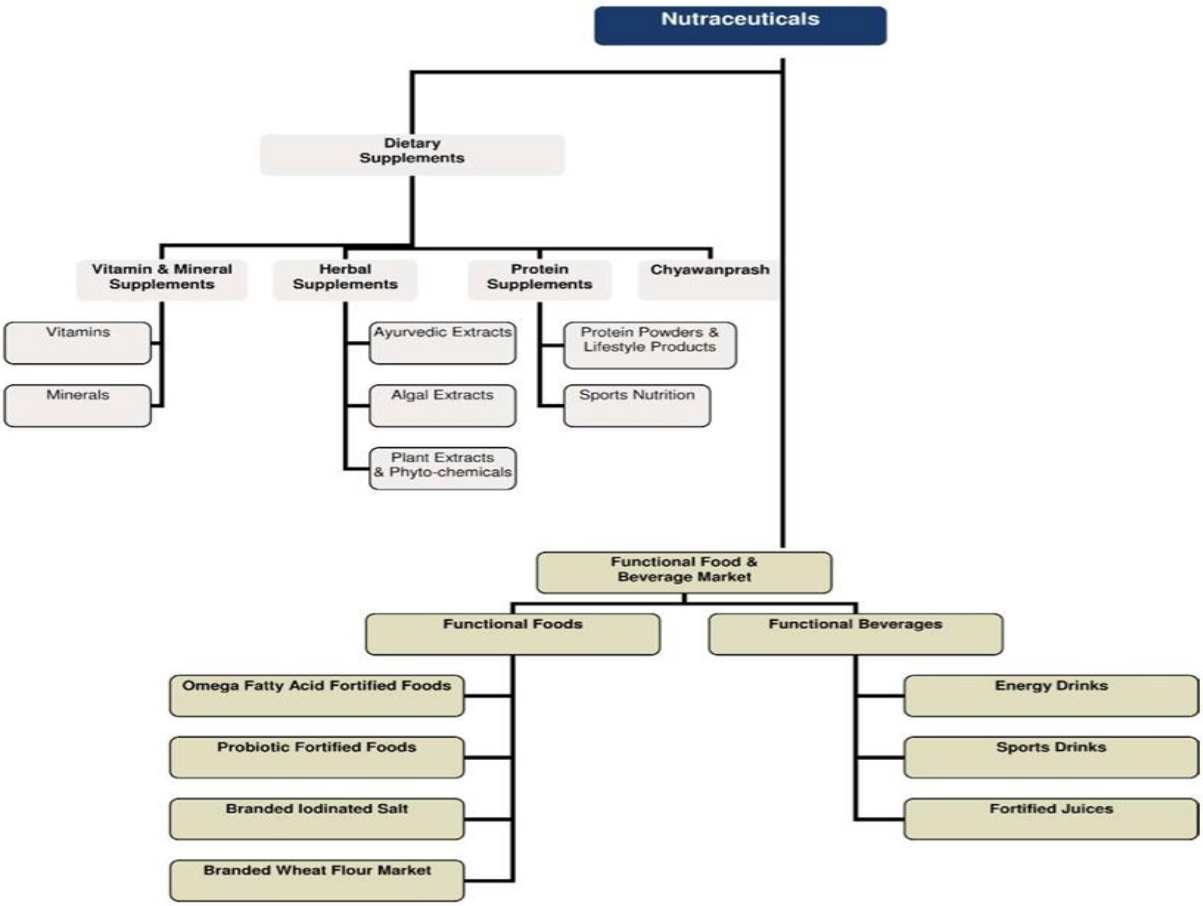


Fig 1. Classification of Nutraceuticals [4]

How do Nutraceuticals work?

Nutraceuticals may provide consumers with added nutrition. If a consumer's diet isn't supplying them with all the nutrients and vitamins their body needs, then nutraceuticals can help. Nutraceuticals can be especially important if a consumer is managing an injury or illness or if they are putting extra physical strain on their body, as these situations can increase the number of nutrients our bodies need.

Metabolism is a process that breaks down the nutrients in our food to produce energy. Nutrients like proteins, carbohydrates and fats provide energy, while nutrients like vitamins, electrolytes, minerals and water help our bodies maintain healthy metabolisms. Having enough nutrients allows the organs and systems in our bodies to function properly and may aid in healing wounds or injuries thoroughly and quickly.

Table 1: Difference between Nutraceuticals and Pharmaceutical:

Sr. No.	Title	Nutraceuticals	Pharmaceuticals
1	Regulation	No need of prescription for Nutraceuticals	Prescription is always required
2	Limitations on research and marketing	They are not backed by scientific research; there are some restrictions on marketing.	They are backed by scientific research; they shine in marketing
3	Consumer perception	They are viewed as prevention of diseases	They are viewed for treatment purpose

Benefits of Nutraceuticals:

- Improve health: Health benefits of Nutraceuticals include an increase in wellbeing and overall health of individuals and the improvement of our ability to cope with stress. These products can complement and boost a healthy diet so that consumers can take control of their health.
- Reduce risk of chronic disease: Rather than battle diseases after onset, consumers can take steps to prevent diseases and infections from manifesting in the first place or stopping the disease before it becomes a serious health problem. Diseases that nutraceuticals may assist or aid in treating include: Diabetes, Heart disease, Obesity, Parkinson's disease, Alzheimer's disease, Cancer.
- Increase Life Expectancy: Nutraceuticals are preventive care, and preventive care has been shown to increase life expectancy significantly. Catching diseases before they're a major problem or before they start to affect the patient health.
- Support Your Body's Functions and Integrity: Nutraceuticals can also play a significant role in the body's immune status and biological processes. These include: Protection of mitochondrial integrity, Antioxidant defense, Gene expression, Cell proliferation [3].

II. APPLICATION

- Nutraceuticals in Allergic Disorders - Quercetin is a plant bioactive often used in nutraceuticals for management of allergy due to its effect on low density lipoprotein, Eucalyptus essential oil is another plant derivative mostly used in nutraceuticals for management of allergy.[5]
- Nutraceuticals in cardiovascular disease - Vitamins, antioxidants, omega 3 fatty acids, dietary fibers and minerals are the formulated as nutraceuticals supported by physical exercise is recommended for cardiovascular disease management. Turmeric has anti-inflammatory property and reduces LDL levels.[6]
- Nutraceuticals used in Cancer Therapy - Nutraceuticals of plant extracts rich in biochanin, isoflavones, tannins and plant bioactive like curcumin, gallic acid, caffiec acid portray remarkable potency against diverse cancers. Regular consumption of fruits can serve the body with different types of nutraceuticals like cysteine, Vitamin C, Vitamin E, lycopene and it can prevent from different types of cancer.[7]
- Nutraceuticals in Management of Diabetes - Omega-3 fatty acid and Ethyl esters of n-3 fatty acid are also used in diabetes management. Lipoic acid and some dietary fibers like psyllium is incorporated in nutraceuticals to mitigate diabetic neuropathy, hyperlipidemia and control of blood sugar level.[8]
- Nutraceuticals in Alzheimer's Disease - Some of the nutraceutical products like β carotene, lycopene, curcumin, lutein are useful in the management of Alzheimer. There are some

research reports which claim that some extracts of plants like Lavandula officinalis, Zizyphus jujube are useful in treatment of Alzheimer's as they contribute in memory enhancements.[5]

- Nutraceuticals in Ophthalmology – Genistein and other flavonoids including luteolin and fisetin shown promising results in ocular pathology.
- Nutraceuticals in mental health- Nutrients such as fish oil, B vitamins, and vitamin D have all been shown to interact with multiple pathways in our body that are can affect mental illness.[9]
- Nutraceuticals in Parkinson disease- Nutraceuticals for Parkinson can be grouped into six themes: ion chelation, cell signaling modulation, anti-inflammation, antioxidation, anti-apoptosis, and mitochondrial homeostasis. Several nutraceuticals used for PD are Vitamin B complex, Vitamin C, E, D.[10]
- Nutraceuticals in Obesity- Obesity and overweight are related pathological conditions related to CVS diseases, Diabetes, Thyroid disorders etc. Various nutraceuticals used are green tea, ginseng, chitosan, psyllium, flaxseed, cucurmin.[11]
- Nutraceuticals in Osteoarthritis- Nutraceuticals include heterogeneous class of molecules with great potential to reduce inflammation, oxidative stress, pain, joint stiffness and improve cartilage formation. Pomegranate juice, Avocado, Soybean, Capsaicin, Cucurmin and ginger are used in prevention of Osteoarthritis.[12]
- Nutraceuticals in Constipation- Magnesium oxide supplements are effective at improving cardinal symptoms of chronic constipation. Senna and kiwifruit supplements did not impact symptoms; however, findings were based on a small number of studies. Further research is required to investigate the effect of food supplements (e.g., kiwifruit supplements), as well as their whole food equivalents (e.g., whole kiwifruits) in chronic constipation.[13]
- Nutraceuticals in Hypertension- The BP lowering nutraceuticals can be categorized as foods (i.e., tea and cocoa), nutrients (i.e., magnesium, calcium, vitamin C, omega 3 polyunsaturated fatty acids (PUFAs), soluble fibers) and non-nutrient nutraceuticals (i.e., coenzyme Q10, lycopene, prebiotics).[14]
- Nutraceuticals in Hyperlipidemia- The different nutraceuticals may have different mechanisms of action: inhibition of cholesterol synthesis primarily through action on the enzyme HMG-CoA reductase (policosanol, polyphenols, garlic and, above all, red yeast rice), increase in LDL receptor activity (berberine), reduction of intestinal cholesterol absorption (garlic, plant sterols, probiotics), and also the ability to interfere with bile metabolism (probiotics, guggul).[15]

Table 2: Nutraceuticals used in various diseases

Sr. No.	Disease	Nutraceuticals
1	Cancer	Tea, lycopene, flaxseeds
2	CVS	Omega 3 fatty acid, polyphenols
3	Diabetes	Bitter melon, Gymnema, Amla
4	Alzheimer's Disease	Lycopene, cucurmin, lutein
5	Parkinson's Disease	Vitamin B complex, C, D, E
6	Eye Health	Lutein, Zeaxanthin
7	Mental Health	Phosphatidylserine, Soy, Isoflavones
8	Sleep Enhancement	Melatonin
9	Bone Health	Melatonin, L-carnitine
10	Skin Health	Tea, Soy, Isoflavones

III. NUTRACEUTICALS IN MARKET

Various dosage forms of nutraceuticals are present in market for prevention and maintainance of different types of diseases. Some of them are capsules, tablets, syrups, arka, powder, jellies,etc.

Table 3: Tablet formulation

Sr. No.	Brand Name	Herbal Ingredients	Dose Frequency
1	Pure Nutrition Diabetic Care	Gymnema, Vijaysar, Berberine extract, Fenugreek, Jamun, Karela, Turmeric,etc.	1 Tablet twice a day before meals.
2	Dabur Glycodab	Amra, Karela, Jamun, Gudmaar,etc.	2 Tablets twice a day

Table 4: Capsule formulation

Sr. No.	Brand Name	Herbal Ingredients	Dose Frequency
1	Himalaya Glucocare	Amla, Gymnema, Indian kino tree, Bitter melon, Aloe vera, Turmeric, Guggul, Ginger, Jamun, Levant cotton, Shatavari, Shilajeet, Liquorice, Tribulus, *Phyllanthus amarus*	2 capsules twice daily before meals
2	Cureveda Gluco Guide	Bitter melon, Gymnema, Amla, Jamun, Cinnamon, Turmeric, Tulsi, *Tinospora cardifolia*, Pterocarpus,	1-2 capsules 2-3 times daily before meals.
3	Sugar Knocker	Bitter melon, Tulsi, Jamun, Amla, Turmeric, Cinnamon, Gymnema, Pterocarpus, Salacia Retriculata, Guduchi, Banaba	1-2 capsules 2-3 times daily before meals
4	Zandu Karela Capsules	Karela extract.	1-2 capsules twice a day.
5	Bioayurveda Bio Diabless	Gular, Ashwagandha, Meshashringi, Jamun, Karela, Haldi, Tulsi, Methi, Giloy, Amla, Haritaki, Vibhitaki, Shudh Shilajit,etc.	1-2 capsules twice a day.

Table 5: Liquid formulation

Sr. No.	Brand Name	Herbal Ingredients	Dose Frequency
1	Kapiva Dia free juice	Bitter melon, Vijaysar, Methi, Amla, Giloy, Gudmad, Jamun, Belpatra,etc.	30ml per glass
2	Krishna's Diabic Care	Jamun, Belpatra, Amla, Methi, Karela, Giloy, Kutki, Vijaysar, Tulsi, Gudmaar, Neem,etc.	30 ml in 30 ml warm water.
3	Vansa diab balance juice	Neem, tulsi panner daba,bael,gudmar ,cinnamon,giloy, methi, karela	30 ml in 30 ml warm water.
4	Amrit noni	Jamun, amla, guduchi, noni fruit, methi ,madhunashini, haridra	30 ml in 30 ml warm water.
5	Rasayanam Gluco care juice	Karela, jamun	30 ml in 30 ml warm water.

Table 6: Powder formulation

Sr. No.	Brand Name	Herbal Ingredients	Dose Frequency
1	Oziva Greens and Herbs – D	Spinach, Mint, Moringa, Basil leaves, Cinnamon, Gymnema, Fenugreek, Jamun, Fennel seed, Pomegranate, Turmeric, Amla, black salt, Lemon powder.	6 gm (2 scoops)

Various Nutraceuticals are available in market for prevention of diabetes. Type 2 diabetes mellitus is one of the most widespread endocrinological diseases in the general population and especially among hospitalized patient. [16] In present research we are focusing on Nutraceuticals used in Diabetes

Diabetes

Diabetes is a chronic disease that occurs either when the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produces. Insulin is a hormone that regulates blood glucose. Hyperglycemia, also called raised blood glucose or raised blood sugar, is a common effect of uncontrolled diabetes and over time leads to serious damage to many of the body's systems, especially the nerves and blood vessels. [17]

Types of diabetes-

Different types of diabetes:

- Type 1: Type 1 diabetes is an autoimmune disease. The immune system attacks and destroys cells in the pancreas, where insulin is made. It's unclear what causes this attack.[17]
- Type 2: Type 2 diabetes occurs when your body becomes resistant to insulin, and sugar builds up in your blood. It's the most common type—about 90% to 95% trusted source of people living with diabetes have type 2.[18]
- Type 1.5: Type 1.5 diabetes is also known as latent autoimmune diabetes in adults (LADA). It occurs during adulthood and sets in gradually like type 2 diabetes. LADA is an autoimmune disease that cannot be treated by diet or lifestyle.[19]
- Gestational: Gestational diabetes is high blood sugar during pregnancy. Insulin-blocking hormones produced by the placenta cause this type of diabetes.[18]

Symptoms –
Symptoms of diabetes include: Feeling very thirsty, need to urinate more often than usual, blurred vision, feeling tired, losing weight unintentionally, have numb or tingling hands or feet.[20]

Prevention-
1.Reach and keep a health body weight.
2.Stay physically active with at least 30 minutes of moderate exercise each day.
3.Eat a healthy diet and avoid sugar and saturated fat.
4.Not smoke tobacco.[21]

Treatment-
People with type 1 diabetes need insulin injections for survival. Some people with type 2 diabetes will need to take medicines to help manage their blood sugar levels. These can include insulin injections or other medicines.
Some examples include: Metformin, Sulfonylureas, Sodium-glucose co-transporters type 2 (SGLT-2) inhibitors.[22]

IV. HERBS USED AS NUTRACEUTICALS IN DIABETES

1.Momordica charantia (Bitter gourd)

- Common name: Karela
- Family: Cucurbitaceae
- Parts used: Fruit, seed, bark, root, leaves, oil
- Chemical constituents: charantin, vicine, and polypeptide-p, and antioxidants.
- Mechanism: The fruit juice significantly increased the number of β-cells, decreases blood sugar levels by inhibiting fructose-1, 6-phosphatase and glucose-6-phosphatase.[25]

2. Syzygium cumini (Blackberry)

- Common name: Jamun
- Family: Myrtaceae
- Parts used: Seeds, leaves, fruit,
- Chemical constituents: phenol, steroids, saponins and flavonoids.
- Mechanism: It enhances insulin secretion or decreased insulin breakdown. The activation of pancreatic cells and subsequent production of insulin which is mediated by saponin.[28]

3.Trigonella foenum-graecum (fenugreek)

- Common name: Methi
- Family: Fabaceae
- Parts used: Leaves, seeds
- Fig.4 fenugreek
- Chemical constituentsb: saponins, high fibre content, 4- hydroxyisoleucine, and the alkaloid trigonelline
- Mechanism: It has glucose and lipid-lowering potential. Its leaf and seed extract, mucilage and powder can lower blood glucose. [26]

4.Cinnamomum zeylanicum (cinnamon)

- Common name: Dalchini
- Family name: Lauraceae
- Parts used: Leaves, bark
- Fig.5 Dalchini
- Chemical constituents: cinnamaldehyde, cinnamyl acetate, cinnamyl alcohol and eugenol and other volatile substances.
- Mechanism: It inhibits the activity of aldose reductase, the key enzyme of polyol pathway. Inhibition of this enzyme prevents the conversion of glucose to sorbitol, thus preventing several

diabetic complications like cataract, neuropathy, and retinopathy.[27]

5. Nigella sativa (Black cumin)

- Common name – Kalonji
- Family – Ranunculaceae
- Part used – seeds Fig.6 Kalonji
- The chemical constituents: nigellicine, nigellidine, thymol, linoleic, oleic, etc.
- Mechanism: It helps in insulin secretion by restoring the activity of enzymes involved in glucose metabolism such as glucose-6-phosphatase and fructose-1, 6- phosphatase and fructose-1, 6- bisphosphates of gluconeogenesis. [25]

6. Allium sativum (Garlic)

- Common name – Garlic
- Family – Amaryllidaceae
- Parts used – leaves, flower, cloves
- Chemical constituents: Allicin (0.2-0.53%). Fig.7 Garlic
- Mechanism: Allicin helps as a hypoglycemic compound by activating PI3K/AKT pathway which helps in secretion of insulin and reduces the production of advanced glycation end products.[27]

7. Gymnema sylvestre

- Common name: Gurmar
- Family name: Asclepiadaceae
- Parts used: Rhizomes, leaves, volatile oilsFig.8 Gurmar
- Chemical constituents: gymnemic acid, insulin, stigmasterol, terpenoid, saponin.
- Mechanism: It causes reversible increase in intracellular calcium and insulin secretion in human β-cells with type 2 diabetes. [25]

8. Ocimum sanctum

- Common name: Tulsi
- Family: Lamiaceae
- Parts used: Whole plant and leaf oil. Fig.9 Tulsi
- Chemical constituents: euginal, urosolic acid, carvacrol, linalool, limatrol, and caryophyllene
- Mechanism: A considerable decrease in blood glucose, glycosylated haemoglobin. The physiological mechanisms of insulin secretion have been reported to be stimulated by the leaf extracts.

9. Acacia arabica (Gum Arabic tree)

- Common Name: Babul
- Family: Fabaceae
- Parts used: stem, pod, bark Fig.10 Babul
- Chemical constituents: gallic acid, quercetin, botulin, sitosterol.
- Mechanism: It Acts through release of insulin from pancreatic beta cells, which accounts for the hypoglycemic activity.

10. Aegle marmelos

- Common name: Wood apple
- Family: Rutaceae
- Parts used: leaves, bark, seed, gum.Fig.11 Wood apple
- Chemical constituents: flavonoid, saponin, tannin, coumarin, and tyramine.
- Mechanism: It increases utilization of glucose; either by direct stimulation of glucose uptake or via the mediation of enhanced insulin secretion and also decreases the elevated glucose and glycosylated haemoglobin levels.

11. Allium cepa

- Common name: onion
- Family: Liliaceae
- Parts used: bulb, leaves.Fig.12 onion
- Chemical constituents: allicin, quercetin, fisten, other sulphurous compounds.
- Mechanism: It lowers blood glucose level and has potent antioxidant activity, which may account for the hypoglycemic potential [30]

12. Aloe vera

- Common name: Aloe
- Family: Liliaceae
- Parts used: leaves Fig.13 Aloe
- Chemical constituents: aloin, catechin, anthroquinine.
- Mechanism: It maintains glucose homeostasis by controlling the carbohydrate metabolizing enzymes and stimulates insulin release from pancreatic beta cells.[26]

13. Annona squamosa

- Common name: Sugar apple
- Family: Annonaceae
- Parts used: leaves Fig.14 Sugar apple
- Chemical constituents: alpha-pinene, beta-pinene, sabinene, T-cardinol.
- Mechanism: It lowers blood glucose level.[34]

14. Artemisia pallens

- Common Name: Davana
- Family: Compositae
- Parts used: leaves Fig.15 Davana
- Chemical constituents: davanite, davan ether, davan furan and linalool.
- Mechanism: It inhibits glucose re-absorption or increase in peripheral glucose utilization.[24]

15. Azadirachta indica

- Common name: Neem
- Family: Meliaceae
- Parts used: leaves, stem, barkFig.16 Neem

- Chemical constituents: nimbine, gedunin, azadirichtin, azadirone.
- Mechanism: Inhibits action of epinephrine on glucose metabolism, resulting in increased utilization of peripheral glucose and exhibits hypoglycemic activity.[23]

16. Andrographis paniculata

- Common name: King of Bitter.
- Family: Acanthaceae Fig.17 King of Bitter
- Parts used: leaves.
- Chemical constituents: steroids, alkaloids, saponin, phenol.
- Mechanism: It prevents glucose absorption from gut. Has hypotriglyceridemia effect and antioxidant activity which may be responsible for beneficial effect in the diabetic state.[24]

17. Biophytum sensitivum

- Common name: Life Plant
- Family: Oxalidaceae
- Parts used: leaves Fig.18 Life Plant
- Chemical constituents: flavonoids, lutrolin, isoorientonin, phenols.
- Mechanism: It stimulates pancreatic beta cells to release insulin.

18. Beta vulgaris

- Common name: Garden beet
- Family: Chenopodiaceae
- Parts used: root Fig.19 Garden beet
- Chemical constituents: betanine, syringic acid, oleanolic acid, nitrate, coumaric acid.
- Mechanism: It lowers blood glucose level.

19. Brassica juncea

- Common name: Brown Mustard
- Family: Brassicaceae
- Parts used: seed Fig.20 Brown Mustard
- Chemical constituents: sinigrin, sinapic acid, glycerides, fixed oils, glucosinolate.
- Mechanism: It increases the concentration of hepatic glycogen and glycogenesis and suppressed the activity of glycogen phosphorylase and gluconeogenic enzymes, lead to reduction in glycogenolysis and gluconeogenesis.

20. Cassia auriculata

- Common name: Tanner's Cassia
- Family: Leguminosae
- Parts used: flower, bud, leaves, stem, root. Fig.21 Tanner's Cassia
- Chemical constituents: glycine, dodecanoic acid, linoleic acid, oleic acid, palmitic acid, alpha tocopherol.
- Mechanism: It suppresses enhanced gluconeogenesis during diabetes and enhance utilization of glucose through increased glycolysis in addition to pronounced alpha-glucosidase inhibitory actions resulting in a significant and potent lowering of blood glycemic response.[24]

21. Boerhavia diffusa

- Common name: Tar vine
- Family: Nyctaginaceae
- Parts used: root, aerial parts Fig.22 Tar vine
- Chemical constituents: boerhavia acid, isoflavonoids, punarnavine, palmitic acid, steroids.
- Mechanism: It increases plasma insulin levels and improves glucose tolerance, produces significant antioxidant activity.[24]

22. Citrullus colocynthis

- Common name: Bitter apple
- Family: Cucurbitaceae Fig.23 Bitter apple
- Parts used: pulp, seed
- Chemical constituents: alkaloid, glycoside, flavonoid.
- Mechanism: It exerts an insulinotropic effect.[24]

23. Cajanus cajan

- Common name: Pigeon pea
- Family: Fabaceae
- Parts used: seed Fig.24 Pigeon pea
- Chemical constituents: protein, dietary fibre, thiamine, magnesium, copper, manganese.
- Mechanism: It lowers plasma glucose level.[33]

24. Casearia esculenta

- Common name: Carilla Fruit
- Family: Flacourtiaceae
- Parts used: fruit
- Chemical constituents: ethanol Fig.25 Carilla Fruit
- Mechanism: It exhibits significant reduction in blood glucose level, a decrease in the activities of glucose-6- phosphatase and fructose-1,6-bishosphatase and an increase in the activity of liver hexokinase, resulting in potent hypoglycemic activity.

25. Catharanthus roseus

- Common name: Madagascar periwinkle
- Family: Apocynaceae
- Parts used: shoot, root Fig.26 periwinkle
- Chemical constituents: vinca alkaloid, vinblastine, vincristine, indole alkaloid.
- Mechanism: It increases metabolization of glucose and enhances secretion of insulin either from the beta cells of Langerhans or through extra pancreatic mechanism.[32]

26. Camellia sinensis

- Common name: Green tea
- Family: Theaceae

- Parts used: leaves Fig.27 Green tea
- Chemical constituents: caffeine, catechin, theaflavin.
- Mechanism: Epigallocatechin gallate, present in tea increases insulin activity and prevents oxidative damages, responsible for the hypoglycemic activity.[22]

27. Enicostemma littorale

- Common name: Nahi
- Family: Gentiaceae
- Parts used: leaves, fruit Fig.28 Nahi
- Chemical constituents: apigenin, genkawenin, isovitexin, saponarin, swertisin.
- Mechanism: It enhances glucose-induced insulin release from isolated rat pancreatic islets, mediated through K (+)-ATP channel-dependent pathway.[24]

28. Helicteres isora

- Common name: Screw tree
- Family: Sterculiaceae
- Parts used: root, juice
- Chemical constituents: gallic acid, caffeic acid, vanillin. Fig.29 Screw tree
- Mechanism: It acts through insulin-sensitizing activity.[24]

29. Ipomoea batatas

- Common name: Sweet potato
- Family: Convolvulaceae
- Parts used: root Fig.30 Sweet potato
- Chemical constituents: protein, vitamin, provitamin A, anthracinin.
- Mechanism: It reduces insulin resistance and possibly acts by maltase inhibition.[31]

30. Morus alba

- Common name: White mulberry
- Family: Moraceae
- Parts used: leaves Fig.31 White mulberry
- Chemical constituents: caffeic acid, gallic acid, chlorogenic acid, moracin M.
- Mechanism: It acts by increasing glucose uptake.[24]

31. Scoparia dulcis

- Common name: Sweet Broomweed
- Family: Scrophulariaceae
- Parts used: whole plantFig.32 Sweet Broomweed
- Chemical constituents: alkaloid, saponin, terpenoids, flavonoids.
- Mechanism: It suppresses glucose influx into the polyol pathway leading to increased activities of antioxidant enzymes and plasma insulin and decreases activity of sorbitol dehydrogenase. [24]

32. Murraya koenigii

- Common name: curry-leaf tree
- Family: Rutaceae
- Parts used: leaf extractFig.33 curry-leaf tree
- Chemical constituents: elemene, jasmoni, thujene, mahanimbine.
- Mechanism: It increases glycogenesis and decreases glycogenolysis and gluconeogenesis.[30]

33. Punica granatum

- Common name: Pomegranate
- Family: Punicaceae
- Parts used: peel, flower, seed Fig.34 Pomegranate
- Chemical constituents: ellagic acid, punicalagin, gallic acid.
- Mechanism: It inhibits intestinal alpha-glucosidase activity, leading to anti-hyperglycemic property.[28]

34. Morimga oleifera

- Common name: Drumstick
- Family: Moringaceae
- Parts used: leaves, root, seed, flowerFig.35 Drumstick
- Chemical constituents: cinnamic acid, sinapinic acid, syringic acid.
- Mechanism: The leaves and pods of drumsticks possess anti-diabetic properties. They help lower blood sugar levels, enhance insulin secretion, and promote healthy glucose metabolism.[23]

35. Phyllanthus emblica

- Common name: Indian gooseberry, Amla
- Family: Euphorbiaceae
- Parts used: whole plant Fig.36 Amla
- Chemical constituents: gallic acid, tannin, ellagic acid, ascorbic acid, flavonoids
- Mechanism: Amla has antioxidant activity as well as anti-diabetic property. Dry leaves extract reduces level of serum glucose, triglycerides in diabetes.

Table 7: Various herbs used in diabetes

Sr. No.	Plant Common Name	Biological Source	Phytoconstituents
1	Karela	Momoradica charantia	Charantin, Vicine, Polypeptide-p, antioxidant
2	Jamun	Syzygium cumin	Flavonoids, saponins, glycoside
3	Methi	Trigonella foenum graecum	Saponin, 4-Hydroxy isoleucine and Trigonelline, Alkaloid
4	Dalchini	Cinnamonium zeylanicum	Cinnamaldehyde
5	Kalonji	Nigella sativa	Thymoquinone
6	Garlic	Allium sativum	Allicin
7	Gurmar	Gymnema sylvestre	Triterpene Saponins (gymnemic acid and gymnemo saponins)

V. LITERATURE REVIEW

Sr. N.	Author Name	Article Name	Content
1	Rahashekhar Perusomula, *et a2023l*	Role of Nutraceuticals in Management of Diabetes Mellitus: A Review	Highlight and comment on certain of most widely used Nutraceuticals for diabetes prevention
2	Safaet Alam, *et a2022 l*	Antidiabetic Phytochemicals from Medicinal Plants: Prospective	Phytochemicals and phytosources in discovery and

		Candidates for New Drug Discovery and Development	development of novel antidiabetic therapeutics
3	Harshita Ghuse2023	Formulation Development and Evaluation of Anti-diabetic Nutraceutical Instant Soup Powder Formulation	Development of antidiabetic nutraceutical instant soup powder
4	Ankita Thakur, *et al2024*	Formulation and Evaluation of Herbal Anti-Diabetics Nutraceutical Capsules	Evaluation test parameters

VI. EXPERIMENTAL

Formulation of Nutraceutical Powder

Anti-diabetic powder is used for prevention of type 2 diabetes and to maintain blood sugar level. Moringa leaves have nutritional value as it contains protein, vitamin, iron, riboflavin, antioxidants, etc. Many studies had shown that it has anti diabetic properties, reduce inflammation, lower cholesterol. Amla is used to moderates hypertension, cholesterol, reduce blood sugar level, improve eye health, boosten immunity, hair and skin health. Jamun seed powder controls blood sugar level, blood pressure, boost haemoglobin levels. It is called as antioxidant powerhouse.

Table 8: Formulation table

Sr. No.	Ingredients	Weight (gm) 100 gm
1	Moringa leaves powder (Moringa oleifera)	46.65
2	Jamun powder (Syzygium cumin)	33.35
3	Amla powder (Phyllanthus emblica)	20
4	Talc (1% w/w)	1

Procedure:

1] The required sample of moringa leaves was collected from healthy plant Moringa oleifera. Leaves were separated from stem, pods and flowers.
2] The moringa leaves were rinsed with distilled water to remove dirt, or excess pollutants present on leaf surface. Excess water was wiped with tissue paper.
3] Leaves were dried in shed so that the constituents will not degrade.
4] The dried leaves were collected and proceeded for milling. The leaves were ground to required size using mixer blender.
5] Size reduced powder was passed through sieve no. 44, It was weighed and stored in tightly closed container for further use.
6] Amla powder and Jamun seed powder were passed through sieve no. 44 separately. The same procedure was followed as moringa leaves.
7] The quantity of moringa leaves, Jamun seed powder and Amla powder was weighed 46.65gm, 33.35gm and 20gm respectively. The measured quantities of powder were mixed using blender.
8] The blended formulated powder was transferred to clean and dry container with labeling and further used for evaluation purpose.

Evaluation of powder:

1) Color: For determining the exact color of powder, it was observed under clear sunlight.
2) Odour: By smelling it, odour was detected.
3) Taste: As the powder consists of herbal constituents, it is safe to taste. A pinch of powder was tasted.
4) pH: A suspension of small quantity of powder in water was prepared. The digital Ph meter was calibrated with phosphate buffer solution. The Ph of the prepared suspension was checked by calibrated Ph meter.
5) Density: 25 gm of formulated powder was used to determine the bulk and tapped density.

Bulk volume – By taking 25 gm of powder in 100ml measuring cylinder, the volume of powder was noted without disturbing it.

Tapped volume – The measuring cylinder used for bulk volume determination was tapped for 100 times. The tapped volume was noted.

Bulk density - To determine the bulk density, following formula is used:

$$\text{Bulk density} = \frac{\text{wt. of powder}}{\text{Bulk}}$$

Bulk volume

Tapped density – To determine the tapped density, following formula is used:

$$\text{Tapped density} = \frac{\text{wt. of powder}}{\text{Tapped volume}}$$

6) Flow Properties:

1. Angle of repose – Angle of repose was determined by using fixed funnel method. In this method, funnel was attached to burette stand at fixed height of 2cm above the graph paper from the floor. The powder was poured into the funnel slowly. A rough circle was drawing around the heap of powder. The procedure was repeated for 2 times. The mean diameter was determined for the 3 circles. The angle of repose was calculated by using following formula:

Angle of repose = Tan ^-1 (h/r)

2.Compressibility index – It was determined by using values of bulk density and tapped density in following formula:

$$\text{Compressibility index} = \frac{\text{Tapped density} - \text{Bulk density}}{\text{Tapped density}} \times 100$$

Compressibility index= Tapped density *100
Tapped density

3. Hausner's Ratio- It was determined by using values of bulk density and tapped density in following formula:

$$\text{Hausner's ratio} = \frac{\text{Tapped density}}{\text{Bulk density}}$$

4.Moisture content- A formulated powder of 25gm was taken in china dish. Initial weight was taken. It was kept in preheated hot air oven at 102℃ until the final constant weight was determined.

$$\text{Moisture content} = \frac{\text{Initial wt.} - \text{Final wt.}}{\text{Initial wt}} \times 100$$

Dosage frequency:

2 spoons in 30 ml water before meals twice a day

VII. METHODOLOGY

Formulation and Evaluation of Nutraceutical Powder for Diabetes Management

1. Selection of Ingredients

Natural herbal ingredients possessing antidiabetic activity were selected based on literature review, traditional use, nutritional value, safety, and availability. The selected ingredients included fenugreek powder, cinnamon powder, jamun seed powder, amla powder, moringa leaf powder, flaxseed powder, and stevia as a natural sweetening agent.

2. Preformulation Studies

All selected ingredients were subjected to preformulation studies in order to determine their physicochemical properties and suitability for powder formulation. The parameters evaluated included color, odor, taste, particle size, moisture content, solubility, bulk density, tapped density, angle of repose, and Carr's index.

3. Authentication of Crude Drugs

The crude herbal drugs used in the formulation were authenticated by organoleptic and morphological evaluation with the help of standard literature and pharmacognostic studies. The authentication ensured purity, quality, and genuineness of the herbal materials used in the formulation.

4. Preparation of Nutraceutical Powder

The collected herbal materials were dried under shade and powdered separately using a grinder. The powders were passed through sieve number 60 to obtain uniform particle size. All ingredients were weighed accurately according to the formulation design and mixed uniformly by geometric mixing method. Flavoring and sweetening agents were added to

improve palatability. The prepared nutraceutical powder was packed and stored in airtight containers for further evaluation.

5. Formulation Design

Different formulations of nutraceutical powder were prepared by varying the concentration of herbal ingredients in order to obtain an optimized formulation with better antidiabetic activity and acceptable physical characteristics. The formulations were coded as F1, F2, and F3.

6. Evaluation of Nutraceutical Powder

The prepared formulations were evaluated for various parameters. Organoleptic evaluation included color, odor, taste, and texture. Physicochemical evaluation included pH, moisture content, ash value, and extractive value. Flow properties such as bulk density, tapped density, Hausner ratio, Carr's index, and angle of repose were also determined. Nutritional analysis including protein, carbohydrate, fat, and fiber content was performed.

7. In-vitro Antidiabetic Activity

The antidiabetic activity of the prepared nutraceutical powder was evaluated using α-amylase inhibition assay. In this method, the sample solution was mixed with α-amylase enzyme and incubated with starch solution. DNS reagent was added after incubation, and absorbance was measured using a UV spectrophotometer. The percentage inhibition was calculated using the following formula:

%\ \mathrm {Inhibition}=\frac {\mathrm {Control}-\mathrm {Sample}}{\mathrm {Control}} \times100

60%

8. Stability Study

The optimized formulation was subjected to stability studies under room temperature and accelerated conditions for a period of three months. During the study, parameters such as color, odor, moisture content, and flow properties were evaluated at regular intervals to determine the stability of the formulation.

9. Statistical Analysis

All experimental data were expressed as mean ± standard deviation. Statistical analysis of the obtained results was carried out using suitable statistical methods such as t-test or ANOVA with the help of Microsoft Excel or GraphPad Prism software.

10. Conclusion

The prepared nutraceutical powder formulations were compared based on physicochemical properties, nutritional value, flow characteristics, stability, and in-vitro antidiabetic activity. The formulation showing maximum antidiabetic activity and acceptable evaluation parameters was selected as the optimized formulation.

VIII. RESULT

The formulation and evaluation of 6089utraceutical powder was performed. According to evaluation parameter tests, the formulated 6089utraceutical powder has shown following results.

Table 9: Result

A] Before adding glidant

Sr. no	Evalution Parameter	Value
1	Colour	Olive green
2	Odour	Characteristics
3	Taste	slightly bitter and earthy
4	Ph	Acidic (2.16)
5	Bulk density	0.423gm/ml
6	Tapped density	0.67gm/ml
7	Angle of repose	41.34
8	Compressiblity index	37.31
9	Hausner's ratio	1.59
10	Flow property	Poor
11	Moisture content	2.8%

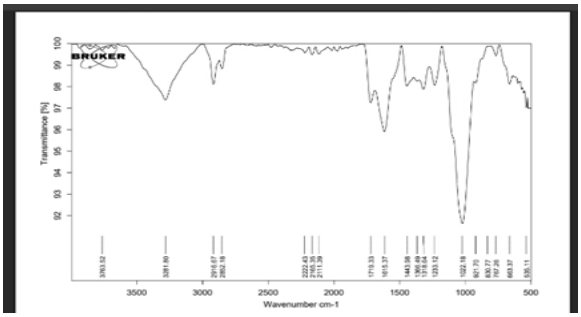
B] After adding glidant

Sr. No.	Evaluation Parameter	Value
1	Bulk density	0.403gm/ml
2	Tapped density	0.5 gm/ml
3	Angle of repose	33.42
4	Compressiblity index	19.4
5	Hausner's ratio	1.24
6	Flow property	Good

In-vitro Antidiabetic Activity

The antidiabetic activity of the prepared nutraceutical powder was evaluated using α-amylase inhibition assay. In this method, the sample solution was mixed with α-amylase enzyme and incubated with starch solution. DNS reagent was added after incubation, and

absorbance was measured using a IR spectrophotometer



Batch-wise Evaluation of Anti-diabetic Nutraceutical Powder (F1–F5)

Prepared for the project: Formulation and Evaluation of Anti-diabetic Nutraceutical Powder.

Table 1. Formulation Batches (g per 100 g)

Ingredient	F1	F2	F3	F4	F5
Moringa oleifera powder	40.0	43.0	46.65	48.0	46.65
Jamun seed powder	35.0	34.0	33.35	32.0	33.35
Amla powder	24.0	22.0	20.0	19.0	20.0
Talc (Glidant)	1.0	1.0	1.0	1.0	1.0
Total	100	100	100	100	100

Table 2. Batch-wise Evaluation Readings

Parameter	F1	F2	F3	F4	F5
Colour	Olive Green	Olive Green	Olive Green	Dark Olive Green	Olive Green
Odour	Characteristic	Characteristic	Characteristic	Characteristic	Characteristic
Taste	Slightly Bitter	Slightly Bitter	Bitter-Earthy	Bitter-Earthy	Slightly Bitter & Earthy
pH (1% suspension)	2.25	2.20	2.16	2.12	2.18
Bulk Density (g/mL)	0.395	0.399	0.403	0.406	0.403
Tapped Density (g/mL)	0.520	0.510	0.500	0.498	0.500
Angle of Repose (°)	35.84	34.62	33.42	33.10	33.42
Carr's Index (%)	24.04	21.76	19.40	18.47	19.40
Hausner Ratio	1.32	1.28	1.24	1.22	1.24
Moisture Content (%)	3.20	3.00	2.80	2.65	2.80
Flow Property	Passable	Fair	Good	Good	Good
Alpha-Amylase Inhibition (%)	52.4	56.8	60.0	63.5	60.0

Optimized Batch Selection: F5 was selected as the optimized formulation because it showed good flow properties, acceptable physicochemical characteristics, low moisture content, and approximately 60% alpha-amylase inhibition indicating promising antidiabetic activity.

IX. CONCULSION

The combined powder of Moringa leaves, Amla and jamun seed may be potential nutraceutical mixture with rich macro and micronutrients. The formulation product mixture will be effective in lowering blood sugar level and can be a good Anti-diabetic Nutraceutical. It can also help to moderate hypertension, cholesterol; improve eye health, hair and skin health. Studies shown that it has antioxidant property too. In diabetes and cardiac diseases oxidative stress is the underlying reason which can be controlled with nutraceuticals like these.

In present study Nutraceutical with combination of Moringa leaves, Amla and Jamun seed powder formulation was formulated and evaluated for various parameters. According to them, the flow property was found to be poor which can be improved by using glidants. It was shown that, it has olive green colour, characteristics odour, slightly bitter and earthy taste, acidic pH. The primary evaluation studies were done. More future studies can be done on this formulation like stability studies, in-vivo, in-vitro bioavailability studies.

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