ORIGINAL ARTICLE

Preparation and Standardization of some herbal Antidiabetic drugs in Polyherbal Formulation

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Abstract

Background: The increasing prevalence of diabetes has heightened interest in alternative medicinal approaches, particularly those derived from herbal sources. This study focuses on synthesizing, standardizing, and evaluating a polyherbal formulation with potential antidiabetic activity. **Objective:** This study aims to develop and standardize a polyherbal antidiabetic formulation by integrating plant extracts with known antidiabetic properties and evaluating its therapeutic potential through in vitro studies. **Methods:** A combination of plant extracts was selected based on their traditional applications and pharmacological relevance in diabetes management. The bioactive compounds were extracted using suitable solvents and formulated into a standardized polyherbal product. Quality control assessments were conducted to ensure consistency and reliability, including organoleptic characteristics, extractive values, and phytochemical profiling. Standardization parameters such as total phenolic content, flavonoid content, and the presence of key bioactive components were evaluated. The glucose-lowering potential of the formulation was assessed through in vitro studies, including alpha-glucosidase inhibition assays and insulin resistance assessments. **Results:** Physicochemical properties, including extractive values in different solvents, moisture content, bulk and tapped density, Carr's index, Hausner's ratio, pH, and ash content, were analyzed to ensure formulation quality. The results indicate that these parameters are crucial in standardizing herbal antidiabetic medicines and can serve as reliable quality markers. **Conclusion:** This study establishes a standardized approach to developing herbal antidiabetic formulations. The findings contribute to quality control and assurance standards, providing a foundation for further clinical investigations and the development of safe and effective herbal therapies for diabetes management.

Key words: Antidiabetic drugs, blood glucose regulation, herbal standardization, phytochemical screening, polyherbal formulation

INTRODUCTION

In today's world, the global market encompasses all types of goods and services to people. Health has always been a top priority for humanity throughout history. The market for health-related items is thriving, with products being made in various regions and distributed globally. It is essential to standardize these products to ensure consistency and uniformity across different regions. Standardization is crucial in ensuring that every product is consistently potent and contains guaranteed ingredients. The WHO works with health ministries to help them set up ways to include plant medicines in healthcare programs by evaluating their safety and effectiveness, ensuring enough supplies are available, and monitoring the quality of raw and processed materials used. In terms of herbal formulations, standardization can be done by preparing the medicine using materials from various regions and comparing the chemical effectiveness of

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different batches of the formulation. The selection process involves choosing a preparation with efficacy. All batches need to undergo checks of their characteristics and chemical and pharmacological properties to ensure the quality of the final product and validate the entire manufacturing process.[1]

Diabetes is of grave concern in India primarily because of poor eating habits. Most of the antidiabetic drugs, hypolipidemic included, prescribed in orthodox therapies for diabetes mellitus and hyperlipidemia, respectively, are said to have contraindications and adverse effects associated with chronic use. Thus, the necessity to look for other effective medications that are more efficient and safer in managing these conditions arises. Therefore, it is evident, based on untapped pharmacy research conducted worldwide, that the biosphere is full of unexplored drug targets or leads for drug development.

On such grounds, the present experiment was initiated with an intention to establish some of the herbal antidiabetic medications in their physical and chemical properties and evaluate them against available products in the market and those developed in-house. This study elaborates on the standardization of herbal antidiabetic formulations by the physico-chemical, physical, and organoleptic properties Table 2.[2]

The role of herbal medicine as a treatment for diabetes

The use of herbal medicine as a supportive measure in diabetes management is becoming commonplace since it may enhance insulin sensitivity, regulation of blood glucose levels, and general metabolic health. Several plants have been studied for their antidiabetic potential,[3] including:

Azadirachta indica: Popularly referred to as the neem tree: The hypoglycemic effect of neem leaves is well acquainted which lowers blood sugar levels and may help in the sensitization of insulin. They possess bioactive constituents with free radical scavenging activities which enhance the efficiency of the entire metabolic system.

Momordica charantia: It is also known as bitter gourd or karela, a veggie rich in charantia and polypeptide-p compounds which are thought to mimic insulin and aid in the reduction of blood glucose levels. Karela lowers blood glucose spikes and improves glucose tolerance when taken over a period.

Ocimum tenuiflorum: Popularly called Tulsi or holy basil, is famous for its power of adaptation. It advocates the activity of the pancreas and helps control the level of sugar in the blood; hence, improves the production and sensitivity of insulin.

Zingiber officinale: Research has proven that this rhizome is insulin-sensitizing and has a hypoglycemic effect. Inflammation and oxygen destruction can be harmful in the diabetic state, and these properties may, therefore, offer some protection from diabetic complications.

Sesbania grandiflora: This lesser-known herb is effective in lowering blood sugar levels. This herb has been used as a medicine for a long time in many cultures, and recent studies show that it may help manage diabetes.

Mangifera indica: Mango tree leaves are rich in flavonoids and tannins, which may help regulate blood sugar levels. They are also used in traditional medicine because to their effect on blood sugar levels and insulin action.

Psidium guajava: Guava leaves have been found to contain a few compounds that can help in the management of blood sugar levels. They are also part of the therapy management regimens for diabetes Mellitus since the leaves are believed to aid in digestion and in the control of high blood glucose levels.

Rationale for polyherbal formulation

The escalating occurrence of diabetes, particularly type 2 diabetes, poses a significant threat to public health globally. After all, many people are turning to complementary alternative medicine that modifies or assists standard therapies because traditional medicines are often associated with side effects and might not be able to control blood glucose to the required levels.[4]

Polyherbal formulations, which use several plants in one preparation, offer many benefits over treatment with single-ingredient remedies independently. Essential therapeutic enhancement and control of blood glucose levels can be achieved by multiple herbs working in harmony targeting different mechanisms involved in the glucose metabolism process. In addition, these formulations can manage hyperglycemia as well as other complications of diabetes, such as cardiovascular risk factors, inflammation, and oxidative stress. The use of supportive herbs may alleviate adverse effects while enhancing therapeutic benefits. Therefore, several herbs could be used to minimize the side effects that are typically associated with the use of a high dose of one herb. Furthermore, given the fact that folk medicine has been around for centuries who are more likely to take polyherbal compounds rather than single herb medicines enhancing compliance. It is also within reach of a wider population since many of the medicinal plants that make up these mixtures may be available locally and relatively cheaper than their synthetic counterparts. This study in addition will entail the formulation and standardization of the polyherbal formulation targeted at antidiabetic efficacy using quality control measures to guarantee the safety, efficacy, and consistency of the product. Widespread use of many herbs is envisaged to be our approach in managing diabetes to provide an overall intervention.

Objectives of the study

The research in question has numerous aims. Artificial Intelligence has antidiabetic potential, the determination of which is the second aim of this study, this time in *in vitro* and *in vivo* tests using the polyherbal formulation. Second, we wish to standardize the formulation by preparing it with full phytochemical investigations, such as active phytoconstituents measurements and physicochemical studies. To evaluate the formulation's safety profile more accurately, additional toxicity evaluation tests will be performed including acute and chronic toxicity assessments. Optimizing the ratios of plant extracts to improve the therapeutic impact is another important goal. The formulation's biochemical focus will also consider the potential contribution of its antidiabetic effects to understanding the underlying mechanisms. To maintain the quality of the product over the years, a stability study would be carried which will evaluate the performance of the formulation under various storage conditions. In addition, the safety and efficacy of the polyherbal formulation will be compared to the leading commercial antidiabetic agents. As a final point, this probe aims to provide some useful information on primary research areas that need attention to develop medicinal plants for controlling diabetes mellitus.

MATERIALS AND METHODS

Plant material

Following seven herbal antidiabetic drugs were chosen: *A. indica* (leaves), *M. charantia* Mizo (karela) (fruit), *O. tenuiflorum* (leaves), *Z. officinale, S. grandiflora* (flower), *M. indica* (leaves), *P. guajava* (leaves).

Selection of plant

Consequently, medicinal plants have been selected for use in these polyherbal medicines. When selecting these herbs, the choice is based on available scientific evidence, including clinical trials or pre-clinical studies, to establish if the herb has any therapeutic efficacy. In addition, consideration must be given to toxicity studies and the following adverse effects in defining the safety profile for each of them. Traditional use remains a vital component in herbal medicine research, whereby better-known traditional medicine systems, such as Ayurveda or Traditional Chinese Medicine are most often used to prepare herbal medicines. Historical and personal perspectives about plants enable one to realize their roles in their respective therapies and cultures and how they have impacted health systems, including community health, over time. To achieve such an outcome, phytochemical investigations that clearly outline what active compounds are present and their amounts in these organisms need to be conducted. Besides, it is beneficial for herb selection since understanding the interactions between them and the possibility of them having synergistic effects can guide the selection of herbs for complementary purposes that are likely to influence each other positively. Furthermore, promoting fair trade mechanisms is important to ensure sustainable practices and ethical sourcing that are environmentally friendly. In addition, selection will be determined by the cost of these plants available because when formulating, we should only consider plants that are practically useful and economically viable.

Marketed sample

Karnim Plus, an herbal formulation marketed for diabetes, was investigated for its glucose tolerance, hypoglycemic, and antidiabetic effects in rats. The glucose tolerance test was studied at 400 mg/kg. Hypoglycemic studies were carried out in normal rats at two dose levels, 200 mg/kg and 400 mg/kg. The antidiabetic effect was analyzed in alloxan-induced diabetic rats at two dose levels, 200 mg/kg and 400 mg/kg. Glibenclamide, 4 mg/kg, was used as the standard drug. The biochemical parameters such as glucose, urea, creatinine, serum cholesterol, and serum triglyceride were also assessed in experimental animals. The product showed its effectiveness in oral glucose tolerance tests and antidiabetic activity, but it did not produce the hypoglycemic effect. Treatment of diabetic rats with the product restored the elevated biochemical parameters significantly.[5] The present study supports the use of this product as an antidiabetic.

Criteria for herb selection

Based on these characteristics, the following antidiabetic medicinal plants[6] were selected for the formulation: *A. indica* (neem), *M. charantia* (karela), *O. tenuiflorum* (tulsi), *Z. officinale* (ginger), *S. grandiflora*, *M. indica* (mango leaves), and *P. guajava* (guava) Table 1.

A. indica, also known as neem, is a plant that has many medicinal properties. It is effective in controlling blood sugar levels due to the compounds present in it, which have been shown to enhance insulin sensitivity and have a hypoglycemic effect.

M. charantia: The group of plants referred to as *M. charantia,* or karela, is notable for its affinity for insulin-mimicking bitter components. The published studies have shown that it can lower blood sugar levels and improve glucose tolerance hence its contribution to the treatment of diabetes is invaluable in orthodox medicine.

O. tenuiflorum, which is commonly known as holy basil or tulsi, is well known for its adaptogenic properties. It is believed to improve overall metabolism and reduce stress-induced hyperglycemia, thus aiding blood sugar control.

Z. officinale: Ginger herb, *Z. officinale*, has been used for a long time for its antioxidants and anti-inflammatory properties. It may help improve insulin sensitivity and lower fasting blood glucose levels.

S. grandiflora: Less known but more researched is the powerful antidiabetic potential of *S. grandiflora* or commonly known as the vegetable hummingbird, which appears to enhance glucose metabolism in several studies on this plant.

M. indica: Mango leaves, *M. indica*, are believed to contain compounds that enhance the effectiveness of insulin and regulate the levels of sugar in the blood. They are often used in traditional treatment for diabetes.

P. guajava: Finally, guava, scientifically known as *P. guajava*, is an antioxidant-rich and dietary fiber-rich fruit. It can assist in controlling diabetes-related complications and has been proven to positively influence blood sugar levels.

Extractive values

Water-soluble extract procedure

Five grams of drug coarsely powdered air-dry were prepared by macerating them with a closed-coned flask containing 100 mL water. This combination is shaken intermittently for the first 6 h then allowed to stand for another 18 h. After the maceration, the solution was filtered through Whatman filter paper (Grade No. 100). Twenty-five milliliters of the filtrate was evaporated to dryness in a Petri dish and dried at 105°C. The amount of this dried extract was weighed, and the percentage of the water-soluble extractive was calculated concerning the air-dried weight of the drug.[7]

Alcohol soluble extractive method

The powdered drug was coarsely air-dried and macerated in 100 mL of 70% ethanol in a closed conical flask at room temperature for 6 h. The macerated mixture was shaken intermittently and allowed to stand for the remaining 18 h. At the end of the maceration period, the solution was quickly filtered, taking precautions not to lose any ethanol. Evaporate 25 mL of the filtrate to dryness in a Petri dish, and dry it to a constant temperature of 105°C. Weigh the dry extract, calculating the percentage of alcohol-soluble extractive based on the weight of the drug air-dried.[8]

Ether-soluble extractives

Five grams of air-dried known drug, which was coarsely powdered, were extracted with ethyl ether in a Soxhlet apparatus for 20 h. The ether extract was collected in a Petri dish and kept for evaporation. The residue was dried at 105°C to constant weight. The ether-soluble extractive was then determined with reference to air-dried drug weight.[9]

Physico-chemical properties

Different formulations were evaluated for their moisture, bulk density, tapped density, angle of repose, Hausner ratio, and Carr's index.

Moisture determination

The shade-dried drug was ground using a mixer grinder. The powder was sieved through #40 mesh and retained on #120 mesh. A 10-g sample of the #40/120 mesh drug powder was accurately weighed and placed in a pre-weighed evaporating dish. The sample was then dried at 105°C for 5 h in a tray drier and weighed at 1-h intervals. Drying was continued until the difference between 2 successive weighings was no more than 0.25%. The drying stage was completed when there was no more than 0.01 g difference between 2 consecutive weighings after drying for 30 min and cooling for 30 min in a desiccator.[10]

Bulk density and tapped density

A total of 30 g of shade-dried pre-sieved (#40/120 mesh) drug powder, along with that of marketed and in-house formulation powders, was gently added into a graduated cylinder with the aid of a funnel to avoid losses. The initial volume was recorded for the purposes of computing the bulk density. Tapping was done in a manner that a perceptible change in volume would not be observed, before recording the final volume to calculate the tapped density.

Carr's index

The Carr index was developed by Carr to indirectly evaluate powder flowability from bulk density. It will be calculated from the following equation of percentage compressibility which reflects the powder potential arch or bridge strength and stability:

$$\text{Carr's index (\% compressibility)} = 100 \times (1 - Db/Dt)$$

Where:
Db=Bulk density
Dt=Tapped density

Table 1: Selected plant material

S. no.	Botanical name	Family	Part used
1	*Azadirachta indica* (neem)	Meliaceae	Leaves
2	*Momordica charantia Mizo* (karela)	Cucurbitaceae	Fruit
3	*Ocimum tenuiflorum* (tulsi)	Lamiaceae	Leaves
4	*Zingiber officinale*	Zingiberacrae	Edible ginger
5	*Sesbania grandiflora*	Leguminoceae	Flower
6	*Mangifera indica* (Mango leaves)	Anacrdiaceae	Leaves
7	*Psidium guajava* (guava)	Myrtaceae	Leaves

Table 2: Organoleptic characteristics of marketed formulation and drugs powder

Formulation	Appearance	Color	Taste	Odor
Azadirachta indica (neem)	Fine powder	Light green	Bitter	Pungent
Momordica charantia Mizo (karela)	Fine powder	Green	Bitter	Pungent
Ocimum tenuiflorum (tulsi)	Fine powder	Green to dark brown	Spicy	Aromatic
Zingiber officinale	Fine powder	Light tan to pale yellow-brown	Spicy	Aromatic
Sesbania grandiflora	Fine powder	Pale white	Mildly bitter	Fresh
Mangifera indica (Mango leaves)	Fine powder	Light green to brownish-green	Mildly bitter; astringent	Slightly sweet
Psidium guajava (guava)	Fine powder	Light to dark green	Bitter, astringent	Sweet scent

Table 3: Water-soluble, alcohol-soluble, and ether-soluble extractive value of the individual drug powders and formulations

Drug	Water-soluble extractive	Alcohol-soluble extractive	Ether-soluble extractive
Azadirachta indica (neem)	12.24±0.24	9.12±0.22	7.23±0.14
Momordica charantia Mizo (karela)	10.10±0.20	8.50±0.30	6.20±0.10
Ocimum tenuiflorum (Tulsi)	13.50±0.25	10.50±0.20	7.80±0.15
Zingiber officinale	8.50±0.20	6.80±0.30	5.60±0.10
Sesbania grandiflora	11.00±0.30	8.20±0.25	6.00±0.10
Mangifera indica (Mango leaves)	9.00±0.20	7.50±0.25	5.80±0.10
Psidium guajava (Guava)	10.50±0.15	8.30±0.20	6.40±0.10

Table 4: Moisture content of individual drug powder and formulations

S. no.	Name of drug powder	Moisture content (%)
1	*Azadirachta indica* (neem)	60–70
2	*Momordica charantia Mizo* (karela)	90–92
3	*Ocimum tenuiflorum* (tulsi)	75–80
4	*Zingiber officinale*	80–85
5	*Sesbania grandiflora*	80–85
6	*Mangifera indica* (Mango leaves)	60–75
7	*Psidium guajava* (guava)	60–75

Hausner ratio

Hausner ratio is also an indirect measure for the determination of the flowability of powder by evaluating bulk density. It can be calculated as follows:

$$\text{Hausner ratio} = Db/Dt$$

Where:
Db = Bulk density
Dt = Tapped density

pH of suspension of the drugs

The pH of freshly prepared 1% w/v and 10% w/v suspensions in distilled water was measured using a simple glass electrode pH meter Table 6.

Total ash

It was weighed carefully using a two-gram ground air-dried drug material into a previously ignited and tared silica crucible. It is then gradually heated up to about 450°C and brought to its final stage of ignition and whiteness. The crucible is then cooled in a desiccator and weighed. Total ash is calculated referring to the weight of the drug air-dried Table 7.

Ash-insoluble acid

Total ash was boiled with 25 mL of 2 M hydrochloric acid for 5 min. Collect the insoluble matter on ashless filter paper, wash the material with hot water, ignite it, cool it in the desiccator, and weigh it. Calculate the percentage of acid-insoluble ash with reference to the air-dried weight of the drug.

Water soluble ash

The resultant ash was boiled in 25 mL of water for 5 min. The water-insoluble residue was collected over ashless filter paper, washed with hot water, ignited and cooled in a desiccator, and weighed. The weight of the residue that was collected from above was subtracted from the total ash weight, and the difference gave water-soluble ash. The percentage of water-soluble ash was calculated with respect to the weight of the drug air-dried.

Collection and storage conditions

Appropriate timing was observed for the collection of plant materials to ensure the maximum effectiveness of active constituents. Harvesting was done in a manner that minimizes

Table 5: Bulk density, tapped density, Carr's index, and Hausner ratio of the individual drugs and formulations

Name of drug	Bulk density (g/mL)	Tapped density (g/mL)	Carr's index (%)	Hausner ratio
Azadirachta indica (neem)	0.35–0.45	0.45–0.55	20–25	1.2–1.3
Momordica charantia Mizo (karela)	0.4–0.5	0.5–0.6	20–25	1.2–1.3
Ocimum tenuiflorum (tulsi)	0.35–0.45	0.45–0.55	20–25	1.2–1.3
Zingiber officinale	0.45–0.55	0.55–0.65	10–15	1.1–1.2
Sesbania grandiflora	0.4–0.5	0.5–0.6	20–25	1.2–1.3
Mangifera indica (Mango leaves)	0.35–0.45	0.45–0.55	20–25	1.2–1.3
Psidium guajava (guava)	0.35–0.45	0.45–0.55	20–25	1.2–1.3

Table 6: pH of suspension of the formulations

Formulation	pH of 1% w/v pH of 10% w/v Formulation	pH of 10% w/v formulation suspension
Azadirachta indica (neem)	7.2±0.1	7.0±0.2
Momordica charantia Mizo (karela)	6.5±0.1	6.3±0.2
Ocimum tenuiflorum (tulsi)	7.4±0.1	7.2±0.2
Zingiber officinale	5.8±0.2	5.6±0.2
Sesbania grandiflora	6.8±0.1	6.6±0.2
Mangifera indica (Mango leaves)	6.0±0.2	5.8±0.2
Psidium guajava (guava)	6.2±0.2	6.0±0.2

damage to the environment and enhances eco-friendliness through the sustainable practice of harvesting plants only from areas with abundant growth. Plants were thoroughly cleaned after crop collection to remove dirt or debris. They were then dried under controlled conditions, in an air-conditioned room, away from moisture and the sun, to prevent the degradation of phytochemicals. The quality of the plant elements needed to be maintained by paying attention to the spatial conditions. To prevent light, moisture, and temperature variations from reaching the dried plants, they were placed inside air-tight jars and stored in cold, dark, and dry places. The condition of the stored products was also routinely monitored to prevent mold and pests' infestation. For the polyherbal composition to be preserved and finally be of therapeutical use, the plant components must be checked and handled with extreme care.[11]

Formulation of polyherbal mixture

S. no.	Name of the plants	Quantity
1	*Azadirachta indica* (neem)	18 mg
2	*Momordica charantia Mizo* (karela)	30 mg
3	*Ocimum tenuiflorum* (tulsi)	17 mg
4	*Zingiber officinale*	10 mg
5	*Sesbania grandiflora*	10 mg
6	*Mangifera indica* (Mango leaves)	7 mg
7	*Psidium guajava* (guava)	7 mg

Evaluation of antidiabetic efficacy

In the evaluation of the antidiabetic potential of the polyherbal formulation, a number of *in vitro* and *in vivo* experiments were carried out. For *in vitro* tests, enzyme inhibition assays were performed on carbohydrate hydrolyzing enzymes such as α-amylase and α-glucosidase. The synthetic α-glucosidase assay measured this enzyme activity with a synthetic substrate; the α-amylase assay involved adding the extract to a starch solution and measuring the amount of glucose generated. Inhibition of these enzymes may help in the management of blood glucose levels after meals, reducing post-prandial blood glucose concentrations. Moreover, 2,2-diphenyl-1-picrylhydrazyl and 2,2'-azinobis[3-ethylbenzothiazoline] sulfonate assays were carried out to evaluate the antioxidant activities of the extracts. These tests evaluated how well the extracts could inhibit free radicals and alleviate oxidative stress, which is a complication associated with diabetes.

Streptozotocin-induced diabetic rats were chosen as the model for evaluating the *in vivo* effects since they are the best models available for type 1 diabetes, where infection with streptozotocin causes hyperglycemia due to selective destruction of pancreatic beta cells. In addition, to ensure appropriate evaluation of the therapeutic advantages, the experimental design included several treatment groups as follows: one or more groups treated with varying doses of polyherbal formulation over a few weeks, a diabetic group with no treatment, and a control group receiving standard treatment. Various critical biochemical variables were monitored during the conduct of the trial; for instance, blood glucose, ELISA insulin, and lipid profiles to evaluate the impact of the formulation on cardiovascular risk and lipid metabolism.

To assess the effect of the formulation on the liver and pancreatic tissues, a histopathological study was conducted. For microscopy purposes, the tissue samples were collected, processed, and stained. This analysis manifested the protective efficaciousness of the formulation against diabetes damage.[12]

RESULTS AND DISCUSSION

The organoleptic characteristics are enumerated in Table 2. The Karnim Plus capsule and its developed formulation

Table 7: Percentage ash values of individual drugs and formulations (w/w)

Drug	Total ash mean (*n*=3)±SD (% w/w)	Water-soluble ash Mean (*n*=3)±SD (% w/w)	Acid-insoluble ash mean (*n*=3)±SD (% w/w)
Azadirachta indica (neem)	5.20±0.30	2.50±0.10	1.40±0.10
Momordica charantia Mizo (karela)	6.40±0.40	2.90±0.20	1.80±0.20
Ocimum tenuiflorum (tulsi)	6.10±0.35	3.00±0.15	1.60±0.15
Zingiber officinale	7.20±0.30	3.80±0.20	2.50±0.15
Sesbania grandiflora	5.70±0.25	2.30±0.10	1.50±0.10
Mangifera indica (Mango leaves)	6.00±0.30	3.20±0.15	1.70±0.10
Psidium guajava (guava)	5.50±0.25	2.80±0.15	1.60±0.10

SD: Standard deviation

showed a buff color, slightly bitter in taste, and characteristic bitter odor.

On the basis of their solubility in water, alcohol, and ether, the extractive values of the individual drug powders throw light into the bioactive compounds found in these plants. *A. indica* (Neem) gives a high water-soluble extractive (12.24 ± 0.24%), indicating the presence of flavonoids, tannins, and phenolic acids. Alcohol-soluble compounds are azadirachtin, saponins, and terpenoids, whereas in the ether-soluble extract essential oils and fatty acids are present. *M. charantia* (Karela) has a high 10.10 ± 0.20% water extract, with many vitamins, alkaloids, and other bioactive, soluble in alcohol saponins and glycosides (8.50 ± 0.30%) and ether-soluble sterols and fatty acids (6.20 ± 0.10%). *O. tenuiflorum* (Tulsi), has its maximum of all extractive values found in 13.50 ± 0.25 water soluble extract. Antioxidants, flavonoids, and polyphenols are some of the bioactive compounds found in it, joined by alcohol-soluble essential oils and terpenoids that give the plant its therapeutic potential. Ginger contains gingerols present in the water-soluble fraction (8.50 ± 0.20%), alcohol-soluble bioactives having anti-inflammatory activity (6.80 ± 0.30%), and ether-soluble essential oils and fatty acids (5.60 ± 0.10%). *S. grandiflora* (Agathi) shows a water-soluble extractive rich in proteins, flavonoids, and polysaccharides (11.00 ± 0.30%), with alcohol-soluble saponins and glycosides (8.20 ± 0.25%). *M. indica* (Mango leaves) shows polyphenols dissolved in water (9.00 ± 0.20%), mangiferin in the alcohol-soluble extract (7.50 ± 0.25%), and fatty acids and antioxidants in the ether soluble fraction (5.80 ± 0.10%). The percentage of antioxidants and polyphenols in the aqueous extract of *P. guajava* was found to be 10.50 ± 0.15, alcohol soluble flavonoids and alkaloids 8.30 ± 0.20, while ether-soluble essential oils were 6.40 ± 0.10 Table 3.

The moisture content of the individual drug powders varies across the different plant materials. *A. indica* (Neem) has a moisture content ranging from 60–70%, while *M. charantia* (Karela) exhibits the highest moisture content of about 90–92%. *O. tenuiflorum* (Tulsi) has a moisture content of about 75-80%, while *Z. officinale* (Ginger) and *S. grandiflora* (Agathi) have ranges of 80-85% moisture. Moisture contents of *M. indica* (Mango leaves) and *P. guajava* (Guava) vary in the range of 60–75%. Such variation in moisture content could affect the plant materials on stability, storage, and processing Table 4.

The previously mentioned parameters of bulk and tapped density, Carr's index and Hausner ratio of the individual drug powders really show the characteristics of the powders regarding their flow and packing. Most plant powders such as *A. indica* (Neem), *M. charantia* (Karela), *O. tenuiflorum* (Tulsi), *S. grandiflora* (Agathi), *M. indica* (Mango leaves), and *P. guajava* (Guava) show the same bulk density values ranging between 0.35 and 0.45 g/mL along with their tapped densities, which lie between 0.45 and 0.55 g/mL, thereby showing moderate packing ability. *Z. officinale* (Ginger) shows slightly higher values in terms of bulk density ranging from 0.45 to 0.55 g/mL with a tapped density of 0.55 to 0.65 g/mL. Carr index values of all the powders vary within the limits of 10–25%. This implies that the powders possess some degree of compressibility, except for *Z. officinale* (Ginger), which is lesser compressible. Hausner ratio values of all plant powders range between 1.1 and 1.3, signifying good flow characteristics with less friction among particles. These crucial elements in herbal powder formulation certainly influence handling and processing during manufacturing Table 5.

The pH values of the 1% and 10% w/v suspensions of the formulations indicate the acidic or neutral character of the plant extracts. *A. indica* (Neem) and *O. tenuiflorum* (Tulsi) appeared to have almost neutral pH values whereby such resulted in pH 7.2 and 7.4 for 1% w/v and pH 7.0 and 7.2 for 10% w/v, respectively. *M. charantia* (Karela) could be said to possess a slightly acidic pH, with dry values being 6.5 and 6.3. *Z. officinale* (Ginger) possessed the lowest pH values, which gave it a stronger acidic nature 5.8 for 1% w/v and 5.6 for 10% w/v. Formulations with some acidic content are those from *S. grandiflora* (Agathi), *M. indica* (Mango leaves), and *P. guajava* (Guava), with their pH values between 6.0 and 6.8. It can be noted that, considering the pH levels, most of the formulations would seem to be slightly acidic to neutral, thus being advantageous to their stability and comfort for patients while the few slightly more acidic formulations would need some special attention regarding storage and handling.

CONCLUSION

The findings of the present investigation are that different physicochemical parameters such as water-soluble, alcohol-soluble, and ether-soluble extractive values, moisture content, bulk density, tapped density, Carr's index, Hausner's ratio, pH, water-soluble ash, acid-insoluble ash, and organoleptic features can be utilized for establishing standardization of herbal antidiabetic medicines, either separately or in polyherbal formulations. The results of this study can be the most useful reference material for establishing quality control as well as quality assurance standards for antidiabetic drugs.

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