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Polyherbal Cookies for Diabetic Patients: Formulation and Evaluation

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Abstract

In order to control their hunger and obtain some energy, most people eat cookies for breakfast, snacks, and at leisure. Refined flour, sugar, and butter are the major ingredients of the various types of cookies that are sold in stores. Because they raise blood sugar levels, obese and diabetic individuals typically avoid them. As a result, we have created Polyherbal cookies in this latest study utilizing oats, wheat flour, and various Ayurvedic herbs. To determine the ideal cookie composition based on palatability, a variety of types were created utilizing various plants. Following selection, cookies were prepared for nutritional, sensory, and physicochemical examination. Organoleptic qualities, such as color, taste, scent, and general acceptability, were used to assess sensory analysis using a 9-point Paledonic scale. The physicochemical analysis includes the following: total cash value, total moisture content, total water and alcoholic extraction, and total moisture content. Our formulation has a larger protein content than the other commercially available preparation, according to a comparison of its nutritional values.

Keywords: Diabetic, cookies, polyherbal, nutritional, formulation

INTRODUCTION

Plants have been a source of inspiration for new medical compounds, as drug development from them has greatly enhanced human health and well-being. More than 80% of the world's population still receives health coverage from traditional medicine that uses plant extracts, particularly in impoverished nations. A multitude of nations utilize botanical elements as therapeutic agents, serving as the foundation for numerous potent pharmaceuticals.

Medicinal plants are essential to our daily lives and offer effective treatments for human illnesses. All Indian medical systems are founded on the understanding of plant-based medications. Since ancient times, higher plants have maintained a leading role in maintaining human health as sources of therapeutic chemicals. Natural products constitute the foundation of over fifty percent of modern clinical medications, with the pharmaceutical sector significantly depending on them for drug research endeavors. Since ancient times, people in India have employed herbs and natural remedies to heal a variety of illnesses. Scientists are making an earnest effort to assess the numerous plant medications utilized in traditional medicine throughout the last 20 years of the century [1].

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Diabetes is a prevalent, non-communicable metabolic disease that primarily affects young people and is linked to other illnesses like cardiovascular and kidney problems. It occurs when the pancreas fails to produce enough insulin or when the body is unable to absorb it adequately. According to the WHO survey report, 422 million people worldwide were estimated to be suffering in

2014, representing an increase of 4.7% to 8.5%. Diabetes mellitus, a chronic metabolic disorder, causes symptoms, such as hyperglycemia, hyperlipidemia, negative nitrogen balance, glycosuria, and, on occasion, ketonemia. In essence, it can be divided into three categories: T-cell-mediated autoimmune destruction of beta cells that secrete insulin is the primary cause of type-1 diabetes mellitus, insulin-dependent diabetes mellitus, and juvenile-onset diabetes mellitus. Type 2 diabetes and non-insulin-resistant A mild decrease in β cell mass or poor insulin circulation brought on by a combination of hereditary and metabolic factors can result in dependent diabetes mellitus. Type 2 diabetes affects about 90% of people with diabetes. Additionally, Type 3 occurs during pregnancy when either cells stop producing insulin or insulin is not created correctly.

Insulin is a hypoglycemic hormone that is composed of two chains of 51 polypeptides. The human pancreas secretes 1U of insulin each hour, with the greatest amount occurring after meals, and is regulated by chemical, hormonal, and neurological mechanisms. Although insulin is found on all cell membranes and is site-specific, its density varies depending on the kind of cell; fat and liver cells have higher levels of it. Some secondary messengers, such as PIP3, help insulin work on metabolic enzymes by activating PI3 kinase. By transferring the glucose transporter (GLUT-4) to the plasma membrane in an ATP-dependent manner, insulin initiates the transport of glucose across the cell membrane.

GLUT-4 is assisted in moving from the cytosol to the plasma membrane by the secondary messenger PIP3 and certain tyrosine phosphorylated guanine exchanger proteins. Current medications are used to treat diabetes all over the world, but it would be prudent to treat and control diabetes and its related conditions using natural medicines, natural foods, and lifestyle modifications. More than 1200 different plants, their parts, or their derivatives have been found to be hypoglycemic with few adverse effects [2].

Combining different herbs and grains, polyherbal antidiabetic cookies have the ability to increase insulin secretion through a variety of mechanisms. Oats, *Tecoma stans* leaves, Tulsi leaves, ashwagandha, honey, fake sugar (sucralose), and other ingredients make these cookies delicious, nutritious, and helpful for diabetic patients of all ages. Because the product comprises herbs and cereals, it has a less negative impact on the body. According to a WHO report from 2016, an action plan was created for the years 2013–2020. It included a number of action plans and recommended that more be done to produce natural food products that help lower or stabilize blood glucose levels [3].

LITERATURE REVIEW

A Complete Review of *Avena sativa*

Kinthali Usha Rani et al. (2021). Review of all clinical data research on *Avena sativa* possible candidate as a nutraceutical & pharmaceutical agent. The advantages shown within clinical research, however, must be effectively tested in larger studies, for further exploration of the therapeutic aspect would be good.

Assessment of the Antidiabetic Effects of Cookies Made with Plant Material from Costus igneus

ARajani Chowdaryetal, (2020), The goal of the current study was to create a nutrient-dense cookie using costusigneus leaf extract and to ascertain how eating cookies affected type 2 diabetic patients' blood glucose levels.

Tecomastans Linn's Medicinal Qualities and Uses

Abisha Vince Jeo V. Setal's (2020). The pharmacological, phytochemical, and therapeutic potential of *Tecoma stans* is discussed in this review. According to a recent study, the plant contains chemical constituents, such as alkaloids, amino acids, phytosterols, monoterpenes, triterpenes, glycosides, phenols, tannins, saponins, and flavonoids.

Preparation of Polyherbal Antidiabetic Cookies

Kajal Pathak et al. (2018). Cookies are often avoided by obese and diabetic people because they raise blood sugar levels. So, the goal of this research was to create polyherbal cookies using oats, wheat flour,

and several Ayurvedic herbs.

Phytopharmacology of Ashwagandha as an Anti-Diabetic Herb

Vikas Kumar et al. (2017). Ashwagandha (With *aniasomnifera*) extract and several pharmaceutical formulations containing it were the focus of the study. These formulations are currently widely used as tonics that help prevent and treat mental health issues, such as sleep disruptions, that accompany chronic diseases. Diabetes related to metabolic abnormalities may be treated with *W. somnifera*.

AIMS AND OBJECTIVES

Aims

The aim of the present study is to design and formulate a cookie formulation as a drug delivery system for diabetic patients.

Objectives

- The objective of the study is to design polyherbal cookies containing *Tecoma stans*, Tulsi leaves, and Ashwagandha.
- The essential target of the study was to formulate and evaluate antidiabetic polyherbal cookies that will have to work on the antidiabetic enhancing property.
- Polyherbal formulation has a wide therapeutic range, fewer side effects, is cheaper, eco-friendly, and rapidly available.

DRUG PROFILE

Oats (*Avena sativa*) belong to the family *Poaceae*. It contains soluble fiber called beta glucan, which is made up of polysaccharides with glucose residues that bind with 1, 3, and 4 linkages. For thousands of years, products containing β-glucan have been utilized to improve human health; however, β glucans have lately been examined as an active ingredient. Since then, they have been thoroughly investigated for their effects on immunological stimulation and created to treat a variety of illnesses, such as infectious disorders and cancer. Oat β-glucan has been utilized to lower blood sugar levels in a number of clinical investigations. Oat β-glucan was found to reduce postprandial glycemia.

Delaying stomach emptying may allow dietary glucose to be absorbed more gradually, which could mediate the action of β-glucans on lowering blood glucose. The blood glucose level was reduced at 15, 30, and 45 minutes after consuming oats (bran flour or crisp), but it was higher at 90 minutes after consuming 12.5 grams of glucose loading. As a result, the plasma glucose response curve has a flatter contour and a considerably smoother peak level. These modifications lessen the sensation of hunger brought on by a sharp drop in blood sugar. As a result, β-glucan may decrease appetite and food consumption [4].

Ashwagandha (*Withania somnifera*) belongs to the family *Solanaceae*. The rejuvenating herb ashwagandha root, which is mostly composed of steroids and alkaloids, is used to treat mental health issues linked to various illnesses. In contrast to oral hypoglycemic agents, it regulates the lipid profile, including blood glucose and cholesterol levels. The ashwagandha root's flavonoids and antioxidants provide it with its antidiabetic properties by enhancing liver and kidney function and balancing the albumin to globulin ratio, all of which are essential for the treatment of diabetes [5].

Tecoma stans is popular as an ornamental in warmer climates around the world due to its vivid yellow flowers and pinnate foliage. *Tecoma stans* is a valuable medicinal herb. This plant has yielded significant bioactive substances, such as alkaloids, phenols, terpenoids, glycosides, flavonoids, and saponins. The leaves, bark, and roots contain physiologically active compounds, and preparations of those tissues are used as traditional folk remedies. Phytoconstituents, such as phytosterol, triterpenes, glycosides, phenols, flavonoids, saponins, and tannins, either alone or in combination, may have a synergistic effect on wound healing [6].

- *Tecomastans:* (Figure 1)
- *Scientific name: Tecoma stans (L) kunth.*

TAXONOMY

- *Kingdom:* Plantae (Plantes, Planta, Vegetal, Plants).
- *Subkingdom:* Viridaeplantae (Green plants).
- *Infrakingdom:* Streptophyta (Land plants).
- *Division:* Tracheophyta (Vascular plants, Tracheophytes).
- *Subdivision:* Spermatophytina (Spermatophytes, Seed plants, Phanerogams).
- *Infradivision:* Angiospermae (Flowering plants, Angiosperms, Plantas con flor, Angiosperma, Plantes à fleurs, Angiospermes, Plantes à fruits).
- *Class:* Magnoliopsida.
- *Superorder:* Asteranae.
- *Order:* Lamiales.
- *Family: Bignoniaceae (Bignonias).*
- *Genus: Tecoma Juss. (Trumpetbush).*
- *Species: Tecoma stans (L.) Juss. ex Kunth (Yellow elder, yellow trumpet-flower, Trumpetbush, Trumpetflower).*

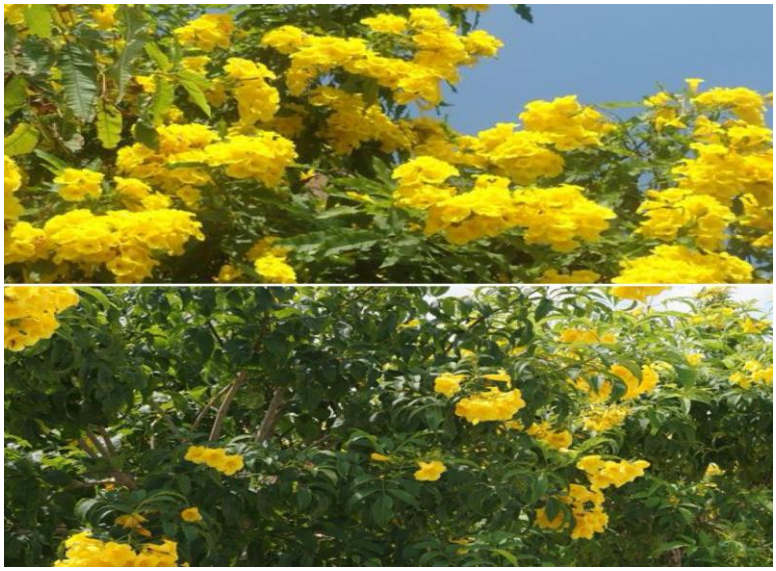

Figure 1. *Tacoma stans*.

DESCRIPTION

Within the *Bignoniaceae* family of trumpet vines, *Tecoma stans* is a species that shows promise. Esperanza, yellow bells, yellow elder, and yellow trumpet bush are some of the common names. It is a little tree or flowering perennial shrub that grows to a height of 5–7.6 meters. As it ages, the bark becomes rougher and more pale brown to grey. With two to five leaflet pairs and a bigger single terminal leaflet, the opposite, compound, and imparipinnate leaves are present.

Flowers are trumpet-shaped, measuring 6 cm in length, and contain five rounded lobes. They are pale to bright yellow and have faint orange stripes at the throat. They are located at the extremities of the branches. Fruits are narrow, slightly flattened to pointed capsules that can be up to 20 cm in length and contain numerous winged seeds. They are green when young and turn pale brown as they ripen. They remain on the tree in haphazard clusters for many months. Stamens 4 are attached at the top of the tube in two unequal pairs, with filaments pilose at the base and curved above. The anthers are versatile, linear, yellow, and pilose, and they are 6 mm long [7].

PHYTOCHEMICAL PROPERTIES

Many biologically active compounds can be found in *Tecoma stans'* leaves, bark, and roots. Traditional folk medicine has utilized extracts from these tissues to treat a variety of illnesses. Alkaloids, phenols, terpenoids, glycosides, flavonoids, and saponins are among the main bioactive substances that have been identified. Numerous phytoconstituents are included in these bioactive substances. The solvents used to extract the leaves had an impact on the *Tecoma stans* plants' phytochemical screening. Tecomine, an alkaloid extracted from the plant that was harvested in Egypt, has been shown to be one of the components responsible for the hypoglycemic activity, which is a therapeutically significant active principle of Tecoma stan. *Tecoma stans* has anti-inflammatory properties in both its bark and its leaves. The biosynthesis of monoterpene alkaloids in *Tecoma stans* callus tissues has been studied, in addition to identifying the presence of lapachol and other primary and secondary plant metabolites, such as sugars (glucose, fructose, sucrose, and xylose), triterpenoids (ursolic and oleanolic acids and α-amyrine), p-sitosterol, and phenolics (chlorogenic, caffeic, vanillic, o-ceramics, and sinapicnacids).In both in vitro and in vivo tests, alkaloids boschniakine and 5β-hydroxyskitanthine, formerly known as Base C, were inactive. Phytosterols, alkaloids, quinones, amino acids, monoterpenes, triterpenes, glycosides, phenols, flavonoids, saponins, and tannins are other chemical constituents. It has recently been determined that this plant's leaves contain indolic chemicals and iridoid glycosides [8].

Pharmacological Activities

Tecoma stans have various pharmacological activities like antidiabetic, anti-inflammatory, wound healing, antimicrobial, antioxidant, cytotoxic, antifungal and anti-proliferative activity.

Anti-Diabetic Activity

Tecoma stans' antidiabetic properties were ascribed to the alkaloids tecomine and tecostanine. According to reports, both acute and subchronic injection of the alkaloid tecomine reduced triglyceride and plasma cholesterol levels without altering fasting glucose levels. With negligible proadipogenic or antiadipogenic side effects, *Tecoma stans* aqueous leaf extract stimulates glucose absorption in both insulin-sensitive and insulin-resistant mouse and human adipocytes to produce its antidiabetic benefits [9].

In another study, the ethanolic extract of *Tecoma stans* stem (200 mg/kg) showed a statistically significant decrease in blood glucose levels; the ethanolic extract shows a more significant value of 147.5 ± 4.4 compared to the positive control group, which is near that of the standard group (124.6 ± 3.9). The ethanolic extract of *Tecoma stans* stem may have antidiabetic effects by increasing the amount of insulin secreted by the pancreatic β-cells. It contains phytochemicals, like flavonoids, saponins, and alkaloids, that may have antidiabetic [10].

Anti-Inflammatory Activity

By preventing heat-induced albumin denaturation and red blood cell membrane stabilization, *T. stans* methanol, ethanol, and water extracts demonstrated anti-inflammatory properties. Another study found that administering alcohol extract at doses of 250 and 500 mg/kg prevented edema from developing three hours after a carrageenan challenge, and administering aqueous extract at doses of 250 and 500 mg/kg prevented edema from developing four hours after a carrageenan challenge. This suggests that the extract inhibits various aspects and chemical mediators of inflammation [11].

Wound Healing Activity

Beginning at the site of the damage and lasting anywhere from months to years, the wound healing process involves a complicated sequence of processes. The inflammatory, proliferative, fibroblastic, and maturation phases are the stages of wound healing. Two distinct types of wound models were used to test the potential for wound healing of several bark extracts from *Tecoma stans*. When compared to controls, the methanolic extract of *Tecoma stans* (METS) leaf significantly increases wound contraction, causes scarring, and reduces the area of the wound. This activity is brought on by the presence of phytoconstituents like phytosterols, triterpenes, glycosides, phenols, flavonoids, saponins,

and tannins. These compounds may work in concert to promote wound healing, either separately or in combination [12].

Antimicrobial Activity

At varying doses, the growth of *B. subtilis* and *E. coli* was inhibited by the alcoholic and aqueous extract of *T. stans*, which demonstrated antibacterial action. In one study, *Tecoma stans* leaf extracts in ethanol, methanol, and water were tested against a variety of bacteria, including *Pseudomonas fluorescens, Clavibactermichiganensis, Staphylococcus aureus, E. coli, Pseudomonas aeruginosa*, and *Klebsiella pneumonia*. The results indicated that the extracts were effective. Phytochemical analysis identified alkaloids, flavonoids, saponins, phenols, steroids, anthraquinones, and tannins.

The antibacterial activity of the three extract fractions may be the cause for their highest overall phenolic content (177–216 mg gallic acid equivalent/g). A number of pharmacological and metabolic characteristics, including antibacterial ones, have also been reported for flavonoids [13].

Antioxidant Activity

According to *Tecoma stans'* phytochemical analysis, the plant contains alkaloids, steroids, glycosides, and carbohydrates. Flavonoids have the ability to scavenge free radicals and halt the radical chain events that take place in food systems when triglycerides oxidize. Plants are the main source of antioxidants, such as carotenes, phenolic acids, etc. [14].

Its strong bioactivities, which include strong antioxidants, may be explained by the tannins present in the extracts. The ability of *Tecoma stans* plant parts to scavenge free radicals using DPPH was used to test the antioxidant activity of the methanolic and ethanolic extracts in relation to the standards butylated hydroxytoulene and ascorbic acid. According to the results of the DPPH assay, *T. stans* methanolic extract exhibits superior antioxidant potential at higher concentrations than the conventional L-ascorbic acid. At a dosage of 20 μg/mL, they demonstrated a significant antioxidant potential [15].

Cytotoxic Activity

Tecoma stans' cytotoxic effects were found to be concentration and time-dependent in both the presence and absence of fetal bovine serum (FBS). MTT was used to measure cytotoxicity spectrophotometrically, and the results were expressed as a percentage of cell viability. In another study, the normal mouse embryo fibroblast cell line (MEF) and the treated cell line were used to investigate the cytotoxicity effects of various doses of alcoholic and aqueous extracts. The MEF cell line was significantly more susceptible to cytotoxicity from the higher concentrations of the plant extracts than from the lower concentrations. Inverted microscopy of the grown cells was used for morphological evaluation, and the results showed that the treated cell lines experienced cell death. The plant extract's active ingredients result in cell death and morphological alterations [16].

Antifungal Activity

The antifungal activity was tested using the drop diffusion method; most extracts had antifungal activity against *Candida albicans*, *Cryptococcus neoformans*, and *Microsporum gypseum*, but *Tecoma stans* differed greatly in their actions against the pathogens tested; *Tecoma stans* were found to provide the best zone of inhibition against fungal activity. In another investigation, *Tecoma stans* was tested using the agar dilution method at a dose of 100 μ/mL against two species of subcutaneous fungi: Fonsecaeapedrosoi and Sporothrixschenckii. At MIC 12.5 μg/mL, *Tecoma stans* demonstrated efficacious action against *F. pedrosoi* [17].

Anticancer Activity

The application of natural treatments derived from medicinal plants to cancer treatment has become more significant. More than half of antiproliferative medicines are compounds that are derived from plants in one way or another. *Tecoma stans'* bark and flowers are traditionally used to cure a variety of malignancies. The bark and leaves of *Tecoma stans* exhibit anti-proliferative properties. 5-hydroxy-

skytanthine hydrochloride, a new monoterpene alkaloid that was isolated from *Tecoma stans* Juss. fruits and flowers have anti-proliferative and NO-inhibiting properties against MCF-7.

In breast cancer, the anti-proliferative properties of the several Tecoma stan components were investigated in vitro. MCF-7 cell lines using the MTT test. On the cell line (MCF-7), the stem, root, bark, and flower extracts demonstrated a strong anti-proliferative effect; however, the stembark of *Tecoma stans* exhibited the strongest effect. *Tecoma stans'* ethanolic leaf extract exhibits remarkable anticancer activity in vitro against the human breast cancer cell line (MCF-7) at escalating doses, with an inhibitory concentration of 64.5 µg/ml, according to another study [18, 19].

- *Ashwagandha:* (Figure 2).
- *Scientific Name: Withaniasomnifera* (WS).

TAXONOMY

- *Kingdom:* Plantae (Plants).
- *Subkingdom:* Tracheobionta (Vascular plants).
- *Superdivision:* Spermatophyta (Seed plants).
- *Division:* Angiosperm.
- *Class:* Dicotyledons.
- *Order:* Tubiflorae.
- *Family: Solanaceae.*
- *Genus: Withania.*
- *Species: Withania somnifera Dunal.*

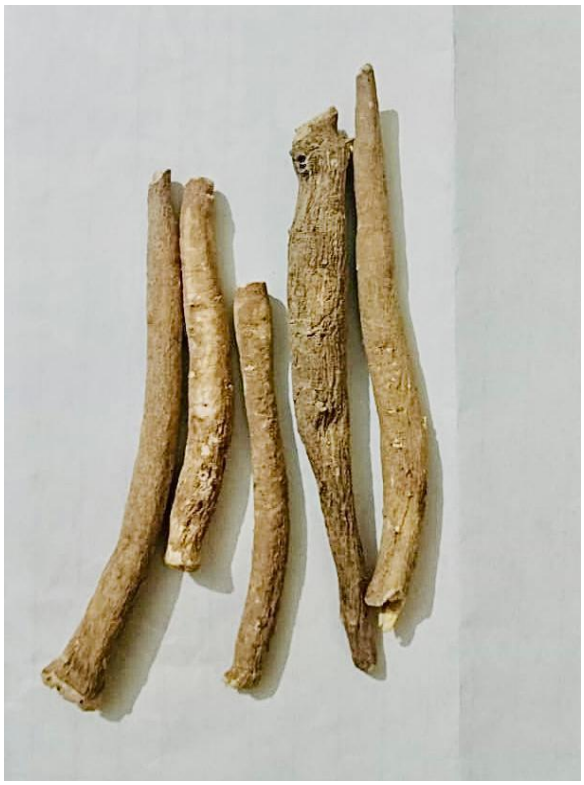

Figure 2. *Withaniasomnifera*.

Description

For more than 3,000 years, this herb – also referred to as winter cherry, Indian ginseng, or ashwagandha – has been used extensively in Ayurvedic and traditional medicine. As an aphrodisiac, liver tonic, adaptogen, antioxidant, astringent, and anti-inflammatory, the plant has long been used for

both sexes and all age groups, including during pregnancy. Recently, it has been used to treat bacterial infections, ulcers, venom poisons, and senile dementia. The plant's roots are classified as rasayanas, which are said to improve disease resistance, stop the aging process, revitalize the body in weakened states, and promote mental well-being to promote health and longevity.

The use of WS for anxiety, neurological and cognitive disorders, inflammation, hyperlipidemia, and Parkinson's disease is supported by both clinical studies and animal research. For patients receiving chemotherapy and radiation therapy, its WS chemo preventive qualities make it a potentially helpful adjuvant. Recently, WS has also been used to prevent the development of tolerance and reliance on long-term usage of a variety of psychiatric medications.

In the Solanaceae family, WS is a tiny, woody shrub that reaches a height of roughly two feet. Africa, the Mediterranean, and India are among the places where it grows. Throughout the drier regions of India, this upright, evergreen, tomentose shrub grows on bunds and in waste areas. It is 30 to 150 cm high. Stout, fleshy, white-brown roots; simple, ovate, glabrous leaves, with smaller, opposite leaves in the floral region; inconspicuous, greenish or lustrous-yellow flowers in axillary, umbellate cymes; small, globose, orange-red berries when mature, enclosed in the persistent calyx; yellow, reniform seeds. The primary part of the plant that is used therapeutically is the roots. The seeds of the brilliant red fruit are dried and planted the following spring after being gathered in the late fall [20].

PHARMACOLOGICAL ACTIVITY

Antidiabetic Activity

The anti-diabetic benefits of Ashwagandha are also taken into consideration. Relatively few reports exist on this problem, though. In an intriguing review report, the drug detailed the raw material's antidiabetic qualities. The preclinical studies yielded encouraging outcomes. It has been demonstrated in animal experiments to reduce blood glucose levels. Withaferin A has great therapeutic potential since it can successfully regulate the generation of type 1 diabetes in rats by modulating Nrf2/NFκB signaling. Using molecular docking, in silico studies have also validated the potential of *Withaferin* A. Nevertheless, a single clinical study conducted in 2000 showed a direct reduction in blood glucose levels. However, numerous studies have demonstrated a positive impact on the lipidemic profile.

White albino rats with hypercholesterolemia were used in a study to observe decreased cholesterol levels and the antioxidant benefits of *Withania somnifera*. Although there was no effect on blood sugar levels in the diabetes clinical trials, there were some intriguing outcomes, including improvements in blood pressure, body weight, and lipidemic profile, as well as improved patient assessment using the DDS17 scale to measure patients' distress. Administering a standardized Ashwagandha extract under the brand name SENSORIL enhanced the lipidemic profile and antioxidant parameters while proving the raw material's safety and tolerability. It has been shown to have an impact on the lipidemic profile and alter the reflection index in terms of tolerance and safety [21, 22].

- *Oats: (*Figure 3).
- *Scientific Name: Avenasativa* L.

Taxonomy

- *Kingdom:* Plantae.
- *Superdivision:* Spermatophyta.
- *Division:* Magnoliophyta.
- *Class:* Liliopsida.
- *Order:* Cyperales.
- *Family:* Poaceae.
- *Genus: Avena.*
- *Species: Avena sativa.*
- *Common Names:* Oat, cultivated oat, oats, side oat, tree oat, red oat.

Figure 3. Oats.

Description

The Sanskrit words "avi," which denotes sheep, and "avasa," which means food material, are the roots of the word "avena." *Avena sativa L*., often known as oat or common oat, is an annual grass that grows to a height of about 1.5 meters. Its culms can be tufted or solitary, erect or bent at the bottom. The Indian variant is comparable to A. byzantina C. Koch. The green, non-articulate leaves have blunt, membrane-bound ligules. The inflorescence can be a widespread raceme with two to three florets, all of which are bisexual, or the distal one or two may also be reduced and male or sterile; the length of the glumes is 17 to 30 mm; the glumes are sub-equal and 7 to 11 patterned; the lemmas are 7 to 9 patterned, either divided or with an apex; the lowest lemma is 12 to 25 metric linear units. Unlike many weed species, the cultivated oat's rachilla does not separate at maturity. Seldom are its lemmas awed. The lemma and palea, which are tough, closely enclose the grain. It has been discovered that seed size varies with variety [23].

PHARMACOLOGICAL ACTIVITIES

Antidiabetic Activity

Dietary prevention of type 2 diabetes may benefit from foods that produce low postprandial glycemic reactions. The oats' soluble β-glucan fiber can lower the glycemic response. For β-glucan to have a beneficial influence on the peak blood glucose level, the intestinal fluid viscosity must be increased due to its high molecular weight. According to some reports, adding oat β-glucan to breakfast cereals can lower the postprandial glycemic response by as much as 50%. The reaction was dose dependent at low levels (less than 5%), but there were no appreciable decreases in the glycemic response at levels beyond 5%.

Determining the proper amounts of β-glucan incorporation in food systems will be aided by these findings. The glycemic indices (GI) of Type 2 diabetic patients who participated in studies to assess the impact of adding β-glucan-enriched cereal to their diets were found to be considerably lower than those of the group that consumed white bread. The study's findings indicate that β-glucan-rich meals can help lower blood glucose levels in people with diabetes and pre-diabetes, thus, oats have a lot of promises. Magnesium, which is abundant in oats, functions as a cofactor for over 300 enzymes, including those involved in the body's utilization of glucose and the release of insulin.

The FDA allows foods with at least 51% whole grains by weight (and low levels of fat, saturated fat, and cholesterol) to make a health claim that eating them lowers the risk of heart disease and several

types of cancer. Type 2 diabetes and major dietary sources, calcium, and magnesium had inverse correlations, according to data from the black women's health study, an 8-year experiment with 41,186 participants. Black women who frequently ate whole grains had a 31% lower incidence of type 2 diabetes than those who ate fewer of those foods that are high in magnesium.

A positive, but smaller, 19% decrease in the incidence of type 2 diabetes was observed when the women's dietary intake of magnesium was considered alone. This suggests that whole grains provide unique advantages in fostering appropriate blood sugar regulation. Consuming low-fat dairy products on a daily basis also helped reduce the risk of type 2 diabetes by 13% [24].

Planofwork

- Comprehensive literature.
- Collection of crude drugs.
- Phytochemical screening.
- Carbohydrates.
- Alkaloids.
- Tannins.
- Glycosides.
- Saponins.
- Flavonoids.
- Proteins.
- Aminoacids.

Formulation of Polyherbal Antidiabetic Cookies

Evaluation of Physical Properties of Polyherbal Antidiabetic Cookies

- Phytochemical evaluation of powdered flower extract of *Tecoma stans.*
- Physicochemical properties of cookies.
- Nutritional analysis.

RESULTS AND DISCUSSION

Materials and Methods

Materials

The formulation of the cookies was based on the ingredients listed in Table 1, which includes various polyherbal components known for their health benefits. The equipment used during the preparation and analysis is outlined in Table 2, detailing both the traditional and modern tools employed in the study. The visual representation of the key ingredients used in preparing the polyherbal cookies is shown in Figure 4, providing a clear overview of their variety and proportions.

Table 1. List of ingredients used.

Name of Ingredients
Tecoma stans
Ashwagandha
Tulsi
Oats
Milk
Black gram flour
Flavoring agents
Butter
Salt
Baking soda
Baking powder
Artificial sugar
Wheat flour

Table 2. List of equipment used.

Name of Equipment	Make/Mode
Digital weighing balance	MAB220, WENSAR
Soxhlet apparatus	LTSW-5, LABTECH
Hot air oven	SClean-135947175, S Clean
Desiccator	JII-1504, ASKYINSTRUMENT

Collection of Samples

Fresh aerial sections of Ashwagandha (bark), Tulsi (leaves), and *Tecoma stans* (leaves) were gathered from the surrounding area. The gathered plants were thoroughly cleaned and allowed to dry in the sun. The dehydrated plant was ground into a coarse powder and stored in a sun-protected container for later use. We bought milk, butter, baking soda, baking powder, salt, and cocoa flavoring from the local store [25].

Figure 4. Ingredients are used to prepare polyherbal cookies.

Methods

Preparation of Cookies

Oats, wheat flour, roasted black-gram flour, *Tecoma stans* leaves powder, ashwagandha powder, tulsi powder, milk, cocoa flavoring agent, salt, baking powder, baking soda, butter, and artificial sugar (sugar-free Natura) were used to create various cookie compositions. The final product was chosen for sensory evaluation and nutritional value analysis based on its palatability and aesthetic appeal. The ingredients, after being selected and measured (Figure 4), were thoroughly mixed as shown in Figure 5, ensuring uniform distribution of components. The prepared dough was then baked using standard conditions (as described in Figure 6) to obtain the final product. The completed polyherbal cookies are presented in Figure 7, showcasing their texture and appearance post-baking.

Preliminary Batch for Polyherbal cookies

Several preliminary trials were conducted to optimize the formulation of the polyherbal cookies. The different combinations tested during these trials are presented in Table 3, which outlines the preliminary batches developed based on variations in ingredient proportions.

Evaluation Parameters

Phytochemical Evaluation of Powdered Flower Extract of Tecoma stans

Tecoma stans' powdered flower sample was collected, and using common reagents, phytochemical screening was carried out to determine the phytoconstituents present.

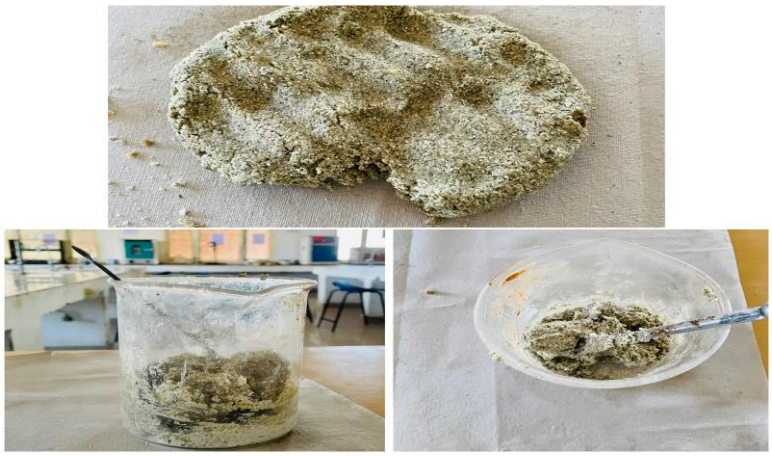

Figure 5. Mixing of ingredients.

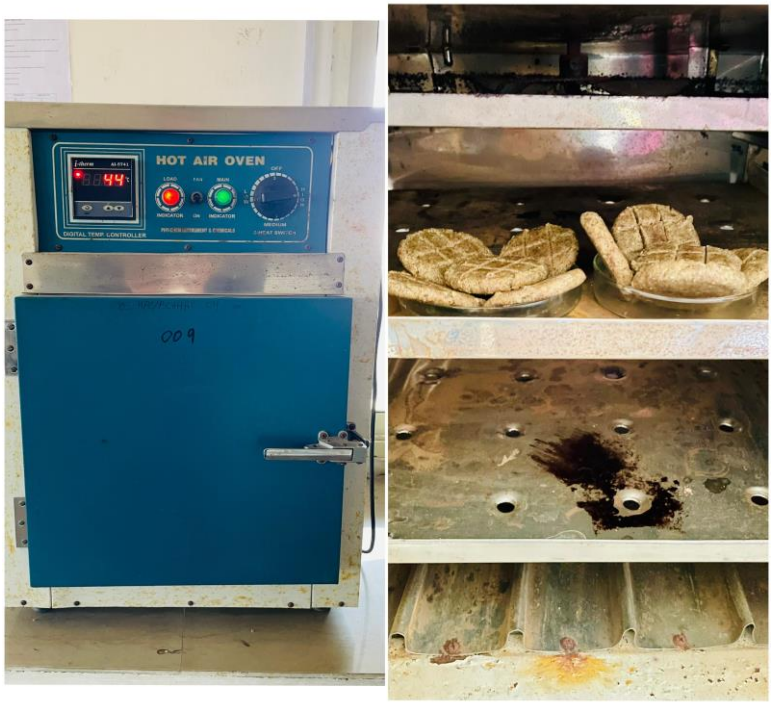

Figure 6. Baking polyherbal cookies.

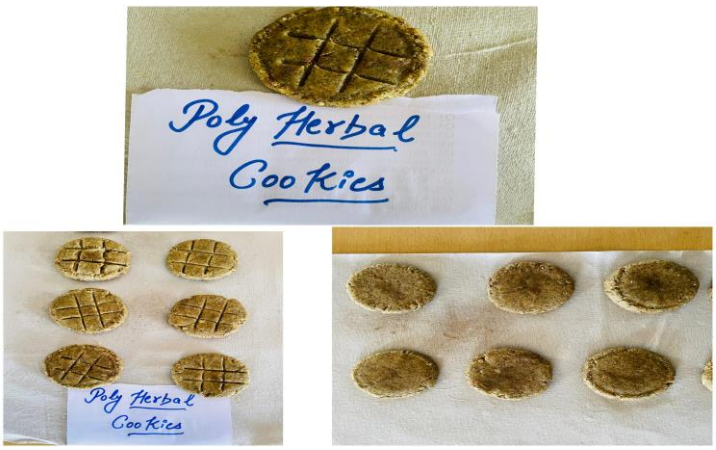

Figure 7. Preparation of cookies.

Table 3. Preliminary batches for poly herbal cookies.

Content	Quantity
Tecoma stans	15 gm.
Ashwagandha	10 gm.
Tulsi	5 gm.
Oats	40 gm.
Milk	10 ml.
Black gram flour	40 gm.
Flavoring agents	1 ml.
Butter	15 ml.
Salt	1 gm.
Baking soda	1 gm.
Baking powder	1.5 gm
Artificial sugar	10 gm.
Wheat flour	100 gm.

CARBOHYDRATES

Molisch's test

A bluish violet zone formed when 2 milliliters of powdered flower extract, 0.2 milliliters of 10% alcoholic α-naphthol solution, and 2 milliliters of sulfuric acid were mixed together. This zone indicated the presence of glycosides and/or carbohydrates (Figures 8 and 9).

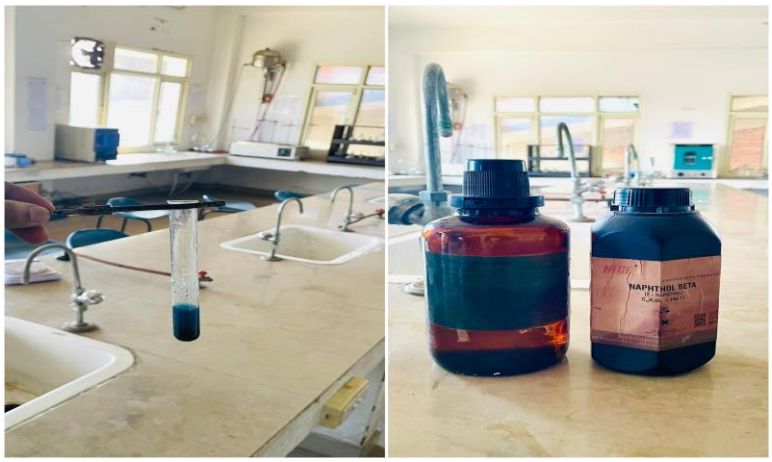

Figure 8. Molisch's test.

Alkaloids

2% H2S04 was used to heat about 0.2 g of powdered floral extracts for two minutes. Dragendorff's reagent was added in a few drops after it had been filtered. Alkaloids may be present if a precipitate turns orange-red.

Tannins

A tiny quantity of water and powdered flower extract was heated over a water bath. Ferric chloride was added to the filtrate after the mixture had been strained. Tannins are indicated by a dark green solution (Figure 10).

Glycosides

HCl was used to hydrolyze the powdered flower extract, and NaOH solution was used to neutralize it. Fehling's solutions A and B were added in multiple drops. Glycosides are shown by a crimson precipitate (Figures 11-15).

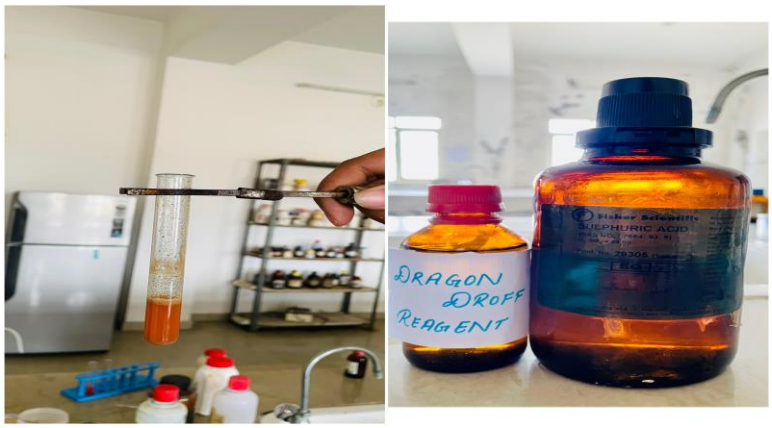

Figure 9. Dragendorff's reagent.

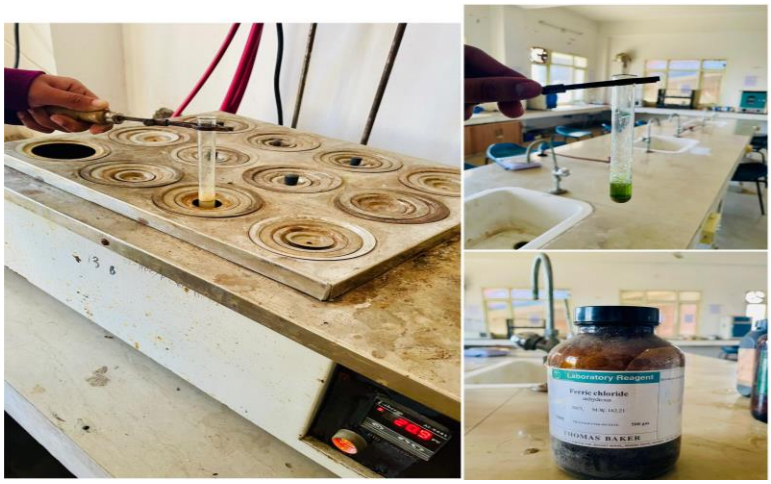

Figure 10. Tannins.

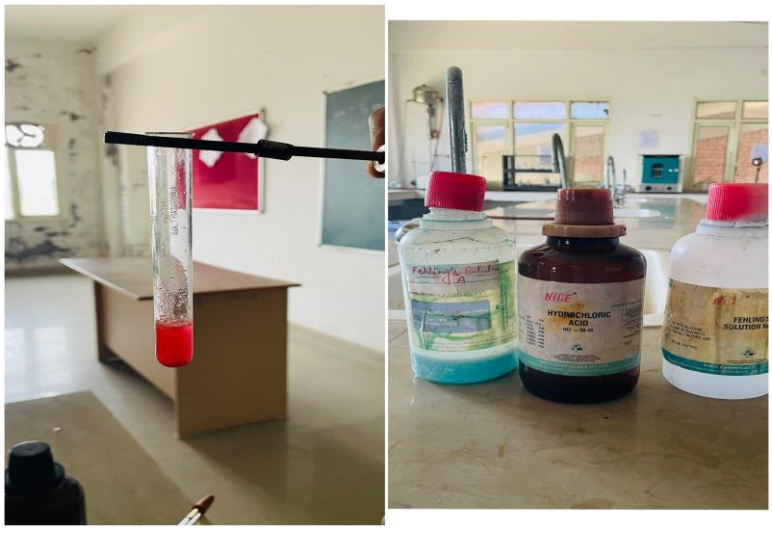

Figure 11. Fehling's solutions.

Saponins

Five milliliters of distilled water were combined with roughly 0.2 grams of powdered flower extract, and the mixture was then heated to a boil. The presence of saponins is indicated by frothing, which is the appearance of creamy foam with tiny bubbles.

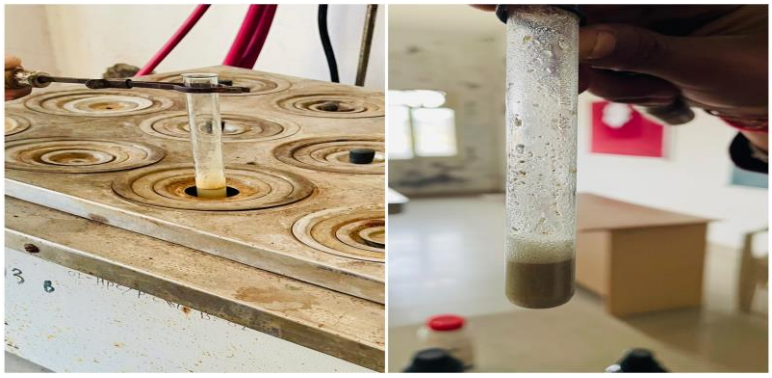

Figure 12. Saponins.

Flavonoids

Before adding HCl, around 0.2 g of powdered flower extract was dissolved in diluted NaOH. Flavonoids are indicated by a yellow solution that turns colorless.

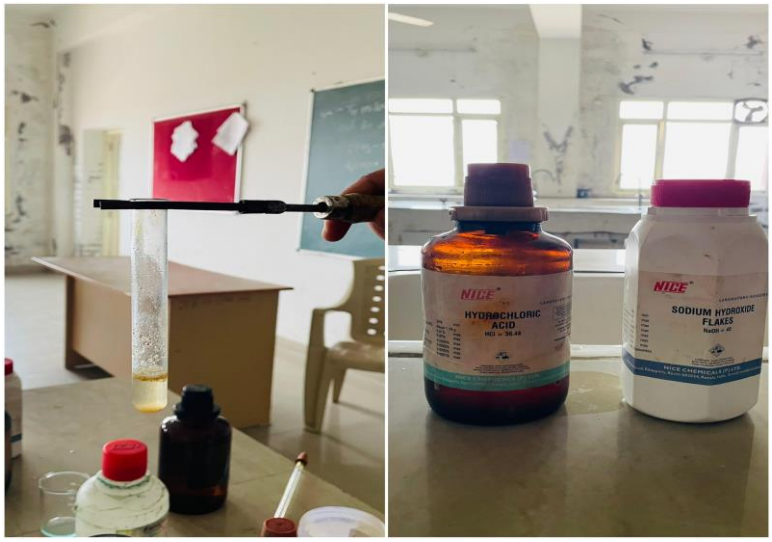

Figure 13. Flavonoids indicators.

Proteins

A mixture of 1% copper sulphate and 5% NaOH was combined with the powdered flower extract. The presence of proteins is shown by the violet color that is produced.

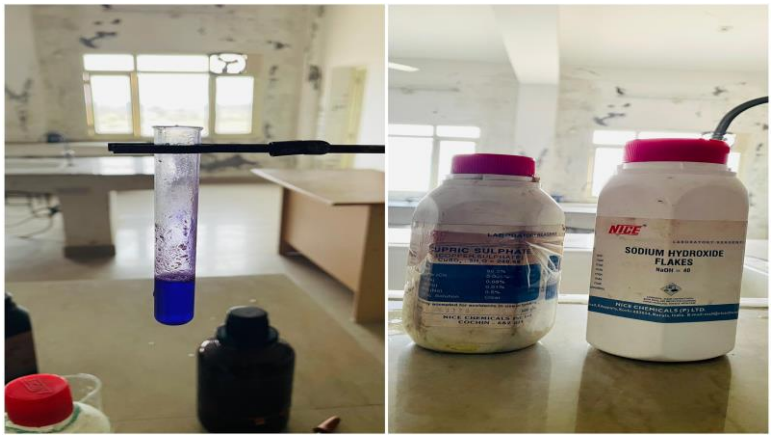

Figure 14. Protein test.

Amino Acids

The powdered flower was treated with Million's reagent. Red hue demonstrated the presence of amino acids.

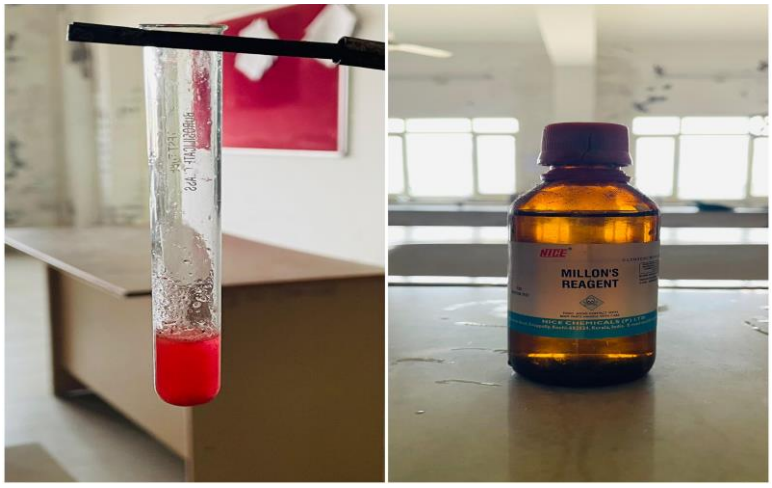

Figure 15. Million's reagent.

Physicochemical Properties of Cookies

Moisture Content

The moisture content was determined using the method provided in the food's chemical analysis. As specified in the process, a sample of the cookies was precisely weighed in a moisture dish and placed in a hot air oven for approximately 2 hours at 105°C before being cooled in desiccators and weighed again. Heating was repeated for 30 minutes, followed by cooling and weighing. Until the difference between two consecutive weighings was less than 0.001 gm, the procedure was repeated. The following equation was used to determine the test sample's moisture content:

$$\text{Moisture \% by weight} = \frac{100(w1-w2)}{w1-w}$$

where,

- W1 = Weight of moisture dish with sample before drying.
- W2 = Weight of moisture dish with sample after drying.
- W = Weight of moisture dish.

Ash Value

The total ash content of the prepared cookies was determined using the following procedure: 1 g of cookie sample was placed in a tarred crucible and burned on a Bunsen burner until all of the carbon was burned. Following cooling, the sample was weighed, and the process was repeated until the weight remained constant. The total cash value was then calculated using the equation below.

$$\text{Total ash content (\% by weight)} = \frac{100(w1-w2)}{w1-w}$$

where

- W2 = Weight of empty dish.
- W = Weight of sample taken.
- W1 = Weight of crucible with sample after complete burn.

Total Alcoholic and Water Extractive Values

To determine the total alcohol/water extractive value, 5 grams of cookie powder was placed in 250 ml volumetric flasks containing 90% ethyl alcohol or distilled water and was put aside for 24 hours. After 24 hours, samples were filtered and collected in porcelain plates. All alcoholic and water extract samples were heated to 100°C for evaporation, then cooled, and advanced calculations were performed using the procedure outlined below.

Calculation: 5 gm of sample gives 4x of alcohol extract, so 100 gm of sample gives = 80 × x/4, where, Sample after drying [2].

Nutritional Analysis

Protein Estimation

Protein estimate was performed using the procedure outlined in the included DGHS Manual. This approach involved placing 200–300 mg of cookie powder in four test tubes and then adding 3 g of catalyst (K_2SO_4+$CuSO_4$) to each. 10 ml of strong sulphuric acid, H_2SO_4, was added to each tube and digested for 3–4 hours. Later, these samples were distilled with boric acid, potassium permanganate, and 40% sodium hydroxide, followed by acid titration. The titrant was neutralized with ammonia, and the percentage of protein was determined using the equation below.

$$\text{Protein concentration} = \frac{\text{Amount of sample in } \mu g \times 1000}{V\ (\mu l)}$$

Fat Content

Two grams of the cookie sample were put in a Soxhlet apparatus with a 1:1 mixture of diethyl alcohol and petroleum ether for six hours in order to follow the protocol. After distillation, the ether was dried in an oven set to 110±1°C and then cooled in a desiccator. Weighing the dry sample was done once again. After washing the remaining residue with two to three milliliters of diethyl ether, the procedure was repeated until the weight remained consistent.

% of fat content = (M1 – M2) x 100/weight of the sample

where

- M1 = Weight of Round bottom flask with fat.
- M2 = Weight of the Round bottom flask.

Carbohydrate Estimation

The method described in the DGHS Manual was used to determine carbohydrates: A 200 ml volumetric flask was filled with 2 g of cookie powder, 50 ml of lead acetate, and 6 ml of 0.5 N HCl, and the mixture was cooked on a hot water bath. Following heating, the sample was cooled and neutralized using 6 milliliters of 0.5 N NaOH. Distilled water was then used to bring the sample volume up to 200 milliliters. Prior to inversion, Lane determined the invert sugar.

According to this approach, 10 ml of mixed Fehling A and B solution was placed in a conical flask, and titration was carried out with the sample solution within 3 minutes without inversion, using 1% aqueous Methylene Blue as an indicator.

- Reducing sugar % before inversion = F X 10/C X R.
- Where, C = concentration; R = Reading; F = Factor of Fehling solution.
- Total sugar % after inversion = F X 10/C X R.
- C = concentration; R = Reading; F = Factor of Fehling solution.
- Total carbohydrate = total invert sugar after inversion – invert sugar % before inversion x 0.95

Total Energy

The amount of carbs, proteins, and lipids in the cookie sample was used to calculate the total calories.

Energy (Kcal) = Fat × 4 + Protein × 9 + Carbohydrates × 4.

Sensory Analysis

A total of 64 people took part in this survey, which evaluated sensory attributes, such as flavor, aroma, taste, appearance, and odor using a 9-point hedonic scale. During the session, volunteers were given mouthwash and questionnaires, and the product was presented along with an explanation of the questions. Microsoft Excel was then used to evaluate the collected data by age group [26, 27].

RESULTS AND DISCUSSION

According to the results provided, these Cookies had excellent nutritional properties, with controlled fat and carbohydrate content and a high protein content, making them acceptable to health-conscious people, growing people, and cases of malnutrition. Comparative tests of numerous sensory evaluation parameters revealed that using curry leaves as an active ingredient resulted in a pleasant and flavorful effect. The selected cookie composition has made it acceptable at 90–96%, giving us optimism of converting this formulation to large-scale production. In terms of physicochemical qualities, nutritional value, sensory evaluation, and comparison to other marketed products, the results were acceptable (Table 4).

Table 4. Chemical and physicochemical parameters.

S.N.	Chemical and Physicochemical Parameters	Results
1	Ash content	7.10%
2	Moisture content	6.91%
3	Alkaloid	Present
4	Alcohol extraction	6.58%
5	Water extraction	5.30%
6	Fat content	14.04%
7	Carbohydrate content	60.51%
8	Protein content	11.65%
9	Total energy	414.9874 Kcal

CONCLUSIONS

Statistical data revealed that, in contrast to other commercially available products, herbal cookies have a high protein content and a controlled fat and carbohydrate content. The presence of *Tecoma stans* leaves and ashwagandha bark has given a new direction to convert home remedies into a marketed preparation that gives the highest acceptance in terms of flavor, and the ingredients used in formulation has already proven significant role in controlling non-insulin dependent diabetes.

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