



Review Article

Review On: Synergistic Herbal Blend for Effective Blood Glucose Regulation (Antidiabetic Herbal Churna)

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Diabetes mellitus is a long-term metabolic disorder marked by increased blood glucose levels and oxidative stress. A polyherbal formulation provides a holistic way to control blood sugar by using multiple synergistic actions, such as slowing carbohydrate absorption, enhancing insulin sensitivity, improving peripheral glucose utilization, offering antioxidant support, and protecting pancreatic β -cell function. This study focuses on a polyherbal powder (Churna) prepared for this purpose, made from seven Ayurvedic ingredients: • Moringa oleifera (Moringa leaves) • Syzygium cumini (Jamun seeds) • Momordica charantia (Bitter gourd) • Elettaria cardamomum (Cardamom) • Zingiber officinale (Dry ginger) • Aegle marmelos (Bael leaves) • Piper nigrum (Black pepper) The results indicate that this herbal blend has potential hypoglycaemic (blood sugarlowering) activity, supporting its traditional use in Ayurveda. For preparation, all raw ingredients were shade-dried, ground into a fine powder, passed through a sieve, and then mixed thoroughly in predetermined ratios. The final Churna was evaluated through various quality control tests, including organoleptic examination, flow properties, particle size analysis, moisture content, ash values, and extractive values.

Keywords: Diabetes mellitus, Churna, Blood glucose, Moringa, Hypoglycaemic.

INTRODUCTION

Current status of diabetes in India

India is often called the "diabetes capital of the world" because of the high number of patients with diabetes. According to the ICMR-INDIAB study, India has more than 100 million adults with diabetes (2023 data). More than 130 million people have prediabetes, which means they are at high risk of developing diabetes. Cases are increasing rapidly in urban and rural populations. [1] Diabetes mellitus is one of the most significant global health challenges, and its prevalence continues to rise in both developed and developing nations. In comparison with synthetic antidiabetic drugs -which often lead to side effects such as hypoglycaemia, weight gain, and cardiovascular complications-herbal medicines have gained renewed interest due to their safety, lower cost,

and holistic mode of action. Ayurvedic literature, including the Charaka Samhita and Bhava Prakash Nighantu, describes numerous plants with Madhumehahara (antidiabetic) properties. Ayurveda also strongly supports the use of polyherbal formulations because they act on multiple targets, show synergistic effects, and present minimal toxicity. The present churna combines bioactive compounds such as alkaloids, flavonoids, tannins, saponins, and bitter constituents like charantin. Together, these phytochemicals help regulate blood glucose through mechanisms such as insulin-mimicking activity, stimulation of pancreatic β -cell, and reduction of glucose absorption. With diabetes rates increasing worldwide, interest in effective and safe plant -based therapies has grown considerably. Each plant used in this formulation is known to possess hypoglycemic (blood glucose-lowering) activity. [2] Medicinal plants have been used for

thousands of years across different cultures to treat a wide range of diseases. It is now well recognized that many plant-derived compounds have therapeutic value or serve as lead molecules for the development of new drugs. Natural sources continue to play a major role in pharmaceutical research, contributing to more than half of modern medicines. Herbal remedies remain an integral part of traditional healthcare systems, and many indigenous communities rely on them for managing various illnesses. Some of these formulations have been evaluated using pharmacopeial standards, although many traditional preparations still require detailed scientific exploration. This review highlights natural agents capable of preventing or managing diabetes through insulin-secretagogue or insulin-mimetic pathways. It further emphasizes the importance of traditional medicinal plants and herbal therapies in diabetes management and their strong potential for developing new, effective antidiabetic drugs. [3] Medicinal plants, which serve as accessible natural resources, can help regulate blood sugar by inhibiting carbohydrates, these herbs delay glucose absorption and reduce the sharp rise in postmeal blood sugar levels. Many traditional medicinal plants exhibit strong α -amylase inhibitory activity. Their therapeutic effects are largely attributed to secondary metabolites such as flavonoids, phenols, alkaloids, saponins, and terpenoids-which play important physiological roles in the human body. Diabetes mellitus is a long-term disorder that affects how the body regulates and utilizes glucose, leading to persistent high blood sugar levels. With the increasing number of people facing this condition worldwide, the demand for safer and more natural treatment options is growing. [4] Herbal churnas, made from finely powdered medicinal plants, offer a traditional yet scientifically relevant approach to diabetes management. These formulations combine multiple herbs that work together to support healthy glucose metabolism, improve digestion, balance energy levels, and protect the body from metabolic stress. Because they are plant based, easy to prepare, and generally well-tolerated, herbal churna have become a promising complementary option for individuals seeking natural support along with conventional diabetic care. This introduction highlights the significance of using herbal churna as a holistic approach for maintaining

blood sugar levels and promoting overall metabolic wellness. [5]

How are herbs used?

Herbs are usually used in their whole form instead of isolated chemical compounds. Since healthy plants contain many natural components, they can work together to provide therapeutic benefits while minimizing the risk of side effects. Herbalists often combine several herbs to improve their overall effectiveness, promote synergistic activity and reduce potential toxicity. When choosing and prescribing herbal medicines, herbalists consider many important factors, such as the specific species and variety of the plant, the environment in which it was grown, the methods used for storage and processing, and the possibility of contamination. Some herbs have even been taken off the market, like kava, for safety reasons.

What is antidiabetic churn?

Antidiabetic churn 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 churn is commonly used as a supportive therapy for managing diabetes mellitus. [6]

Synergistic effect

The interaction of two or more drugs to produce a combined effect is an efficiency greater than the sum of their individual abilities. The effect of the drug is called synergistic effect. In Pharmaceutical science, synergistic properties of drugs are divided into two categories, namely pharmacodynamics and pharmacokinetic synergy. Pharmacodynamic synergy illustrates two or more drugs that interact in the same way receptors and produce higher therapeutic effects through their positive interactions. In addition, the pharmacokinetics synergistic expression of the interaction of two or more drugs leads to better absorption, distribution, metabolism and drug

elimination that causes an increase in concentration of drugs in the body and increases their therapeutic properties. It has been reported that complex synergistic effects produced by mixing medicinal plants in complex polyherbal formulations increase the bioavailability of the active ingredients, promote therapeutic effects and reduce toxicity. [10-12] Therefore combinations of two or more herbs that retain antidiabetic properties present synergistic antidiabetic potential. [7,8,9]

Polyherbal formulation

The Polyherbal formulation is defined as a formulation that includes two or more herbs. Individual medicinal plants contain sufficient antioxidant substances such as phenolic compounds and flavonoids that are responsible for the treatment of diabetes. The Polyherbal formulation controls diabetes better than the individual drug due to the synergistic and minimal side effect. [10]

Churn

The powder of a drug or a combination of two or more drugs, powdered separately before being uniformly combined, is called churna. Churna is defined as a

finely ground medicine or combination of medicines in the Indian Ayurvedic diet. The term 'churna' means 'Pesascurnikaranam', according to Sabda Kalpa Drum. Churna, as defined by the Indian Ayurvedic formulary, is the substance that is obtained by the process of Pesana (trituration or pounding) and is defined as a fine powder of medicament or drugs. [11] A single medicine or a combination of two or more drugs that are powdered separately before being homogeneously blended might be referred to as churna. Sharangadhara defines Churna as a finely ground dry medication that is filtered through a cloth. The synonyms for Churna that have been explained are Rajaha and Ksoda. One Karsa Pramana is the recommended dosage for administration. The material that is ground into a fine powder is referred to as churna by Acharya Kashayapa. This churna is utilized for Anjana, Amavikara, Vrana, and Grahani roga, among other purposes. [12] Acharya Kashayapa states that churna is the term for the material that is ground into a fine powder. This churna is utilized for Anjana, Amavikara, Vrana, and Grahani roga, among other things. Churna is a dry powder that has been sifted through a fine cloth. [13]

Vernacular names [14]

Table No.1 (Vernacular names of churna)

English	Powder
Sanskrit	Suska Kalka, Suska Pista, Ksoda, Raja
Hindi	Churna
Kannada	Pudi, Hittu, Churna
Latin	Pulver, Pulverata
Unani	Safaf, Atus, Avadhilana

Classification of churn

• According to components

1. Simple
2. Compound

• According to size:

Sthula - Coarse powder- for Hima, Phanta, Kasaya, Sieved through NO.20 sieves.

Suksma - Fine powder for Vati, Leha, Nasya, Sieved through No.60 sieves.

Atyanta Suksma (Vastra Galita) - Bhasmas, Anjannas, sieved through No.100 sieve (very fine powder).

• According to structure:

1. Crystalline
2. Amorphous

• According to composition

1. Herbal powder
2. Herbo- mineral
3. Mineralo- metallic powder

- **According to karma**

1. Deepana
2. Virechana

HISTORY

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).

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:

- Development of fast and long insulin

- Introduction of glucometers in the 1970s
- The use of the HbA1c test in the 1980s
- The advent of insulin pumps in the 1990s

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. [15,16]

Causes

- Genetics and Family history
- Increasing age
- Physical inactivity
- Obesity
- Unhealthy

Symptoms

- Increased thirst
- Frequent urination
- Increased hunger
- Fatigue
- Slow healing of wounds [17,18]

Types of Diabetes [19]

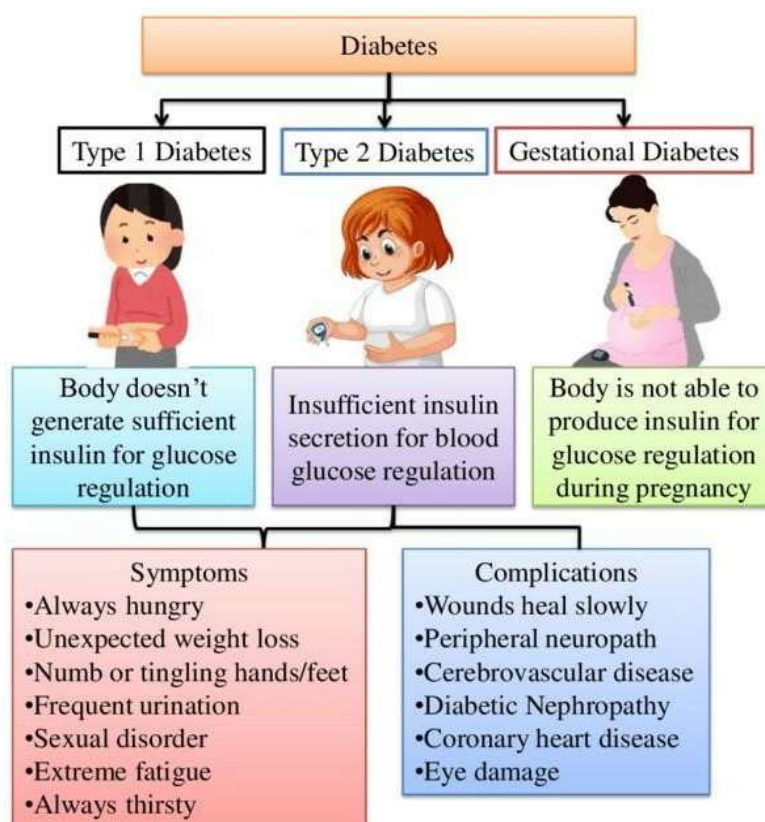


Fig No.1 (Types of diabetes)

OBJECTIVES

- 1) To investigate the different biological processes that plants carry out.
- 2) To determine the general phytochemical profile of the plant.
- 3) To find out whether the plant extract is harmless or cytotoxic.

- 4) To determine and characterize the active ingredients in these plant extracts.
- 5) The polyherbal formulation's effect on blood glucose levels was examined. [20,21]

The Biological Active Herbal Extract Use in The Formulation Are: -

1) Moringa Leaves



Fig No.2 (Moringa leaves)

Scientific Name-Moringa Oleifera

Synonyms-Drumstick Tree, Miracle Tree.

Family-Moringaceae

Geographical Source

Moringa oleifera was introduced from India to Africa, Southeast Africa, and the Philippines in ancient times.

Chemical Constituents

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

Uses

Used in diabetes mellitus.

Nourishing the hair and skin.

Improve eye health.

Provides vitamins & minerals. [22,23]

2) Jamun Seed



Fig No.3 (Jamun seeds)

Scientific Name- Syzygium Cumini

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

Family- Myrtaceae

Geographical Source

It is originally found across the Indian subcontinent, including the Andaman Islands, Bangladesh, Nepal, the Eastern Himalaya region, Pakistan, Assam, the Lakshadweep Islands and Sri Lanka.

Chemical Constituents

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

Uses

Improves insulin secretion.

Antioxidant and anti-inflammatory.

Helps control frequent urination in diabetes.

Slow down the conversion of starch into sugar. [24,25]

3) Bitter Gourd

Fig No.4 (Bitter gourd)

Scientific Name-Momordica Charantia

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

Family-Cucurbitaceae

Geographical Source

It is found throughout India, Africa and Southeast Asia.

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, β -Sitosterol and Stigmasterol.

Uses

Improves glucose uptake by tissues.

Helps to treat digestive problems.

Supports weight management.

Lower the blood sugar. [26,27]

4) Cardamom

Fig No.5 (Cardamom)

Scientific Name- Elettaria Cardamomum

Synonyms- Cardamom Seeds, Cardamom Fruits, Cardamon, Small Cardamom.

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. [28,29]

5) Ginger



Fig No.6 (Dry ginger)

Scientific Name- Zingiber Officinale

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

Family- Zingiberaceae [30]

Geographical Source

It is said to be native to South East Asia, but is cultivated in Caribbean islands, Africa, Australia, Mauritius, Jamaica, Taiwan and India.

Chemical Constituents

Proteins, Volatile oil, Gingerols, Shogaols, Terpenes, Organic acids, Carbohydrates, Lipids, α - Zingiberene, β -bisabolene, α -farnesene, β -sesquiphellandrene, α -Curcumene, Minerals and Vitamins. [31]

Uses

Enhances insulin sensitivity.
Improves digestion and reduces bloating. Helps to reduce fasting blood sugar.
Good for cholesterol management.

6) Bael



Fig No.7 (Bael leaves)

Scientific Name-Aegle Marmelos

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

Family-Rutaceae

Geographical Source

It is indigenous to India and found in Myanmar and Sri Lanka. [32]

Chemical Constituents

Marmelosin, Carbohydrates, Proteins, Volatile oil, Vitamins (Vit-A and Vit-C), Alkaloids and Tannins.

Uses

Reduce Blood Sugar Levels.
Improves Pancreatic B-Cell Function.
Anti-Inflammatory And Antimicrobial.
Helps In Constipation and digestive disorders. [33]

7) Black Pepper



Fig No.8 (Black pepper)

Scientific Name-Piper Nigrum

Synonyms-Pepper, Piper Nigrum, Maricha.

Family-Piperaceae

Geographical Source

It is indigenous and cultivated in South India. It is also cultivated in Indonesia, Brazil, Malaysia and Sri Lanka. [34]

Chemical Constituents

It contains an alkaloid piperine, volatile oil, pungent resin, piperidine and starch. [35]

Uses

Enhance absorption of other herbs.
Improves digestion and reduces indigestion.
Helps to regulate blood sugar levels.
Support weight management.

METHODOLOGY (PROCEDURE)

Choose antidiabetic herbs such as *Moringa oleifera*, *Syzygium cumini*, *Momordica charantia*, *Elettaria cardamomum*, *Zingiber officinale*, *Aegle marmelos*, *Piper nigrum* etc. Remove dust, impurities, damaged parts from all raw herbs. Shade-dry all herbs for 5–7 days until moisture is removed completely [36,37]. Grind each dried herb separately using a pulverizer to obtain a fine powder. Pass each powder through #80 sieve to ensure uniform particle size. Mix all powders in required proportions in a clean stainless-steel blender. Pack the final churna in airtight, moisture-free containers. Label with name, ingredients, dose, date of preparation, batch number. [38,39]

Evaluation Parameters

A) Organoleptic Evaluation [40]

Organoleptic evaluation refers to sensory assessment using sight, smell, taste, sound, and touch. It helps in quality control of herbal churna before further physicochemical and pharmacological analysis.

Organoleptic Properties of Herbal Churna

1. Colour

Observe visually under natural daylight. Should match the typical colour of the powdered ingredients.

2. Odour

Smell the churna directly and then after gentle rubbing between the fingers. Identify characteristics: aromatic, pungent, pleasant, strong, weak, characteristic.

3. Taste

A small quantity is placed on the tongue. Tastes may be sweet, pungent, bitter, astringent, sour, salty, or mixed.

4. Texture

Assess by rubbing a pinch between the fingers. Should be fine, smooth, coarse, gritty or fibrous depending upon formulation.

5. Appearance

Evaluate visually for: Uniformity, Presence of visible particles, Foreign matter etc.

6. Particle Size

Checked by rubbing between fingers or passing through a standard sieve.

B) Physicochemical Evaluation

1) Determination of loss on drying (moisture content)

Loss on drying is the loss in weight in% w/w determined by means of the procedure given below. It determines the amounts of volatile matter of any kind (including water) that can be driven off under the condition specified (Dessicator or hot air oven). If the sample is in the form of large crystals, and then reduce the size by quickly crushing to a powder. About 1.5 gm. The powdered drug was weighed accurately in a tared porcelain dish which was previously dried at 105 °C in a hot air oven to constant weight and then weighed. From the difference in weight, the percentage loss of drying with reference to the air dried substance was calculated.

$$\% \text{ of Loss on drying} = \frac{\text{Loss in weight in sample}}{\text{Weight of the Sample}} \times 100$$

2) Determination of total Ash value

Ash values are helpful in determining the quality and purity of crude drug, accurately weighing about 3 gm of air-dried powdered drug was taken in a tared silica

crucible and incinerated by gradually increasing the temperature to make it dull red hot until free from carbon. Cooled and weighed, repeated for constant value. Then the percentage of total ash was calculated with reference to the air-dried drug.

$$\text{Total Ash value} = \frac{\text{Weight of total ash}}{\text{Weight of crude drug taken}} \times 100$$

3) Determination of acid insoluble ash value

The ash obtained as directed under total ash was boiled with 25 ml of 2N HCl for 5 minutes. The

insoluble matter was collected on an ash-less filter paper, washed with hot water, ignited and weighed, then calculated the percentage of acid insoluble ash with reference to the air dried drug.

$$\text{Acid insoluble ash value} = \frac{\text{Weight of acid insoluble ash} \times 10}{\text{Weight of crude drug taken}}$$

4) Determination of water-soluble ash value

The total ash obtained was boiled with 25 ml. Of water for 5 minutes. The insoluble matter was collected on an ash-less filter paper, washed with hot water and ignited for 15 minutes at a temperature not

exceeding 450 C. The weight of insoluble matter was subtracted from the weight of total ash. The difference in weight represents the water-soluble ash. The percentage of water-soluble ash was calculated with reference to the air dried drug.

$$\text{Water soluble ash value} = \frac{\text{Weight of acid soluble ash} \times 100}{\text{Weight of crude drug taken}}$$

5) Determination of PH

20 g or the powder will be dissolved in 100 ml of distilled or deionized water and be sure that all the powder is dissolved in the water, then measure the pH using any pH meter. [41,42,43]

I. Water Soluble Extractive Value

5gms of churna was accurately weighed and placed inside a glass stoppered conical flask. It is then macerated with 100ml of chloroform water for 18hours. It was then filtered and about 25ml of filtrate was transferred into a China dish and was evaporated to dryness in a water bath. It was then dried to 105°C for 6hours, cooled and finally weighed.

6) Determination of extractive values [44,45]

$$\text{Water soluble extractive value} = \frac{\text{Weight of dried extract} \times 100}{\text{Weight of sample}}$$

II. Alcohol Soluble Extractive Values

5gms of churna was accurately weighed and placed inside a glass stoppered conical flask. It is then macerated with 100ml of ethanol for 18-hours. It was

then filtered and about 25ml of filtrate was transferred into a China dish and was evaporated to dryness in a water bath. It was then dried to 105°C for 6hours, cooled and finally weighed

$$\text{Alcohol soluble extractive value} = \frac{\text{Weight of dried alcoholic extract} \times 100}{\text{Weight of sample}}$$

7) Determination of microbial content

1gm of churna was dissolved in lactose broth and volume adjusted to 100ml with the same medium. About 10ml of sample was transferred into 100ml of Macconkey broth and incubated for 18-24 hours at 43-45° C. A subculture was prepared on a plate with Macconkey agar and incubated at 43-45° C for 18-24 hours. The growth of red, generally nonmucoid colonies of gram-negative rods appearing as reddish zones indicates the presence of E. coli if not then it indicates the absence of E. coli. [46,47]

C) Flow properties**1) True density**

Take a clean and dry density bottle. Accurately measure volume of density bottle using solvent upto the mark. Transfer accurately 10 grams of powder to density bottle. Fill density bottle that contains powder with known amount of any solvent in which powder is insoluble. Note the volume of the solvent. Repeat the procedure thrice and take the average of all to obtain correct data. Calculate the true density of the powder sample.

True density = mass / true volume

2) Bulk density

Take a clean and dry measuring cylinder. Weight accurately 5 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

3) Tapped density

Take a clean and dry measuring cylinder. Weight accurately 2 gm of powder. Place it in a dried graduated measuring cylinder and note the volume as V 1 ml. Place the measuring cylinder in the tap density tester. Adjust apparatus and operate it for 100 taps. Record the volume occupied by the powder as V2 ml.

Tapped density = weight of powder / minimum volume occupied by powder

4) 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 2cm 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. After emptying the powder from the funnel, 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. [48]

5) Carr's index (The Compressibility index)

(Carr's index) is a metric for a powder's tendency to be compacted. It can be calculated using the mass and pierced densities. Theoretically, a substance is more flowable the less deformable it is. It serves as a gauge for the relative significance of particle interactions. Such interactions are typically less important in a free-flowing powder, and the values of the bulk and tapped

densities will be closer. There are commonly more particle contacts in poorly moving materials, which results in a larger discrepancy between the bulk and tapped densities.

$$\text{Compressibility index} = [(p_{\text{tap}} - \rho_b) / p_{\text{tap}}] \times 100$$

Where,

ρ_b = Bulk Density, p_{tap} = Tapped Density. [49]

6) 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. [50]

D) Qualitative chemical test

Alkaloids, carbohydrates, cardiac glycosides, polyphenols, saponins, tannins, and terpenoids were all identified using qualitative chemical assays.

1) Test for alkaloids

- **Dragendorff test:** - To 1 ml of extract, add 1 ml of dragendorff reagent. An orange ppt indicates the presence of alkaloids.
- **Mayer's test:** - To 1 ml of extract, add 1 ml of Mayer's reagent. Whitish yellow or cream colored ppt indicates the presence of alkaloids.
- **Hager's test:** - To 1 ml of extract, add 3 ml of Hager's reagent. Yellow colored ppt indicates presence of alkaloids.
- **Wagner's test:** - To 1 ml of extract, add 2 ml of Wagner's reagent. Formation of reddish brown ppt indicates the presence of alkaloids.

2) Test for saponin

Take a small quantity of alcoholic and aqueous extract separately and add 20 ml of distilled water and shake

in a graduated cylinder for 15 minutes lengthwise. A 1cm layer of foam indicates the presence of saponins

3) Test for glycosides

- **Legal test:** Dissolve the extract in pyridine and add sodium nitroprusside solution to make it alkaline. The formation of pink red to red colour shows the presence of glycosides.
- **Baljet test:** To 1ml of the test extract, add 1ml of sodium picrate solution and the yellow to orange colour reveals the presence of glycosides.
- **Keller-Killiani test:** 1gm of powdered drug is extracted with 10ml of 70% alcohol for 2 minutes, filtered, add to the filtrate, 10ml of water and 0.5ml of strong solution of lead acetate and filtered and the filtrate is shaken with 5ml of chloroform. The chloroform layer is separated in a porcelain dish and removes the solvent by gentle evaporation. Dissolve the cooled residue in 3ml of glacial acetic acid containing 2 drops of 5% ferric chloride solution. Carefully transfer this solution to the surface of 2ml of concentrated sulphuric acid. A reddish-brown layer forms at the junction of the two liquids and the upper layer slowly becomes bluish green, darkening with standing.
- **Borntrager's test:** Add a few ml of dilute Sulphuric acid to 1ml of the extract solution. Boil, filter and extract the filtrate with chloroform. The chloroform layer was treated with 1ml of ammonia. The formation of red colour of the ammoniacal layer shows the presence of anthraquinone glycosides

4) Test for carbohydrates and sugars

- **Molisch's test:** To 2ml of the extract, add 1ml of o-naphthol solution, add concentrated sulphuric acid through the side of the test tube. Purple or reddish violet colour at the junction of the two liquids reveal the presence of carbohydrates.
- **Fehling's test:** To 1ml of the extract, add equal quantities of Fehling solution A and B, upon heating formation of a brick red precipitate indicates the presence of sugars.

- **Benedict's test:** To 5ml of Benedict's reagent, add 1ml of extract solution and boil for 2 minutes and cool. Formation of red precipitate shows the presence of sugars.

5) Test for tannins and phenolic compounds

Take the little quantity of test solution and mixed with basic lead acetate solution. Formation of white precipitates indicates the presence of tannins. To 1ml of the extract, add ferric chloride solution, formation of a dark blue or greenish black colour product shows the presence of tannins.

6) Tests for terpenoids

About 5ml of the extract was treated with 2ml of chloroform and about 3ml concentrated H₂SO₄ was carefully added to form A layer. A reddish-brown coloration of the interface indicates the presence of terpenoids. [51,52,53]

7) Test for Steroid (Salkowski test)

The crude extract (about 100 mg) was separately shaken with chloroform (2 mL) followed by the addition of concentrated H₂SO₄ (2 mL) along the side of the test tube; a reddish-brown coloration of the interface indicates the presence of steroid. [54]

8) Test for flavonoids

The stock solution (1 mL) was taken in a test tube and added a few drops of dilute NaOH solution. An intense yellow colour appeared in the test tube. It became colourless when in addition to a few drops of dilute acid that indicated the presence of flavonoids. [55]

CONCLUSION

Antidiabetic herbal churns offer a natural, economical, and multi-targeted approach for managing diabetes mellitus. The combined action of several medicinal plants enhances insulin activity, improves glucose metabolism, and reduces oxidative stress, making these formulations useful as supportive therapy. Although traditional evidence strongly supports their benefits, scientific validation through standardized preparation, quality control, and clinical studies is still required to ensure safety and efficacy.

With proper research and standardization, antidiabetic herbal churns can become valuable adjuncts in diabetes management.

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Cite: Snehal Gondkar*, Suvarna Sangale, Vaishnavi Dhage, Prerana Jamdhade, Tanvir Pathan, Gursal Kanchan, Review On: Synergistic Herbal Blend for Effective Blood Glucose Regulation (Antidiabetic Herbal Churna), *Int. J. Med. Pharm. Sci.*, 2026, 2 (2), 241-256. <https://doi.org/10.5281/zenodo.18810951>