Int. J. Sci. R. Tech., 2026 3(9)
A Multidisciplinary peer-reviewed Journal
www.ijsrtjournal.com [ISSN: 2394-7063]

Original Article

Formulation And Evaluation Of Antidiabetic Polyherbal Churna

Kranti Akolkar*, Bansode Laxmi, Hemant Gangurde

Abasaheb Kakade College Of B. Pharmacy Bodhegaon

ABSTRACT

Diabetes mellitus is a long-term metabolic disorder marked by consistently elevated blood glucose levels due to impaired insulin production, reduced insulin effectiveness, or both. The increasing global incidence of diabetes, particularly in developing nations such as India, emphasizes the need for safer, more effective, and economical treatment options. In this context, herbal medicines have attracted considerable interest because of their natural origin, fewer side effects, and holistic therapeutic approach. The present study aims to formulate and evaluate an antidiabetic polyherbal churna composed of medicinal plants known for their hypoglycemic and antioxidant activities. The formulation was developed using a blend of Moringa oleifera (moringa leaves), Syzygium cumini (jamun seeds), Momordica charantia (bitter gourd), Elettaria cardamomum (cardamom), Zingiber officinale (ginger), Aegle marmelos (bael), and Piper nigrum (black pepper). These herbs were selected based on their traditional medicinal use and scientifically reported properties, including enhancement of insulin sensitivity, improvement of glucose metabolism, reduction of oxidative stress, and support of pancreatic function. The churna was prepared using standard procedures such as collection, drying, grinding, sieving, blending, and proper packaging to ensure consistency and quality. The prepared formulation was assessed for its organoleptic characteristics, physicochemical properties, flow behavior, and phytochemical composition. It showed desirable features such as a fine powder consistency, brownish-green appearance, characteristic odor, and bitter taste. The physicochemical parameters, including pH, ash values, and moisture content (loss on drying), were found to be within acceptable limits, indicating good stability and purity. Flow property evaluations such as bulk density, tapped density, Carr's index, Hausner's ratio, and angle of repose suggested satisfactory flow characteristics suitable for handling and packaging. Phytochemical analysis confirmed the presence of important bioactive compounds like alkaloids, flavonoids, glycosides, tannins, phenolics, saponins, and terpenoids, which are associated with antidiabetic effects. In summary, the formulated antidiabetic polyherbal churna demonstrated acceptable pharmaceutical quality and promising therapeutic potential. It may serve as a safe, economical, and natural option for managing diabetes. Nevertheless, further experimental and clinical studies are necessary to confirm its effectiveness and safety in humans.

Keywords: Diabetes Mellitus, Antidiabetic, Churna, Blood Glucose, Hypoglycemic.

INTRODUCTION

Current status of diabetes in India

India is widely recognized as the "diabetes capital of the world" due to the rapidly growing number of people affected by diabetes. According to the ICMR-INDIAB study (2023), over 100 million adults in India are living with diabetes, while more than 130 million individuals are classified as prediabetic, placing them at a greater risk of developing the disease. The incidence of diabetes is steadily increasing in both urban and rural regions of the country. Diabetes mellitus has become a major global health concern, with its prevalence rising continuously in developed as well as developing countries. Although synthetic antidiabetic drugs are commonly used for treatment, they are often associated with adverse effects such as hypoglycemia, weight gain, and cardiovascular problems. As a result, herbal medicines are receiving increasing attention because they are considered safer, more affordable, and capable of providing a holistic therapeutic approach.

Diabetes mellitus, commonly referred to as diabetes, is a long-term condition that arises when the body either produces insufficient insulin or is unable to

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

utilize it effectively. Antidiabetic agents are medications used to manage or prevent this condition, which is characterized by the body's inability to regulate blood sugar levels. [1] These agents work by helping to maintain normal blood glucose levels. The two main types of diabetes mellitus are Type 1 diabetes and Type 2 diabetes. In India, the mortality rate due to diabetes was 27.35 deaths per 100,000 individuals in 2019, showing an increase compared to 22.30 deaths per 100,000 individuals in 1990. Diabetes is a lifelong (chronic) condition that belongs to a group of metabolic disorders marked by elevated blood glucose levels (hyperglycemia). It affects over 230 million people globally, and this number is projected to rise to 350 million by 2025.

A significant proportion of affected individuals remain undiagnosed, and only about half receive proper treatment. The condition occurs due to insufficient insulin production, insulin resistance, or both. Insulin, which is produced by the β-cells of the pancreas, plays a key role in regulating blood sugar levels. Common symptoms of diabetes include blurred vision, excessive thirst, fatigue, frequent urination, increased hunger, and unintended weight loss. [2]

Diabetes is a chronic metabolic disorder in which the body is unable to utilize glucose effectively, either completely or partially. It is the fourth leading cause of death worldwide, with one person dying every 10 seconds due to diabetes-related complications. If not properly managed, diabetes can lead to serious conditions such as diabetic ketoacidosis and nonketotic hyperosmolar coma.

In India, various traditional and alternative medicinal approaches have long been used to manage diabetes, and numerous herbal plants are commonly employed in the treatment of Type 2 diabetes mellitus. [3] Diabetes mellitus is a metabolic disorder marked by persistent high blood glucose levels due to impaired insulin secretion, reduced insulin effectiveness, or both (Kharroubi, 2015). If not properly managed, it can lead to serious complications such as nerve damage (neuropathy), kidney damage (nephropathy), eye disorders including retinopathy, and cardiovascular diseases. According to the World Health Organization, around 422 million people worldwide are affected, especially in low- and middle-income countries. [4]

India is often referred to as the diabetes capital of the world. Diabetes mellitus is a chronic metabolic disorder marked by high blood sugar levels, insulin resistance, and a relative deficiency of insulin, along with disturbances in the metabolism of carbohydrates, fats, and proteins. [5] Its prevalence is increasing rapidly worldwide, and over time it can result in severe complications such as neuropathy, nephropathy, retinopathy, cardiovascular diseases, and dyslipidemia. [6]

Currently, type II diabetes accounts for nearly 90% of cases, particularly among younger individuals. This rise is largely linked to lifestyle changes, including reduced physical activity and unhealthy dietary habits. [7] India is widely known as a rich source of medicinal plants because of its diverse bioclimatic regions and its long-standing tradition of using herbal remedies for therapeutic purposes. Herbal medicines have been extensively used in traditional healthcare systems, largely due to their natural origin and relatively fewer side effects compared to synthetic drugs. [8]

Polyherbalism refers to the use of multiple herbs in a single formulation to enhance therapeutic effectiveness. In such combinations, certain herbs may act directly on specific receptors, while others may improve the absorption, distribution, metabolism, or elimination of active compounds, thereby producing a synergistic effect. The present study aims to evaluate the pharmacognostic and physiological properties of a polyherbal powder. Additionally, several plants included in PHP formulations are reported to have potential benefits in the management of diabetes mellitus. [9]

A churna may consist of a single drug or a combination of multiple drugs, all powdered separately and then mixed homogeneously. Sharangadhara describes churna as a finely powdered dry medicine that is passed through a cloth to ensure uniform particle size. It is also known by synonyms such as Rajaha and Ksoda, and the recommended dosage is one Karsa Pramana. Acharya Kashyapa defines churna as any substance reduced to a fine powder and highlights its use in various conditions such as Anjana, Amavikara, Vrana, and Grahani roga.

Overall, churna is characterized as a dry, finely sieved medicinal powder used in Ayurvedic treatments. [10]

Type II diabetes mellitus occurs mainly due to peripheral insulin resistance along with insufficient insulin secretion by the pancreas. It is more prevalent than Type I diabetes. Individuals with Type II diabetes often pass through intermediate conditions such as impaired fasting glucose and impaired glucose tolerance, collectively referred to as prediabetes. Obesity is considered a major contributing factor in the development of Type II diabetes, with nearly 90% of diabetic patients being overweight or obese. Diabetes is recognized as one of the leading causes of mortality worldwide, ranking sixteenth globally. Common symptoms associated with diabetes include blurred vision, excessive thirst, fatigue, frequent urination, and unexplained weight loss.

Modern therapeutic approaches provide several treatment options for both Type I and Type II diabetes. However, diabetes is also associated with various complications, including cardiomyopathy, nephrotoxicity, neuropathy, cerebrovascular diseases, and delayed wound healing. The high economic burden associated with diabetes management has encouraged many patients to explore alternative and complementary treatment approaches. [11]

Churna

Churna refers to a powdered form of a single drug or a mixture of two or more drugs, each ground separately and then blended uniformly. In Ayurveda, it is described as a finely powdered medicinal preparation. According to Sabda Kalpa Drum, the term “churna” is derived from Pesascurnikaranam, meaning the process of grinding or pulverizing. As per the Indian Ayurvedic Formulary, churna is obtained through Pesana (trituration or pounding) and is defined as a fine powder of medicinal substances. [12] It may consist of one drug or a combination of multiple drugs that are individually powdered and then mixed homogeneously. Sharangadhara describes churna as a finely powdered dry medicine that is sieved through cloth, ensuring uniform particle size.The synonyms of churna include Rajaha and Ksoda, and the recommended dose is one Karsa Pramana. Acharya Kashyapa also defines churna as a finely ground substance and mentions its use in conditions such as Anjana, Amavikara, Vrana, and Grahani roga. Overall, churna is a dry, finely powdered formulation that is carefully prepared and sieved to achieve a smooth and consistent texture.

Classification of Churna 1) Based on composition

- Simple churna – prepared from a single ingredient
- Compound churna – prepared from two or more ingredients **2) Based on particle size**
- Sthula churna (coarse powder) -used for preparing Hima, Phanta, and Kasaya; passed through sieve No. 20
- Suksma churna (fine powder) -used for preparing Vati, Leha, and Nasya; passed through sieve No. 60
- Atyanta Sukshma (Vastra Galita)-This refers to extremely fine powders, such as Bhasma and Anjana, which are passed through a No. 100 sieve to obtain a very fine consistency.

3) Based on structure

- Crystalline form
- Amorphous form

4) Based on composition

- Herbal powders
- Herbo-mineral powders
- Mineral-metallic powders

5) Based on therapeutic action (Karma)

- Deepana – substances that stimulate digestion and enhance appetite.
- Virechana – substances that promote purgation or bowel cleansing. [13]

Historical Background of Churna

The origin of Churna is associated with the traditional medicinal system of Ayurveda. Churna refers to a finely powdered formulation made from dried herbs, minerals, and other natural ingredients. It has been widely used in India since ancient times for the

prevention and management of various diseases.The preparation and use of Churna were mentioned in classical Ayurvedic texts such as Charaka Samhita and Sushruta Samhita. Early Ayurvedic practitioners prepared these herbal powders by drying medicinal plants and pulverizing them into a fine consistency**.** [14]

What is antidiabetic churna?

Antidiabetic churna is traditional Ayurvedic polyherbal powder formulation prepared from various medical plants known to help to regulate blood glucose levels. It typically includes herbs such as jamun seed, cardamom, moringa, bael, black pepper and others that work together to improve insulin sensitivity, enhance glucose utilization, inhibit carbohydrate digestive enzymes, and reduce oxidative stress. Because of its multitargeted action and low toxicity, antidiabetic churna is commonly used as a supportive therapy for managing diabetes mellitus.

Pharmacological Activities

Antidiabetic Churna exhibits several pharmacological properties due to the synergistic action of herbal constituents:

- Antidiabetic activity.
- Antioxidant activity.
- Hypoglycemic effect.
- Improvement in insulin sensitivity.
- Reduction of oxidative stress.

Advantages

- Herbal and economical formulation.
- Easy to prepare and administer.
- Better patient compliance.
- Lower risk of adverse effects.
- Suitable for long-term use. [15]

Polyherbal formulation

The Polygrass formulation is defined as a formulation that includes two or more herbs. That individual medicinal plants contain sufficient antioxidant substances such as phenolic compounds and flavonoids that are responsible for the treatment of diabetes. The Polygrass formulation controls diabetes better than the individual drug due to the synergistic and minimal side effects. [16]

Polyherbal Churna

Polyherbal Churna is a traditional Ayurvedic powdered formulation prepared by mixing two or more medicinal herbs in suitable proportions. In Ayurveda, polyherbal formulations are widely used because the combined action of different herbs provides enhanced therapeutic effectiveness and reduced side effects. Churna dosage forms are considered simple, economical, and easy to administer.

Definition

Polyherbal Churna may be defined as a fine powdered preparation obtained by blending dried medicinal plant materials for the treatment and prevention of various diseases. [17]

History

The concept of polyherbal formulations was described in ancient Ayurvedic texts such as Charaka Samhita and Sushruta Samhita. Ancient physicians prepared herbal powders from medicinal plants and used them for therapeutic purposes.

1. Vedic Period (1500 – 600 BCE)

- The concept of mixing multiple herbs starts in the Atharvaveda.
- Single herbs were common, but compound formulations appear for chronic diseases. **2. Samhita Period (600 BCE – 600 CE)**

Charaka Samhita (200 BCE)

- Earliest detailed description of Churna Kalpana. Charaka mentions Churna as one of the Panchavidha Kashaya Kalpana - 5 basic dosage forms.
- Quote: “Churnam choornayitva vastre galitam” - powder and sieve through cloth.

- Polyherbal examples: Sitopaladi Churna for Kasa, Hingwashtak Churna for Agni.

Sushruta Samhita (200 CE)

- Uses churnas mainly for Vrana wound, Prameha, and Kustha.

Ashtanga Hridaya (600 CE)

- Vagbhata systematized Churna Kalpana. Gave particle size rules: "Tanubhasma nibham churnam" - powder should be like fine ash.
- Polyherbal concept strengthened: herbs with similar Rasa-Virya-Vipaka but different Prabhava mixed for synergistic action **3. Medieval Period (600 – 1800 CE)**

Sharangadhara Samhita (1300 CE)

• First text to give a dedicated chapter: Churna Kalpana Adhyaya, Madhyama Khanda

Rules defined:

1. Powder each drug separately.
2. Sieve through 80 mesh equivalent cloth.
3. Mix in specified order - volatile drugs last.
4. Shelf life: Churna jiryati samvatsarat - expires after 1 year, later revised to 2 years**.**

• Polyherbal examples: Triphala Churna, Trikatu Churna, Avipattikar Churna.

Bhaishajya Ratnavali (1800 CE)

- Golden period for polyherbal churnas. ~700 formulations listed.
- Specific Madhumehahara churnas appear: Nyagrodhadi Churna, Nishamalaki Churna.

4. Modern Period (1900 CE – Present)

- 1900-1940s: British Pharmacopoeia influenced standardization. Ayurvedic Pharmacopeia Committee started documenting Churna tests.
- 1964: Drugs & Cosmetics Act brought Churnas under legal purview. Schedule T set GMP for ASU drugs.
- 1976: Ayurvedic Formulary of India Part-I published. First government document standardizing 444 polyherbal formulations including 15+ antidiabetic churnas.
- 2008: Ayurvedic Pharmacopoeia of India gave official quality standards: Loss on Drying, Ash values, extractives, microbial limits for all Churnas. [18]

Advantages of Polyherbal Churna

- Enhanced therapeutic activity due to synergistic effect
- Natural and herbal formulation
- Economical and easy to prepare
- Better patient compliance
- Easy storage and transportation
- Rapid absorption in the body

LITERATURE REVIEW

1. Pooja S Solanki et.al (2017) Diabetes Mellitus (DM) is a chronic metabolic disorder that prevents the body to utilize glucose completely or partially. DM is a fast-growing global problem with huge social, health and economic consequences. The control of blood glucose level is essential for effective management of diabetes. There are many synthetic drugs that are being used as standard treatment for diabetes but they have adverse effects and therefore, there is a need to search for alternative natural therapy against diabetes with lesser side effects. A large number of herbal plants are in vogue for the treatment of types 2 DM. The herbal plants which have antidiabetic properties namely Jamun seed (Syzygium cumini), Fenugreek

seed **(**Trigonella foenum) and Turmeric (Curcuma longa) are used in the present study.

2. Mahesh Gawade1 et.al (2023) Diabetes is a silent killer that causes significant economic damage in underdeveloped nations like India. To reduce the strain on a person's health and economy as well as the burden on society as a whole, better therapies must be developed with fewer side effects. The study's primary objective was to create an Evaluation of the polyherbal powder for diabetic mellitus based on organoleptic, rheological, physical, and phytochemical traits. The herbs used to make the polyherbal powder were annona squamosal, Trigonella foenum-graecum, Murraya koenigii, Aegle marmelos Correa, Mentha spicata Standardized methods were used to conduct the evaluations.

3. Gurgude Harshada Nanasaheb et.al (2024) The aim of this investigation was to assess the antidiabetic properties of Anti-Diabetic Churna using the streptozotocininduced diabetes model, as well as its alpha amylase and alpha glucosidase inhibitory activities. One of particularly prevalent metabolic diseases, diabetes mellitus affecting 2.8% of people worldwide and is projected to reach 5.4% by 2025. Herbal remedies have long been regarded as an extremely valuable form of medicine; as a result, they are increasingly featured in cutting-edge, contemporary care.

4. Mohini.G. B et.al (2024) Syzygium cumini, also called Jamun, or black plum, is an excellent source of bioactive components such as flavonoids, polyphenols, antioxidants, iron, and vitamin C. Bael, Aegle marmelos (Linn.) a tree is originated from India known from ancient time. It has a most mythological importance for Hindus. Utilization of bael in everyday life has very nutritional, environmental as well as precious importance. It has been in use to relieving constipation, diarrhea, dysentery, ulceration and respiratory infections from the ancient time as a medicinal Importance.

HISTORY OF DIABETES:

1. Ancient period (1550 BC - 5th century) ● 1550 BC - Egypt:

The first mention of diabetes is in the Papyrus Ebers, which describes a disease in which a person urinates in large quantities.

- India (5th-6th century BC):

The Indian doctors Sushruta and Charaka called this disease "Madhumeha", which means sweet hunger.

- They noted that:

The ants were attracted to the urine because it contained sugar.

The disease appears in two forms: one observed in young people (similar to type 1) and the other more common in overweight adults (similar to type 2).

2. Greek and Roman era (1st-4th century AD) ● 1st century AD:

The Greek doctor Aretaeus of Cappadocia was the first to use the term "diabetes", which means passing, in reference to the excessive urination seen in patients. He described diabetes as a disease in which the body wears out, saying that "flesh and limbs melt in hunger."

3. Middle Ages (5th-15th centuries)

At that time, progress in the understanding of diabetes was minimal. Doctors identified the disease by tasting the patient's urine: if it was sweet, they diagnosed it as "honey urine". 4. Renaissance in the 18th century ● 1675:

The English physician Thomas Willis added the word "Mellitus" (Latin for sweet honey) after confirming the sweet taste of diabetic urine.

- 1776:

Matthew Dobson discovered that the sweet taste came from sugar in the urine and blood, giving scientists a clearer idea of the disorder.

- 1869:

Paul Langerhans identified special groups of cells in the pancreas, later called the islets of Langerhans.

- 1889:

Minkowski and von Mering discovered that removing the pancreas in dogs causes diabetes. This proves that diabetes is closely related to pancreatic function.

5. The discovery of insulin (early 20 century) ● 1921:

An important breakthrough occurred when Frederick Banting, Charles Best, J.J.R. Macleod and James Collip successfully discovered insulin.

- 1922:

The first injection of insulin was given to Leonard Thompson, a boy, saving his life. This discovery transformed diabetes from a deadly disease to a controllable disease.

- 1923:

Banting and Macleod received the Nobel Prize for this revolutionary discovery.

6. Treatment progress (1950-2000) ● 1955:

Metformin, an important oral antidiabetic drug, was introduced.

Over the years, some major advances have followed:

- Introduction of glucometers in the 1970s
- The use of the HbA1c test in the 1980s
- Development of fast and long insulin

7. Modern Era (2000-present)

Today, the treatment of diabetes has become much more advanced. Modern management includes:

- Continuous glucose monitoring (CGM) systems.
- Artificial pancreas technologies
- New drugs such as GLP-1 agonists and SGLT-2 inhibitors
- Improved insulin formulations
- Ongoing research into stem cell therapy and islet transplantation offers hope for future cures. [19,20]

DIABETES

Diabetes mellitus is a long-term metabolic condition in which blood sugar levels remain consistently elevated due to problems with insulin production, its function, or both.

Types of Diabetes [21]

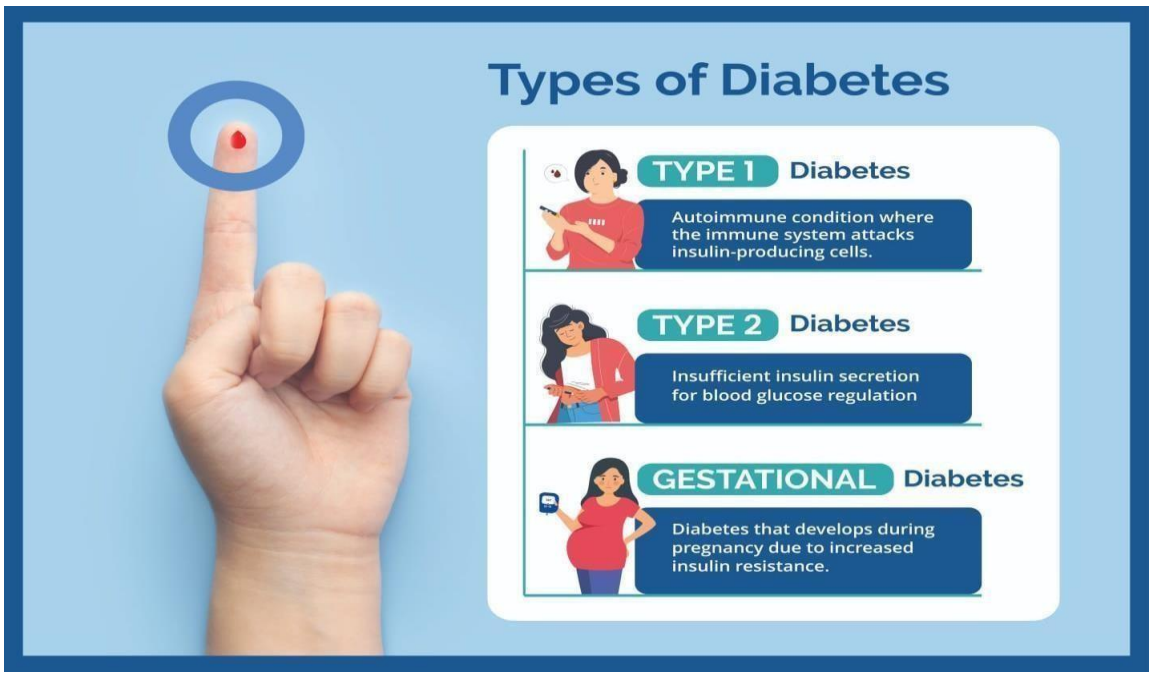

Fig No.1 (Types of Diabetes)

Causes	Symptoms
Lack of Insulin	Frequent urination
Insulin resistance	Excessive thirst
Unhealthy diet	Increased hunger
Obesity	Fatigue
Lack of exercise	Blurred vision
Genetic [22]	Slow healing of wounds [23]

Pathogenesis of Diabetes: [24]

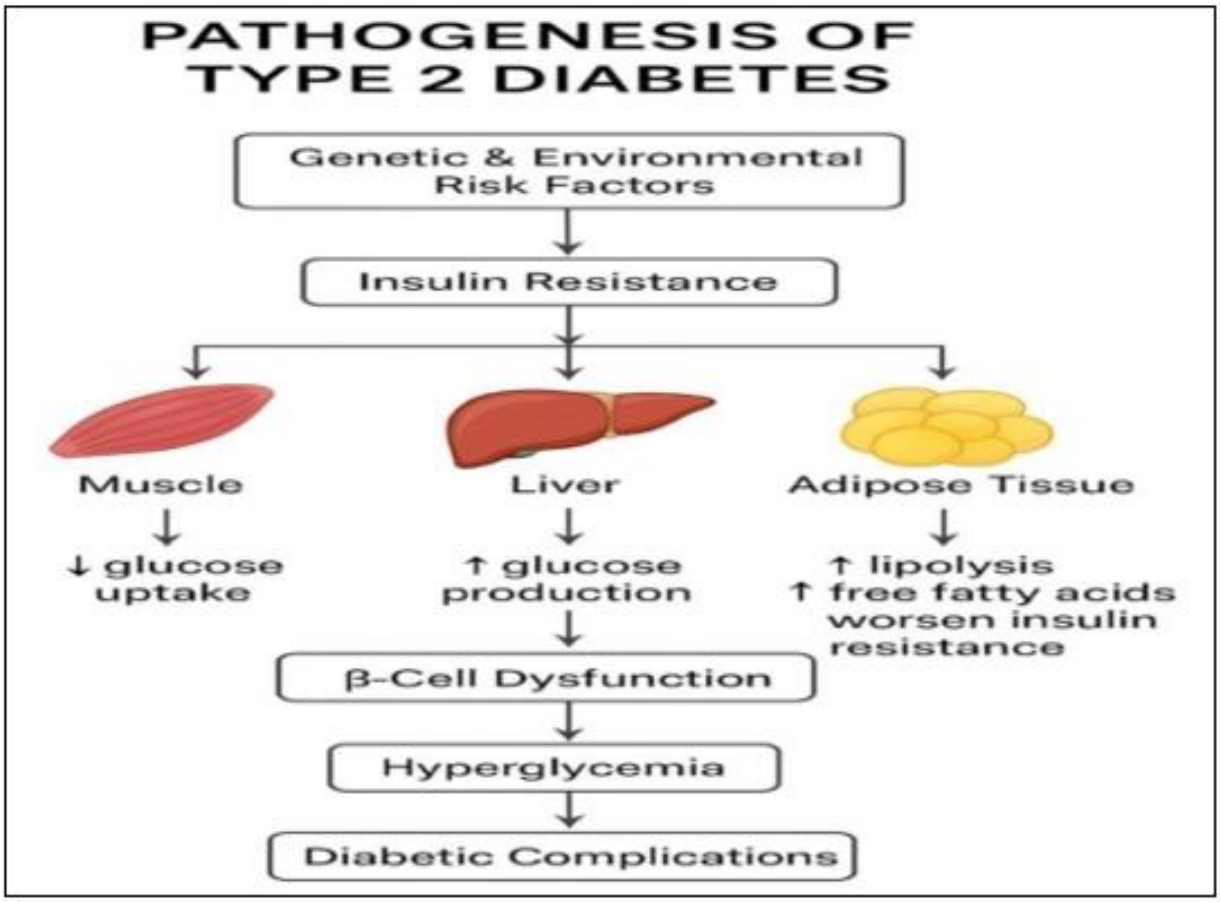

Fig No. 2 (Pathogenesis of Diabetes)

Mechanism of Action of Diabetes: [25]

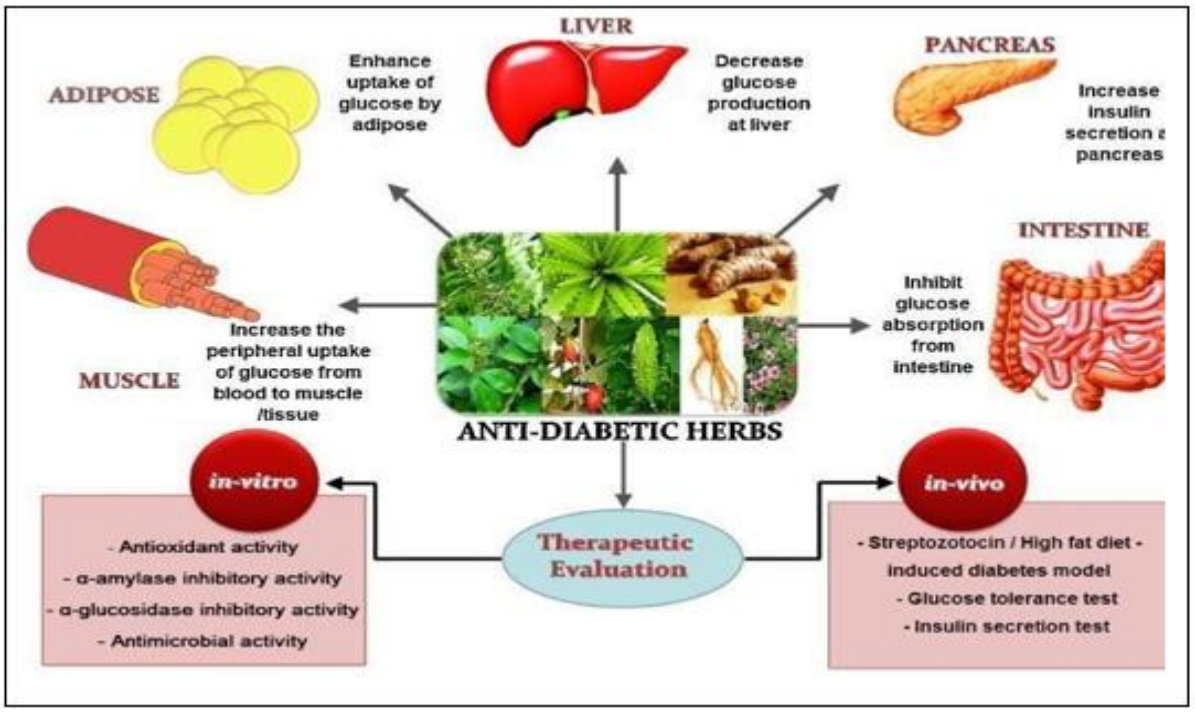

Fig No.3 (Mechanism of Action of Diabetes)

PLANT PROFILE:

1] Moringa leaves

Fig No.4 (Moringa leaves)

Synonyms-Drumstick Tree, Miracle Tree.

Scientific Name-Moringa Oleifera

Family-Moringaceae

Chemical Constituent –

Chlorogenic acid, Quercetin, Kaempferol, Iuteolin, And Apigenin, Caffeic acid, Ferulic acids, Moringin & other related phenolic compounds.

Uses -

- Reducing fasting blood glucose and post-meal sugar levels.
- Improvement insulin secretion and sensitivity.
- Minimizing glucose absorption in the intestine.
- Providing natural antioxidants that protect pancreatic β-cells.
- Lowering oxidative stress, which is linked to diabetic complications.
- Nourishing the hair and skin.
- Improve eye health. [26]

Moringa leaf powder is made from dried leaves of Moringa oleifera and is highly nutritious. It is rich in vitamins, minerals, and antioxidants that support overall health. It helps in controlling blood sugar levels and improving metabolism. It also boosts immunity and aids digestion. It can be easily consumed by mixing with water, milk, or food [27].

2] Jamun seeds

Fig No.5 (Jamun Seeds)

Synonyms- Black Plum, Jamun, Java Plum, Indian Blackberry, Malabar Plum And Damson Plum.

Scientific Name- Syzygium Cumini

Family- Myrtaceae

Chemical Constituents-

Jamun mainly contains Polyphenols, Flavonoids, Anthocyanins, Gallic acids, Tannins, Phenols, Alkaloids, Glycosides, Isoquercetin, Kaempferol.

Use-

- Antioxidant and anti-inflammatory.
- Helps control frequent urination in diabetes.
- Supporting Regulate blood glucose levels.
- Improvement insulin activity and sensitivity.
- Lowering postprandial blood sugar spikes.
- Having antioxidant properties that protect pancreatic cell.
- Enhancement glycogen storage in liver and muscle.

Jamun seed, obtained from the fruit of Syzygium cumini, is widely used in traditional medicine. It is rich in alkaloids, flavonoids, and tannins that help regulate blood sugar levels. The seed powder is commonly used in managing Diabetes mellitus by improving insulin activity. It also has antioxidant and antimicrobial properties that support overall health. Additionally, it aids digestion and may help in reducing frequent urination associated with diabetes. [28]

3] Bitter gourd

Fig No.6 (Bitter Gourd)

Synonyms-Karli, Karela, Bitter Melon, Balsam Pear, Bitter Apple, Karavella

Scientific Name-Momordica Charantia

Family-Cucurbitaceae

Chemical Constituents-

The plant contains Charantin, Polypeptide-p, Alkaloids, Momordicine I and II, Hypoglycemic glycosides such as Charantin, Momordicosides, Triterpenoids including Momordic acid, Quercetin, Saponins, Sterols, ß-Sitosterol and Stigmasterol.

Uses -

- Reducing the demand for synthetic insulin by mimicking insulin-like activity.
- boosting cell absorption and metabolism of Glucose.
- Improves glucose uptake by tissues.
- Helps to treat digestive problems.

- Supports weight management.
- Lower the blood sugar.

Bitter gourd, scientifically known as Momordica charantia, is a medicinal vegetable widely used for its health benefits. It contains active compounds like charantin and polypeptide-p that help lower blood sugar levels. It is commonly used in the management of Diabetes mellitus by improving glucose utilization. Bitter gourd also has antioxidant and anti-inflammatory properties that support overall health. Additionally, it aids digestion and helps in detoxifying the body. [29]

4] Cardamom

Fig No.7 (Cardamom)

Synonyms- Cardamom Seeds, Cardamom Fruits, Cardamon.

Scientific Name- Elettaria Cardamomum

Family- Zingiberaceae

Geographical Source-

It occurs wild in Sri Lanka and also in Myanmar and Malaysia. In India it is cultivated scientifically in Karnataka, Tamil Nadu, Kerala, Malabar hills and Guatemala.

Chemical Constituents -

1,8-Cineole, Flavonoids, Phenolic acid, Terpenoids, α-terpineol, Borneol and tannins.

Uses -

- Improves digestion and metabolic health.
- Helps control blood pressure.
- Acts as an antioxidant and detoxifier.
- Support pancreatic function.
- Helps reduce inflammation.
- Reduce bloating and acidity in diabetic patients.

Cardamom, scientifically known as Elettaria cardamomum, is a popular aromatic spice used in food and medicine. It contains essential oils and antioxidants that help protect the body from damage. Cardamom supports digestion by relieving bloating, gas, and indigestion. It may help regulate blood pressure and improve heart health. Additionally, it has antimicrobial properties and freshens breath naturally. [30]

5] Ginger

Fig No.8 (Dry Ginger)

Synonyms-Adarak, Ginger, Zingiber, Zingiberis, Sunthi.

Scientific Name-Zingiber Officinale

Family-Zingiberaceae

Chemical Constituents-

Proteins, Volatile oil, Gingerols, Shogaols, Terpenes, Organic acids, Carbohydrates, Lipids, αZingiberene,

β-bisabolene, α-farnesene, β-sesquiphellandrene, α-Curcumene, Minerals and Vitamins.

Uses -

- Enhances insulin sensitivity.
- Improves digestion and reduces bloating.
- Helps to reduce fasting blood sugar.
- Good for cholesterol management.
- Protect against cell damage caused by high sugar level.
- Helps to reduce chronic inflammation.

Ginger, scientifically known as Zingiber officinale, is a widely used medicinal spice. It contains active compounds like gingerol that have strong antioxidant and anti-inflammatory properties. Ginger helps in digestion by reducing nausea, bloating, and indigestion. It may also help regulate blood sugar levels and support immunity. Additionally, it is commonly used to relieve cold, cough, and sore throat symptoms. [31]

6)] Beal

Fig No.9 (Beal Leaves)

Synonyms-Bael Fruits, Bel, Indian Bael, Bengal Quince

Scientific Name-Aegle Marmelos

Family-Rutaceae

Chemical Constituents-

Marmelosin, Carbohydrates, Proteins, Volatile oil, Vitamin, alkaloids and Tannins.

Uses -

- Reduce Blood Sugar Levels.
- Improves Pancreatic B-Cell Function.
- Anti-Inflammatory and Antimicrobial.
- Helps in Constipation and digestive disorders.
- Protect body cells from damage caused by high sugar levels.
- Support gut health and metabolism.
- Important for diabetic heart protection. [32]

Bael, scientifically known as Aegle marmelos, is a medicinal plant widely used in traditional medicine. Its fruit and leaves contain tannins, flavonoids, and alkaloids with therapeutic properties. Bael is especially useful for digestive disorders like diarrhea, dysentery, and constipation. It also shows potential in managing Diabetes mellitus by helping regulate blood sugar levels. Additionally, it has antimicrobial and anti-inflammatory effects that support overall health. [33]

7] Black pepper

Fig No.10 (Black pepper) Synonyms-Pepper, Piper Nigrum, Maricha

Scientific Name-Piper Nigrum

Family-Piperaceae

Chemical Constituents -

It contains an alkaloid piperine, volatile oil, pungent resin, piperidine and starch.

Uses-

- Boosts metabolism.
- Rich in antioxidants.
- Improves nutrient absorption.
- Enhance absorption of other herbs.
- Improves digestion and reduces indigestion.
- Helps to regulate blood sugar levels.
- Support weight management.

Black pepper, scientifically known as Piper nigrum, is a commonly used spice with medicinal properties. It contains piperine, an active compound that enhances nutrient absorption and metabolism. Black pepper aids digestion by stimulating digestive enzymes and reducing bloating. It also has antioxidant and anti-inflammatory effects that support overall health. Additionally, it may help in managing Diabetes mellitus by improving insulin sensitivity. [34]

METHODOLOGY

Method of Preparation of Antidiabetic Churna (Procedure)

- **Collection**

Crude herbal drugs are collected from reliable and authentic sources.

- **Cleaning**

The collected materials are cleaned properly to remove dust, dirt, and foreign particles.

• Drying

The cleaned drugs are dried (preferably in shade) to remove moisture and preserve active constituents.

- **Weighing**

Each ingredient is accurately weighed according to the required formulation.

- **Powdering**

The dried drugs are powdered separately using a grinder or pulverizer.

• Sieving

The powdered materials are passed through a suitable sieve (e.g., sieve no. 60) to obtain a fine and uniform powder.

• Mixing

All the sieved powders are mixed thoroughly to ensure uniform distribution of ingredients.

• Packaging

The prepared churn is packed in airtight containers to protect it from moisture and contamination.

• Labeling

The labeling procedure for antidiabetic churn involves checking and confirming details such as product name, ingredients, dosage, batch number, manufacturing and expiry dates, storage guidelines, and warnings, followed by printing and attaching the label to the container and conducting a final inspection for correctness and compliance. [35,36]

BATCH WIES FORMULATION TABLE OF ANTIDIABETIC POLYHERBAL CHURNA

Sr. No	Ingredients	Batch A (100 gm)	Batch B (100 gm)	Batch C (100 gm)	Uses
1	Moringa Leaves	20	10	15	Immunoboost
2	Jamun seeds	25	35	30	Antidiabetic

3	Bitter gourd	25	30	30	Antidiabetic
4	Cardamom	5	5	5	Digestive stimulant
5	Ginger	10	8	8	Improve insulin sensitivity
6	Beal	10	10	10	Mild laxative
7	Black pepper	5	2	2	Enhance bioavailability

Table No.1 (Batch Wise Formulation)

FORMULATION TABLE

Sr. No	Ingredients	Scientific Name	Quantity
1	Moringa Leaves	Moringa Oleifera	15 gm
2	Jamun seeds	Syzygium Cumini	30 gm
3	Bitter gourd	Momordica Charantia	30 gm
4	Cardamom	Elettaria Cardamomum	5 gm
5	Ginger	Zingiber Officinale	8 gm
6	Beal	Aegle Marmelos	10 gm
7	Black pepper	Piper Nigrum	2 gm

Table No.2 (Formulation Table)

ADVANTAGES

1) Multitargeted action -

Herbs work through multiple mechanisms, such as increasing insulin secretion and improving insulin sensitivity.

2) Reduced adverse effects-

Smaller doses of each plant are often required in polyherbal combinations, which helps reduce toxicity and side effects.

3) Synergistic effect-

The combined action of different herbs can enhance overall therapeutic effectiveness.

4) Organ-protective and antioxidant properties-

Many herbs protect the kidneys, liver and pancreas from oxidative stress caused by diabetes.

5) Reasonably priced and readily available-

Especially in India, most herbs like Jamun, Cardamom, Bael, Bitter gourd, Ginger, Moringa and Black pepper are easily available and affordable.

6) Suitable for long term use-

When formulated properly, polyherbal churn can be used for extended periods with relatively low toxicity.

7) Adaptable-

Different combinations can be prepared based on patient needs (e.g., more bitter herbs for high glucose, more digestive herbs for obesity. [37]

DISADVANTAGES

1) Lack of standardization-

Each batch may vary in potency due to differences in plant quality, harvesting time, and processing methods.

2) Delayed onset of action-

Compared to allopathic antidiabetic drugs, herbal formulations usually act more slowly.

3) Potential drug-herb interactions-

They may interact with prescription medicines (such as hypoglycemic drugs), increasing the risk of low blood sugar.

4) Dosage challenges-

The exact amount of active phytochemicals is often unknown. Incorrect measurement may lead to overdose or under dose.

5) Poor palatability-

Many antidiabetic herbs have a bitter taste, making regular consumption difficult.

6) Insufficient scientific evidence-

Although individual herbs have supporting research, complete clinical trials on polyherbal churns are still limited.

7) Storage issue-

Herbal powders can absorb moisture easily, increasing the risk of microbial growth or loss of potency if not stored. [38,39]

EVALUATION PARAMETER

Angle of Repose –

The static angle of repose was measured according to the fixed funnel and free-standing cone method. A funnel was clamped with its tip 2 cm above a graph paper placed on a flat horizontal surface. The powders were carefully poured through the funnel. Block the orifice of the funnel by thumb, Fill the powder in the funnel and remove the thumb immediately. Measure the height of the pile and diameter.

$\theta = \tan^{-1}(h/r)$ Where, θ= angle of repose h- height of the powder in cm, r-the radius of a heap of powder. [40]

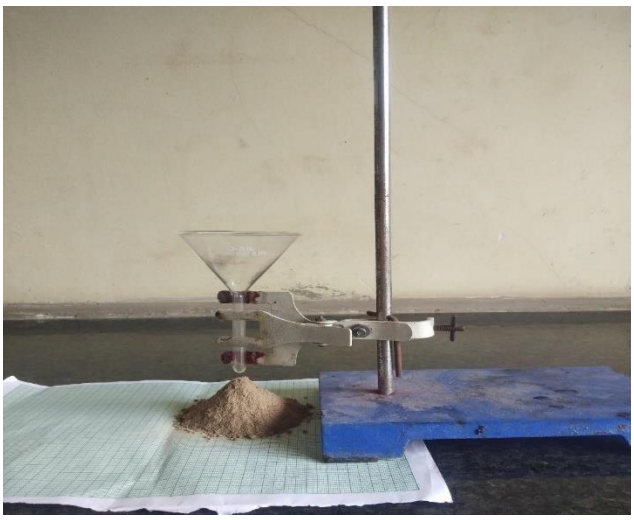

Fig No.11 (Angle of Repose)

Bulk Density-

Take a clean and dry measuring cylinder. Weigh accurately 20 gm of powder. Place it in a dried graduated measuring cylinder and note the volume as ml.

Bulk density = weight of powder / Volume of powder

sample to a solvent, mix until no more dissolves, then filter and measure the dissolved amount.

Fig No.14 (Solubility Test)

Carr's index

Carr's index is a measure used to evaluate the compressibility and flow properties of a powder. It is calculated using bulk density and tapped density. In general, powders that are less deformable tend to flow more easily. This index reflects the extent of particle interactions within the powder. In free-flowing powders, particle interactions are minimal, so the difference between bulk and tapped densities is small. In contrast, poorly flowing powders have more particle contacts, leading to a greater difference between these densities.

Compressibility index = [(ρtap - ρb) / ρtap] / ×100

Where,

ρb = Bulk Density ρtap=Tapped Density

Hausner's ratio

The Hausner's ratio is a proximate indicator of particle movement simplicity. The method used to determine it is as follows.

Hausner's Ratio=Tapped density (PT) / Bulk density (B)

Where,

PT = tapped density

B = bulk density. [41]

PHYSIOCHEMICAL EVALUATION

Physicochemical evaluation involves analyzing basic properties of a sample such as pH, moisture content, and ash values. These parameters help assess the purity, quality, and stability of the material. Standard laboratory methods are used to obtain reliable and reproducible results.

PH

Calibrate the pH meter using standard buffer solutions, immerse the electrode in the sample solution, allow the reading to stabilize, and record the pH value and Ph of sample was found to be 6.5 (slightly acidic). [42]

Determination of moisture content

Moisture content was determined by the loss on drying method. A clean, dry weighing dish was first weighed, and a known quantity of the sample was added and reweighed. The sample was then placed in a hot air oven maintained at a specified temperature and dried for a fixed period. After drying, the dish was removed, cooled in a desiccator to avoid moisture uptake, and weighed again. This drying and weighing process was repeated until a constant weight was obtained. The reduction in weight was used to calculate the percentage of moisture present in the sample. [43]

W2-W1

Determination of ash value

Ash values are used to assess the quality and purity of a crude drug. About 3 g of air-dried powdered drug was accurately weighed and placed in a pre-weighed silica crucible. The sample was then incinerated by gradually increasing the temperature until it became dull red hot and completely free from carbon. After cooling, it was weighed, and the process was repeated until a constant weight was obtained. Finally, the total ash percentage was calculated with reference to the air-dried sample. [44]

Total Ash value = Weight of total ash / Weight of crude drug taken × 100

Determination of water-soluble ash

Total ash of the sample was first prepared and weighed. The ash was then boiled with a measured quantity of distilled water, and the insoluble portion was collected on an ash less filter paper. This residue was washed, dried, and ignited to a constant weight. The weight of the insoluble matter was subtracted from the total ash to obtain the water-soluble ash value. The percentage of water-soluble ash was calculated. [45]

W2-W1

Determination of acid insoluble ash

Total ash obtained from the sample was boiled with dilute hydrochloric acid. The insoluble portion was collected on an ash less filter paper, thoroughly

washed with hot water, and then dried and ignited to a constant weight. The remaining residue represents the acid-insoluble ash, which is calculated as a percentage of the original sample.

Acid insoluble ash value = Weight of acid insoluble ash/Weight of crude drug taken × 100

Determination of loss on drying

Loss on drying was determined by weighing a known amount of the sample in a clean, dry dish and drying it in a hot air oven at a specified temperature. After a set period, the sample was cooled in a desiccator and reweighed. Drying and weighing were repeated until a constant weight was obtained, and the decrease in mass was calculated as the moisture content. [46]

LOD = loss in weight in sample / Weight of the sample X 100

Evaluation of antioxidant activity

Hydrogen peroxide is used as a free radical to assess the antioxidant potential of natural compounds. The reduction in colour of the test sample indicates its ability to donate hydrogen atoms. Hydrogen peroxide, a stable radical that is soluble in methanol, forms a violet solution, which turns yellow when it reacts with an antioxidant. In this method, 2 g of the immune booster sample (0–5 mg/mL in methanol) was mixed with 2 mL of hydrogen peroxide solution (0.4 mM in methanol). The mixture was vortexed properly and kept in the dark at room temperature for 30 minutes. After incubation, the absorbance was measured at 230nm using a spectrophotometer. Gallic acid and Ascorbic acid were used as standard reference compounds. [47]

ORGANOLEPTIC PROPERTIES

Sr. No	Parameter	Observation		
		F1	F2	F3
1)	Appearance	Fine Powder	Fine Powder	Fine Powder
2)	Colour	Brownish Green	Brownish Green	Brownish Green
3)	Taste	Bitter	Bitter	Bitter
4)	Odour	Characteristics	Characteristics	Characteristics

Table No.3 (Organoleptic Properties)

PHYSICAL PARAMETER AND PHYSIOCHEMICAL EVALUATION

Sr. No	Parameter	Observation		
		F1	**F2**	**F3**
1	PH	5.2 (more acidic)	4.8 (highly acidic)	6.5 (slightly acidic)
P2	Ash value	10.5 % w/w	12.8 % w/w	7.8 % w/w
3	Loss on drying	9.5 % w/w	12.0% w/w	5.0 % w/w
4	Acid insoluble ash	3.8 % w/w	4.5 % w/w	1.3 % w/w
5	Water soluble ash	2.0 % w/w	1.5 % w/w	3.2 % w/w

6	Bulk density	0.32 g	0.28 g	0.40 g
7	Tapped density	0.50 g	0.48 g	0.47 g
8	Angle of repose	45 degree	50 degree	34.7 degree
9	Carr's index	36 % w/w (poor flow)	41.6 % w/w (very poor flow)	14.89 % w/w (good flow)
10	Hausner's ratio	1.56 (very poor flow)	1.71 (very poor flow)	1.175 (good flow)

Table No.4 (Physical Parameter and Physiochemical Evaluations)

Phytochemical Tests

Keller-Killiani test for glycosides

In the Keller–Killiani test, 1 g of powdered drug is extracted with 10 mL of 70% alcohol for about 2 minutes and then filtered. To the filtrate, 10 mL of water and 0.5 mL of a strong lead acetate solution are added, followed by filtration. The resulting filtrate is shaken with 5 mL of chloroform, and the chloroform layer is separated into a porcelain dish. The solvent is gently evaporated, and the remaining residue is cooled and dissolved in 3 mL of glacial acetic acid containing 2 drops of 5% ferric chloride solution. This solution is then carefully layered over 2 mL of concentrated sulphuric acid. The formation of a reddish-brown ring at the interface and a bluish-green color in the upper layer, which darkens over time, indicates a positive result. [48]

Mayer's test for alkaloids

Add 1 mL of Mayer's reagent to 1 mL of the extract. The formation of a whitish-yellow or cream-colored precipitate indicates the presence of alkaloids. [49]

Foam test for saponins

A small amount of both alcoholic and aqueous extracts is taken separately, then 20 ml of distilled water is added and the mixture is shaken lengthwise in a graduated cylinder for 15 minutes. The formation of a 1 cm thick foam layer indicates the presence of saponins. [50] **Molisch's test for carbohydrates**

Take 2 ml of the extract and add 1 ml of α-naphthol solution. Carefully pour concentrated sulphuric acid along the side of the test tube. The appearance of a purple or reddish-violet ring at the interface of the two layers confirms the presence of carbohydrates. [51]

Salkowski test for terpenoids

Approximately 5 mL of the extract is mixed with 2 mL of chloroform, and then about 3 mL of concentrated sulphuric acid (H_2SO_4) is carefully added to form a separate layer. The formation of a reddish-brown color at the interface confirms the presence of terpenoids. [52]

Ellagic phenolic assay

Four drops of 5% (w/v) glacial acetic acid and four drops of 5% sodium nitrite ($NaNO_2$) solution were added to 2 mL of the immune booster sample and shaken for about five minutes. The appearance of a muddy brown precipitate indicates the presence of phenolic compounds. For the flavonoid test, 2 mL of the sample was treated with around five drops of 10% ferric chloride solution. A green-blue color change confirms the presence of phenolic hydroxyl groups. [53]

Test for flavonoids

1 mL of the stock solution was placed in a test tube, and a few drops of dilute sodium hydroxide solution were added. This produced an intense yellow coloration. Upon adding a few drops of dilute acid, the solution became colourless, indicating the presence of flavonoids. [54]

RESULT

The prepared antidiabetic polyherbal churn was found to be a fine, brownish-green powder with a characteristic odour and bitter-pungent taste. The physicochemical parameters such as loss on drying, total ash, acid-insoluble ash, and extractive values were within acceptable limits, indicating good purity and stability of the formulation. The flow properties (bulk density, tapped density, Carr's index, Hausner's ratio, and angle of repose) showed good flowability, making the powder suitable for handling and packaging. Phytochemical screening confirmed the presence of important constituents like alkaloids, flavonoids, glycosides, tannins, phenolics, saponins, and terpenoids, which are responsible for its antidiabetic potential. The formulation also complied with microbial standards, ensuring safety. Overall, the results indicate that the developed polyherbal churn possesses satisfactory pharmaceutical quality and promising therapeutic activity.

CONCLUSION

The antidiabetic polyherbal churn formulated with jamun seed, bitter gourd, moringa leaves, bael patra, ginger, cardamom, and black pepper was prepared successfully following standard methods. The formulation exhibited satisfactory organoleptic characteristics, including a brownish-green color, typical odour, bitter and pungent taste, and a fine powder texture, suggesting good acceptability. The physicochemical parameters such as loss on drying, ash values, extractive values, and pH were within acceptable limits, indicating the formulation's quality, purity, and stability. The evaluation of flow properties, including bulk density, tapped density, Carr's index, Hausner's ratio, and angle of repose, confirmed that the powder possesses good flow behavior, making it suitable for processing and packaging. Phytochemical analysis revealed the presence of key bioactive compounds like alkaloids, flavonoids, glycosides, tannins, phenolic compounds, saponins, and terpenoids, which are associated with antidiabetic and antioxidant effects. Additionally, the formulation met the required microbial standards, ensuring its safety for use.

In conclusion, the prepared polyherbal churn showed satisfactory pharmaceutical characteristics, stability, and promising therapeutic potential. Therefore, it can be regarded as a safe, cost-effective, and beneficial herbal formulation for diabetes management, in line with traditional practices. However, further in vivo and clinical investigations are necessary to establish its efficacy and safety more conclusively

REFERENCES

1. Joshi PV, Patil RH, Maheshwari VL. In vitro antidiarrheals activity and toxicity profile of Aegle marmelos Correa ex Roxb. dried fruit pulp. Natural product radiance. 2009;8(5):498-502.
2. Ribeiro C, De AlencarMota CS, Voltarelli FA, de Araújo MB, Botezelli JD, et al. Effects of Moderate Intensity Physical Training in Neonatal Alloxan Administered Rats. J Diabetes Metab. 2010; 1:107.
3. Da Silva SB, Costa JP, Pintado ME, Ferreira DC, Sarmento B. Antioxidants in the Prevention and Treatment of Diabetic Retinopathy A Review. J Diabetes Metab. 2010; 1:111.

4. Aparna K, Vijaya K. Hypoglycemic, Hypocholesterolemic and Hypertensive effect of Syzygium cumini newly diagnosed type 2 Diabetic Subject. Indian J Nutr. Dies. 2009; 46:320-228.
5. Unnikrishnan R Anjana, R.M, & Mohan, v (2016) Diabetic mellitus and its complications in India. Nature Reviews Endocrinology, 12(6), 357-370.
6. Tomy, S. (2016). Antidiabetic effect of Polyherbal formulation "Kathakakhadiradi Kashyam" in Streptozotocin induced Diabetic rats. Journal of Young Pharmacists, 8(4), 496.
7. Dwivedi, C., & Daspaul, S. (2013). Antidiabetic herbal drugs and polyherbal formulation used for diabetes: A review. J Phytopharmacol, 2(3), 44-51.
8. Patel, P., Patel, D., & Patel, N. (2012). Experimental investigation of antirehumatoide activity of pleurotus sajorcaju in adjuvant-induced arthritic rats. Chinese Journal of Natural Medicines, 10(4), 269-274.
9. P. D. P. N. Patel P. (2012). "Experimental investigation of antirheumatoid activity of Pleurotus sajor-caju in adjuvant induced arthritic rats," Chinese Journal of Natural Medicines, vol. 1, no. 3, pp. 50-60.
10. Thillaivanan, S., & Samraj, K. (2014). Challenges, constraints and opportunities in herbal medicines-a review. International journal of Herbal medicine, 2(1), 21-24.
11. Wu, B. Y., Liu, C. T., Su, Y. L., Chen, S. Y., Chen, Y. H., & Tsai, M. Y. (2019). A review of complementary therapies with medicinal plants for chemotherapy-induced peripheral neuropathy. Complementary therapies in medicine, 42, 226-232.
12. Kashyapa, Kashypa Samhita, Commentary by Pandit Hemraj Sharma (1953), Chaukhambha Sanskrit Series, Varanasi.
13. Vagbhatt, Astang Sangraha with Commentary by Rao Pandit P. V. and Pandey Ayodhya (1991). CCRAS.
14. Sharma RK, Dash B. Charaka Samhita. Vol. 1. Varanasi: Chowkhamba Sanskrit Series Office; 2014.
15. Zhou X, Seto SW, Chang D, Kiat H, RazmovskiNaumovski VR, Chan K, Bensoussan A. Synergistic effects of Chinese herbal medicine: A comprehensive review of methodology and current research. Front Pharmacol. 2016; 7:201. doi: 10.3389/fphar.2016.00201, PMID27462269.
16. Anonymous, (1976), The Ayurvedic Formulary of India, Part-I, 1st Edi., Govt. of India, Ministry of Health and Family Planning, 85, 95, 241.
17. Government of India, Ministry of Health and Family Welfare. The Ayurvedic Pharmacopoeia of India. Part I, Vol IX. 1st ed. New Delhi: Government of India; 2016. General methods for Churna; p. 163-165.
18. Sharma PV. Charaka Samhita. Vol 1. Varanasi: Chaukhambha Orientalia; 2014. Sutrasthana, Chapter 4: Shadvirechana-shatashritiya adhyaya; p. 48-52.
19. American Diabetes Association (ADA). (2021). Standards of Medical Care in Diabetes. Diabetes Care, 44(Suppl 1)
20. Papadakis, M. A., & McPhee, S. J. (Eds.). (2021). Current Medical Diagnosis & Treatment. McGraw-Hill Education.
21. Saeedi, P., Petersohn, I., Salpea, P., Malanda, B., Karuranga, S., Unwin, N., ... & IDF Diabetes Atlas Committee. (2019). Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas, 9th edition. Diabetes Research and Clinical Practice, 157, 107843. https://doi.org/10.1016/j.diabres.2019.107843.
22. Jameson JL, Fauci AS, Kasper DL, et al. Harrison's Principles of Internal Medicine. 21st Edition. McGraw-Hill; Chapter: Diabetes Mellitus.
23. American Diabetes Association (ADA). "Standards of Medical Care in Diabetes— 2024." Diabetes Care. 2024.**
24. Kumar V, Abbas AK, Aster JC. Robbins and Cotran Pathologic Basis of Disease. 10th ed. Philadelphia: Elsevier; 2020.
25. Kooti W, Farokhipour M, Asadzadeh Z, et al. "The role of medicinal plants in the treatment of diabetes: A review." Journal of Evidence-Based Complementary & Alternative Medicine. 2016;21(4):1–17. (Covers hepatic glucose reduction, insulin secretion enhancement, glucose uptake mechanisms.)
26. Fahey JW. Moringa oleifera: A review of the medical evidence for its nutritional, therapeutic,

and prophylactic properties. Part 1. Trees Life J. 2005;1(5):1–15.
27. Leone A, Spada A, Battezzati A, Schiraldi A, Aristil J, Bertoli S. Moringa oleifera seeds and oil: Characteristics and uses for human health. Int J Mol Sci. 2016;17(12):2141.
28. Ayyanar M, Subash-Babu P. Syzygium cumini (L.) Skeels: A review of its phytochemical constituents and traditional uses. Asian Pac J Trop Biomed. 2012;2(3):240–246
29. Ayurvedic Pharmacopoeia of India (API), Part-I, Volume V Karavellaka (Momordica charantia) Fruit & Seed Pages 43–45.
30. Ashokkumar, K. et al., "Botany, traditional uses, phytochemistry … cardamom", Journal of Ethnopharmacology, 2019.
31. Ayurvedic Pharmacopoeia of India (API), Part I — Monographs: Shunthi (dried rhizome) / Ardraka (fresh rhizome). (API Vols; see monograph pages).
32. Ayurvedic Pharmacopoeia of India (API), Part I — Bilva (fruit pulp) / Aegle marmelos monograph. (See API monograph pages for Bilva / fruit pulp).
33. Dahiya D.P., Kumari R., Sankhyan A., Sharma A., Thakur S., "Aegle marmelos — review of phytochemical profile and pharmacological application", Plants Journal (2025).
34. Ayurvedic Pharmacopoeia of India (API), Part I — Monograph: Piper nigrum (Black pepper).
35. Khandelwal KR. Practical Pharmacognosy: Techniques and Experiments. 23rd ed. Pune: Nirali Prakashan; 2015.
36. Kokate CK, Purohit AP, Gokhale SB. Pharmacognosy. 55th ed. Pune: Nirali Prakashan; 2019.
37. Patwardhan, B.; Vaidya, A.D.B.; Chorghade, M. 2004. "Ayurveda and Natural Products Drug Discovery. "Current Science, 86(6): 789–799.
38. Ekor, M. 2014. "The Growing Use of Herbal Medicines: Issues Relating to Adverse Reactions and Challenges in Monitoring Safety. "Frontiers in Pharmacology, 4: 177.
39. Bent, S. 2008. "Herbal Medicine in the United States: Review of Efficacy, Safety, and Regulation. "The Journal of General Internal Medicine, 23(6): 854–859.
40. Sinko PJ. Martin's Physical Pharmacy and Pharmaceutical Sciences. 7th ed. Philadelphia: Lippincott Williams & Wilkins; 2017.
41. Aulton ME, Taylor KMG. Aulton's Pharmaceutics: The Design and Manufacture of Medicines. 5th ed. London: Elsevier; 2018.
42. Indian Pharmacopoeia Commission. Indian Pharmacopoeia 2022. Vol 1. 9th ed. Ghaziabad: Indian Pharmacopoeia Commission; 2022. pH; p. 110.
43. Indian Pharmacopoeia Commission. Indian Pharmacopoeia 2022. Vol 1. 9th ed. Ghaziabad: Indian Pharmacopoeia Commission; 2022.determination of moisture content; p. 173.
44. Khandelwal KR. Practical Pharmacognosy: Techniques and Experiments. 30th ed. Pune: Nirali Prakashan; 2022. Determination of ash values; p. 25-26.
45. Ayurvedic Pharmacopoeia of India. Part I. Vol VI. 1st ed. New Delhi: Ministry of AYUSH, Government of India; 2008. p. 284, Appendix 2.2.5 Determination of Water-Soluble Ash.
46. Indian Pharmacopoeia Commission. Indian Pharmacopoeia 2022. Vol 1. Ghaziabad: Indian Pharmacopoeia Commission; 2022. p. 153-154, 2.3.19 Acid-Insoluble Ash and loss on drying.
47. Ruch RJ, Cheng SJ, Klaunig JE. Prevention of cytotoxicity and inhibition of intercellular communication by antioxidant catechins isolated from Chinese green tea. Carcinogenesis. 1989;10(6):1003-8.
48. Kokate CK, Purohit AP, Gokhale SB. Pharmacognosy. 54th ed. Pune: Nirali Prakashan; 2023. p. 6.18, Chemical Tests: Keller-Killiani test for glycosides.
49. Evans WC. Trease and Evans Pharmacognosy. 16th ed. London: Saunders Elsevier;2009. p. 137, Chemical Tests for Alkaloids: Mayer's reagent.
50. Khandelwal KR. Practical pharmacognosy: Techniques and experiments. 26th ed. Pune: Nirali Prakashan; 2016. p. 25.5, Preliminary Phytochemical Screening: Foam test for saponins.
51. Harborne JB. Phytochemical methods: A guide to modern techniques of plant analysis. 3rd ed. London: Chapman and Hall; 1998. p. 48-49, Detection of Carbohydrates.

52. Evans WC. Trease and Evans Pharmacognosy. 16th ed. London: Saunders Elsevier; 2009. p. 285, Tests for Terpenoids: Salkowski test.
53. World Health Organization. Quality control methods for herbal materials. Geneva: WHO; 2011 [cited 2026 May 5]. p. 46, 4.4.6 Test for Phenolic Compounds.
54. Khandelwal KR. Practical pharmacognosy: Techniques and experiments. 26th ed. Pune: Nirali Prakashan; 2016. p. 25.7, Preliminary Phytochemical Screening: Alkaline reagent test for flavonoids.

HOW TO CITE: Kranti Akolkar*, Bansode Laxmi, Hemant Gangurde, Formulation And Evaluation Of Antidiabetic Polyherbal Churna, Int. J. Sci. R. Tech., 2026, 3 (9), 120-141. https://doi.org/10.5281/zenodo.22304293