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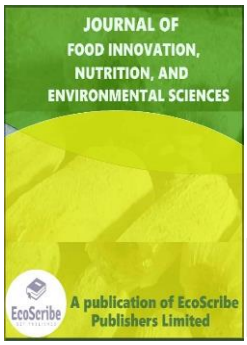

ORIGINAL ARTICLE

Exploring the Therapeutic Effect of *Ficus benghalensis* Fruit Powder against Diabetes in Albino Rats

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ABSTRACT

Diabetes is a chronic metabolic disease. International diabetic federation (IDF) reported that approximately about 8 million people died of diabetes in 2021. This highlights the widespread nature of diabetes, a prevalent non-communicable disease characterized by high blood glucose level. Interestingly, within the realm of traditional medicine particularly ayurveda, the *Ficus benghalensis* (commonly known as Banyan fruit) boasts a long history of medicinal application primarily the bark, fruit and aerial roots of this plant are used to treat diabetes. Banyan fruit contains many bioactive compounds such as glycosides and polyphenols that help the body in the regulation of diabetes. In this study, the fruit was dried by different methods such as hot air method, microwave oven drying, and sun drying. The dried fruit was stored for further usage. The effect of drying treatment on the *Ficus benghalensis* fruit was assessed through proximate analysis, phytochemical profile, total saponin contents, and vitamin C contents present in it. The anti-diabetic potential of the fruit powder was assessed in albino rats. The sample dried through the sun drying showed the best results of moisture, fat, protein, and other proximate values. The value of total phenolic contents (TPC) and antioxidant capacity (DPPH) was highest in the microwave oven dried, while total flavonoid contents (TFC) were highest in the hot air oven-dried sample. The amount of vitamin C contents was also highest in microwave oven dried sample. Then the anti-diabetic effect of the powder at 500mg/kg body showed the best results while the 250mg/kg and 350mg/kg showed less effect against diabetes.

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1. Introduction

Diabetes is a serious non-communicable disease, a chronic and complex multisystem disease that occurs due to insufficient insulin hormone production by the pancreatic cells or improper response of the body cells towards produced insulin (Banday *et al.,* 2020). Insulin resistance decreases the glucose entrance inside the cell and results in extracellular hyperglycemia and intracellular hypoglycemia. Diabetes causes major death worldwide and the number of diabetic subjects in developing countries increases day by day. In Asia regions, diabetic prevalence increased due to development in the economy, more consumption of unhealthy food, sedentary lifestyle, and other environmental factors (Sultana *et al.,* 2023). Diabetes occurrence and its health-related complications are severe threats to the economy of a country (Seiglie *et al.,* 2020).

Globally, diabetes leads to a major burden on the health system and major cause of early death. Approximately 463 million people were suffering from diabetes in 2017 which accounts for 6.28% of the world population. Of these 4.4% are of age 15-49 years, 15% of age 20-69, and 22% of 70+ age with a prevalence of 6059 cases per 100,000. Diabetes accounts for 1 million deaths/year worldwide making it the 9th leading cause of mortality. and about 70% of diabetic patients are in developing nations (khan *et al.,* 2023). In 2019, the total adults of aged 20-79 years diabetics patients were 463 million, and will be raised to 578 million by 2030 (Banday *et al., 2020*). Pakistan has ranked 1st in diabetes and has a prevalence rate of 30.8% according to World of Statistics, a group supported by the Georgia State University Department of Mathematics and Statistics. It also represents that almost one-fourth of adults in Pakistan are living with diabetes and remain undiagnosed. In Pakistan, diabetes mellitus has become is high among people 20-79 years of age and expected to rise from 33 million in 2021 to 13.8 million by 2030 (Alam 2021). According to the International Diabetes Federation (IDF), in 2022 total of 33,000,000 cases were reported with a prevalence of 26.7% of diabetes (Azeem *et al.,* 2022).

Fruits are an essential part of a balanced diet, and regular fruit consumption may reduce the risk of developing chronic conditions including cardiovascular disease (CVD) and several types of cancer. Non-communicable diseases (NCDs) include type 2 diabetes mellitus, cancer, CVDs, and obesity. Numerous essential elements that are necessary for maintaining good health may be found in fruits and vegetables. Vitamin C and vitamin B play major roles among the water-soluble vitamins. The fat-soluble vitamins A, D, E, and K are also crucial for bolstering the body's defensive mechanisms and avoiding infections (Pal and Molnár 2021).
Vegetables are plants grown for their edible components, whereas fruits can be defined as the edible portion of a plant comprised of the seeds along with their surrounding tissues. Fruits and vegetables are essential sources of dietary fiber and micronutrients and are part of a balanced diet that helps in illness prevention. Due to shared phytochemicals, micronutrients, and fiber, fruits and vegetables provide health advantages, although the content and ratio of bioactive substances vary greatly across fruits and vegetables (Amao 2018).

Ficus benghalensis is a laciferous, moraceous, huge evergreen tree of the "Ficus" genus, which has over 800 species, 2000 subvarieties, and is widely known as the "Indian banyan tree." It is native to South Asia and thrives in arid locations throughout India, Sri Lanka, Pakistan, and Bangladesh. It is also widely farmed in practically every moist tropical area throughout the world (Gopukumar *et al.,* 2016). It possesses extraordinary therapeutic properties that have assisted in the treatment of a variety of life-threatening disorders. This tree is extensively used as medicine in traditional medicinal systems such as Ayurveda, Siddha, Unani, and homeopathy. Many severe maladies, such as dysentery, diarrhea, diabetes, leucorrhea, menorrhagia, neurological disorders, tonic, and astringent, can be treated with various parts of these plants (Kmail *et al*., 2018). The fruit, which is cherry-sized and red, has a fleshy pericarp and is edible for both animals and humans. It is high in secondary metabolites like tannins, flavonoids, saponin and phenolics compounds (Radhakrishnan *et al*., 2020).

Banyan (*Ficus benghalensis)* fruits have been discovered to be high in mineral content, fiber, and carbs. The approximate composition of banyan fruit (dry basis) will be 71.02% (wet basis), 2.83% ash, 8.66% crude fat, 17.08% fiber, 4.83% protein, and 66.63% carbohydrates. Fruits are so high in ash (minerals), carbs, and crude fibers, and a strong source of energy. A high mineral content improves digestion by increasing enzyme activity. Fruit has 276 mg/g polyphenols. Polyphenols aid in the chelation of metal ions (particularly copper and iron), which function as pro-oxidants. The presence of anthocyanins, which have significant antioxidant activity, anticancer characteristics, and possible health effects against mild cardiovascular problems, neurological diseases, diabetes, and inflammation. A potential food product might be created by reducing the concentration of anti-nutrients (saponins, alkaloids, and tannins) to acceptable levels by soaking, blanching, and cooking (Bandekar *et al.,* 2013).

In light of the increasing prevalence of diabetes and the urgent need for alternative therapeutic approaches, this study was designed to explore the potential of *Ficus benghalensis* fruit powder as a natural intervention. Specifically, the study aimed to determine and compare the yield and physiochemical properties—such as moisture content, color, and texture—of *Ficus benghalensis* fruit powder obtained through different drying methods, including sun drying, hot air oven drying at a controlled temperature, and microwave drying. Furthermore, the study sought to evaluate and compare the effects of the fruit powder on blood glucose levels in diabetic albino rats over a

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defined treatment period. Lastly, it aimed to assess and compare the impact of *Ficus benghalensis* fruit powder on body weight changes in both diabetic and non-diabetic control groups of albino rats.

2. Materials and methods

2.1 Materials

Ficus benghalensis (Banyan) fruits were collected from the University of Agriculture, Faisalabad. All reagents and chemicals needed for the present research were purchased of analytical grade from local market of Faisalabad.

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2.2 Preparation of raw materials

Raw materials were cleaned for dust particles and other impurities. Banyan fruit was washed well. Banyan fruit was cut into four pieces and placed for drying. Different drying treatments were applied to the fruit and then the fruit was ground. Fruit was dried by microwave oven (MWO) at efficiency of 50-55 for 13 minutes, hot air oven (HAO) at a temperature of 65-70°C for 1 day, and sundry (SD) for 2-3 days. After drying, the fruit was ground using an electric grinder (RAF Multifunctional Electric Grinder R.7113) and stored for further use.

2.3 Proximate analysis

Moisture, fat, protein, fiber, and ash contents of different *Ficus benghalensis* fruits powder samples were determined according to standard procedures given by AOAC (2019).

2.3.1 Moisture (%)

Hot air oven was used for moisture contents s' determination (AOAC, 2019). Both the China dishes and sample material were pre-weighed. China dishes, carrying sample, were kept at 100-110°C in the dehydrator oven (for 24 hours), until constant weight of dry matter was attained. After drying the sample through dehydrator, sample was taken out of dehydrator. Sample was then put in vacuum desiccator. Allowing the sample to cool down at room temperature, sample was weighed and moisture contents s were determined using formula.

$$Moisture\ (\%) = \frac{Loss\ of\ weight}{Weight\ of\ sample}\ x\ 100 \qquad \text{- eqn. 1}$$

2.3.2 Fat content (%)

Crude fat was determined using protocol from AOAC (2019). Soxhlet Apparatus was used for this purpose. Sample (moisture-free) was folded in Whatman filter paper thimble and inserted in extraction tube of the apparatus. Sample was covered by plug of cotton covering followed by storage in extraction thimble and a cool water setup was running there. N-hexane was used as a solvent during this procedure. The heating temperature was set in a way that hexane droplets fell in a continuous manner at trail kept in abstraction portion. Until the completion of sixth siphon, the procedure was kept continuous. Sample was put in pre-weighed dry China dish and thimble was kept in oven for drying purpose. The dried sample was placed in desiccator and weighed, afterwards. Then, sample was placed in hot air oven until persistent mass of dry matter was attained. Following formula was used to calculate fat percentage.

$$Crude\ fat\ (\%) = \frac{initial\ weight - final\ weight}{weight\ of\ sample}\ x\ 100$$

eqn. 2

2.3.3 Crude protein determination

The crude protein was analyzed by Kjeldahl method prescribed in AOAC (2019). The first step, protein digestion started from preparation of digestion mixture using 90% Potassium Sulphate, 7% Copper Sulphate and 3% Ferrous Sulphate. Digestion was carried out by using 5g sample in 250ml flask of Kjeldahl's apparatus. 20 ml of concentrated 98% Sulphuric Acid and 5g digestion mixture was added in flask. Material was heated until transparent. After cooling, distilled water was used to prepare volumetric solution in 250ml flask. Before the last step (protein distillation), 40% Sodium Hydroxide solution and 4% Boric solution was prepared and indicator was added in boric acid solution. Afterwards, 5ml of Sodium Hydroxide solution, 10g Boric Acid solution and 10g of digestion mixture was added that turned into dark pink color. The mixture was steamed through distillation apparatus until color of solution turned to yellow or colorless. Titration was carried out later on, in which 0.1N H_2SO_4 was added in titration solution until color turned to purple of pink. The observed value was noted and crude protein (%) was determined using the equation;

$$N\ (\%) = \frac{V1 \times V2 \times 0.0014}{Weight\ of\ Sample \times V3}\ x\ 100 \qquad \text{- eqn. 3}$$

Where,
V_1 = Volume of 0.1N H_2SO_4
V_2 = Volume of dilution (250ml)

2.3.4 Crude fiber (%)

The enzymatic gravimeter method specified by AOAC (2019) was utilized to determine the dietary fibre contents s of power bites. For power bites' samples, from which fat was extracted, the analysis of crude fibre was conducted using Method no. 978-10, outlined in AOAC (2019). Two samples, fat and moisture free, underwent a half hour heating process in beakers for digestion. Subsequently, filtration using Whatman filter paper and a

filtration flask took place, followed by three washes with hot water. After that, the residue was poured into a second 500 ml beaker that held 200 ml of 1.25% NaOH solution. This entire procedure was repeated until the samples achieved an alkali-free state. They were then transferred to a China dish and subjected to drying in an oven at 100°C for a duration of three to four hours until a constant weight was attained. After being heated over a flame until they were smoke-free, the samples were put in a muffle furnace set at 550°C for four hours in order to gather ash. After cooling in a desiccator, the ash was weighed, and the obtained data were recorded appropriately, with a formula applied for further calculation:

$$Crude\ fiber\ (\%) = \frac{W1 - W2}{W} \times 100 \qquad \text{- eqn. 4}$$

Where,
W = Weight of the original sample
W1 = Weight of the residue after digestion
W2 = Weight of ash after burning the residue

2.3.5 Ash determination

The ash contents s of *Ficus benghalensis* fruit was assessed following the procedure given in AOAC (2019). Three grams of the sample were placed in a crucible and subjected to direct flame from a burner for charring until no fumes were observed. Subsequently, the sample was incinerated in a muffle furnace at a temperature range of 550-600°C for 5-6 hours, resulting in a greyish-white coloured residue. The ash contents s of the sample was determined using the following formula:

$$Ash\ (\%) = \frac{Weight\ of\ sample\ before\ charring}{Weight\ of\ sample\ after\ charring}\ x\ 100$$

- *Eqn. 5*

2.3.6 Nitrogen free extract

The carbohydrate contents of the banyan fruit powder were calculated by subtracting the percentages of moisture, crude protein, crude fibre, fat, and ash from one hundred. The specific formula for the calculation is expressed as follows:
NFE (%) = 100 – (% moisture + % crude fat + % crude protein + % ash + % crude fibre)

2.4 Phytochemical analysis

2.4.1 Total Phenolic Contents (TPC)

The number of phenolic compounds in the methanol extracts of powder samples were measured using the Folin-Ciocalteu technique. To create a standard gallic acid solution (2.0 mg/ml). The methanolic extract were of *Ficus benghalensis* fruit powder samples were prepared by mixing methanol with sample in a 1:10 method. Then the samples were placed on orbital shaker at 150 rpm for 24 hours. The powder was removed and extract was collected after 24 hours. Total phenolic contents were determined by the method used by Naz *et al*. (2016) with some changes

2.4.2 Total Flavonoid Contents (TFC)

The total flavonoid contents of the *Ficus benghalensis* fruit powder samples were determined by following the method described by Rehman *et al*. (2013). By using Catechin as a standard, the flavonoid contents in the banyan fruit powder samples could be quantified based on its equivalent Catechin contents. This method allows for a reliable comparison of flavonoid levels in different samples and provides valuable information about the antioxidant potential of the *Ficus benghalensis* fruit powder sample.

2.4.3 Anti-oxidant potential (DPPH)

Each sample's free radical scavenging activity was determined by following the process explained by Shahid *et al*. (2014). The control group was the solution devoid of plant extract. (Naseem *et al*., 2020). Each test sample of *Ficus benghalensis* fruit powder was in triplicates and the percentage inhibition of DPPH radical samples was calculated

2.5 Quantification of saponins

A 15 ml glass test tube was filled with 0.2 ml of *Ficus benghalensis* fruit powder extract, 0.8 ml of 100% methanol, and 0.35 ml of vanillin (8% in ethanol). After that, it was mixed with 1.25 ml of 72% H_2SO_4 for a few sec. The test tubes were placed in a water bath for 10 min at 60 C and then cooled by using ice crystals. The absorbance of the extract was taken at 544nm. The standard curve was taken by using 100-600mg/ml diosgenin (Akbari *et al.,*2019).

2.6 Ascorbic acid determination

Ascorbic acid (Vitamin C) was measured using a titration method with 2, 6-dich10roindophenol dye as described in the method of AOAC (2019).

2.7 Efficacy trial

After getting permission from the Directorate of Research and Advanced Studies and Society of Ethics of Animals at the University of Agriculture, Faisalabad. A total of 15 rats were taken from the UAF vicinity. For efficacy study, rats were kept and looked after in an animal room for almost 1 month. 5 groups were made with 3 rats in each group. After 1 month, diabetes was induced in rats by injecting with Alloxan monohydrate via intera peritoneally at concentration of 125ml per kg body weight after fasting. The weight of the albino rats, their fasting blood sugar level and random blood glucose level were checked on one-week

intervals. After the diabetes had induced, the rats were fed on *Ficus benghalensis* fruit powder via oral route at different doses described in the table below. The fruit powder dose was adjusted according to the weight of rats and given along with their normal feed to check it anti-diabetic potential.

Table 1. Experimental Grouping and Dietary Interventions for Evaluating the Anti-Diabetic Effect of Ficus benghalensis Fruit Powder in Rats

Sr. No.	Group	Dietary Interventions
G_0	Control group	Normal diet
G_1	Diabetic rats	Normal diet
G_2	Diabetic rats	*Ficus benghalensis* Fruit powder dose 250mg/kg per day
G_3	Diabetic rats	*Ficus Benghalensis* Fruit Banyan fruit powder dose 350mg/kg per day
G_4	Diabetic rats	*Ficus benghalensis* Fruit powder dose 500mg/kg per day

2.8 Physical analysis

During the one month of trail, body weight fluctuations and BMI was recorded at the start and end of trail (Shaheen, 2017).

2.9 Blood glucose

Blood sample were collected and following test (FBG and RBG) were performed as respectively. The purpose of the study was to see how well the body regulated blood sugar level in the absence of food. Using biosensor technology, blood glucose level was measured using a glucometer and finger stick. A registered nurse applied a drop of blood
to the electrode/strip and the reading was recorded on the glucometer's digital window the method described by Shivekar and Joglekar, (2020). The blood samples were collected from non-fasting subjects for determining the amount of blood glucose circulating in the blood. Blood sample were collected from the tail vein and blood was placed on glucometer strip (Shaheen 2017).

2.9 Statistical analysis

The statistics gained for respective factor remained exposed towards statistical examination to observe the level of significance as described by Montgomery (2017) using statistics 8.1. Data was constructed in the form of triplicate and comparison of mean using the factorial design and two-way ANOVA (analysis of variance). Further Tuckey HSD test all pairwise comparisons, the significance of the mean of the analyzed parameter was determined using the test.

3. Results and Discussion

Banyan fruit has several health benefits, including improved gut health and reduced risk of heart disease, stroke, obesity, high blood pressure, cancers, and diabetes. The distribution and profile of proximate values, phenolic compounds, and bioactive compounds of this fruit vary considerably among different genotypes, cultivars, and ripening stages, within different tissues and as well as environmental conditions. Proximate phytochemical, total saponin content, vitamin C, and minerals analysis of fresh and dried apples have been exhibited as follows.

3.1 Proximate Analysis of Banyan Fruits

The proximate composition of the Banyan fruit powder is as indicated in Figure 1 and as discussed below.

3.1.1 Moisture Content

The moisture contents of the banyan fruits dried through three different techniques i.e. Sun drying, microwave drying, and hot air drying were 11.51% ± 0.208, 7.03% ± 0.152, and 6.73% ± 0.095 at 30-35 °C, 50% of power and 70°C temperature respectively. The mechanism of a hot air oven in drying is the mass and heat transfer and it is a time-consuming process (Farias *et al.,* 2020). In contrast, microwave drying also decreases the moisture level. However, exposure to microwaves for longer times could result in uneven moisture across the food material and cause burning at the spots and loss of many heat-sensitive bioactive compounds (Nirmaan *et al.,* 2020). For ease of sun drying, the fruit was subjected to sun drying in under shade at a moderate temperature in a plastic box to prevent contamination, which resulted in a low decrease in moisture reduction compared to other prior techniques used.

3.1.2 Crude Protein

Protein content is an important factor in assessing its nutritional profile and quality. It is complex in structure and formed by the joining of different amino acids. The protein contents of the hot air oven, microwave oven, and sun drying sample were 2.66% ± 0.010, 2.21% ± 0.010, and 2.21% ± 0.011 respectively. Protein is heat-sensitive structure and at high temperatures, it starts degradation. The higher protein content in hot air oven dried is because of the drying temperature of the hot air oven. At 65-70 °C temperature less protein is degraded as compared to the high temperature of microwave oven dried sample that causes spot burning of fruit. While the microwave oven-dried and sun-dried samples have equal amounts of protein. This may be because some proteins present in fruits and vegetables denature when they are exposed to high processing temperatures (Wijewardana *et al.,* 2016).

3.1.3 Crude fiber

Crude fiber is a measure of undigested cellulose, lignin, and other component present in the food. Among the treatments, the sample dried through the HAO showed the maximum amount of fiber 27.95% ± 0.909 compared to the other two samples e.g. sun-dried sample 25.72% ± 0.707, and microwave oven-dried sample 24.47% ± 1.046. The low amount of fiber content in sun-dried and microwave oven-dried samples was due to high temperature. High temperature leads to degradation of heat-sensitive fraction of fiber content, especially soluble fiber. Additionally, the ultraviolet radiations and fluctuating temperatures in sun drying may also contribute to degradation (Wijewardana *et al.,* 2016). Between the three treatments, the fruit dried through hot air oven drying and sun drying were slightly higher than the fruit dried through microwave oven drying in fiber contents.

3.1.4 Ash Content

Ash content is defined as the inorganic part and mineral content of food that is left after combustion at high temperatures after the removal of moisture and organic parts. Means values of ash contents were 6.3% ± 0.120, 4.98% ± 0.020, and 2.90% ± 0.020 in microwave oven drying, hot air oven drying, and sun drying respectively. Microwave heat food unevenly by exciting water molecules within the fruit. This can lead to localized hot spots that reach much higher temperatures than the surrounding air in a sun dryer. Higher temperatures can cause some minerals in the fruit to break down and become more concentrated, increasing the ash contents (Zakaria *et al.,* 2021).

3.1.5 Carbohydrate contents

Carbohydrates are the class of organic compounds that play a vital role in living organisms. Carbohydrate contents in hot air oven drying, sun drying, and microwave oven drying were 49.67 ± 0.879, 48.65 ± 0.926, and 44.80 ± 0.994, respectively. Hot air drying, while faster, generally does not break down a significant amount of carbohydrates. Sun drying, on the other hand, can be susceptible to enzymatic activity and microbial growth over longer drying times, which might lead to some carbohydrate degradation. However, hot air ovens typically use higher temperatures and faster drying times. This removes more moisture, concentrating the remaining components, including carbohydrates (sugars and starches) which make up a significant portion of a fruit's weight. Sun drying, being slower, removes moisture more gradually, leaving slightly higher water contents and a more diluted concentration of carbohydrates compared to the final weight (Ekpo *et al.,* 2022).

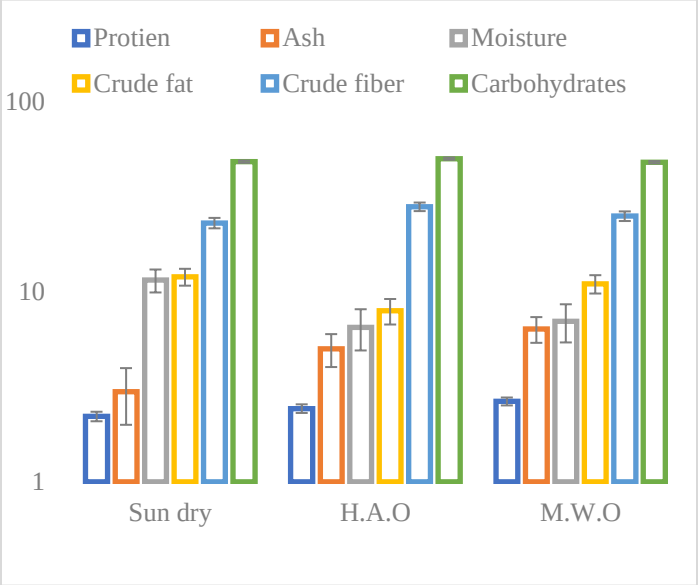

Fig 1. Proximate Composition of *Ficus Benghalensis* Fruit Powder dried under different Drying Methods

3.2 Phytochemical Analysis

3.2.1 Total Phenolic Contents

Phenolic compounds are natural derivatives from natural sources like plants and their products. Generally, it is called a metabolite of plants which makes them important from a nutrition point of view (Pauliuc *et al.*, 2020). Polyphenols have antioxidant characteristics that protect against oxidative damage and reduce the risk of chronic illnesses such as cardiovascular disease, cancer, and neurological problems. Furthermore, total phenolic contents are directly related to the sensory qualities. They may reduce oxidative stress and complications associated with it. The higher the concentration of polyphenols, the lower the oxidation of macromolecules (Martín *et al.* 2020).

Total phenolic contents of different dried samples of banyan fruit powder were measured dried by the microwave oven, hot air oven, and sun drying were 89.16 ± 2.18, 77.30 ± 0.713, and 74.62 ± 3.98 mg GAE/100 g, respectively. The sun-drying and hot air-drying processes cause losses of phenolic compounds. Phenolic are water-soluble compounds which due to this property facilitate the leaching of these phenolic compounds during sun drying. Moreover, these compounds are thermo-sensitive, and therefore they are easily degraded when the food is exposed to heat for a longer period. The results showed that the microwave oven-dried sample showed the best retention of total phenolic contents due to a faster drying rate and in shorter time (Azam *et al.*, 2019).

3.2.2 Total Flavonoid contents

Flavonoids are the most abundant naturally occurring compounds that are present mainly in different plants (Bibi *et al.,* 2022). Flavonoids are an important group of bioactive compounds found in fruits, vegetables grains, and beverages that have anti-inflammatory properties, Flavonoids have been linked to a variety of health advantages, including cardiovascular protection, anticancer effect, and immune system regulation. Therefore, TFC is an important component in determining the quality and nutritional value of food items (Maulana *et al.,* 2019). The number of flavonoid contents present in the sample dried through hot air drying, sun drying, and microwave drying were 497.14 ± 10.27, 377.45 ± 7.18, and 344.86 ± 41 mg QE/100gm, respectively. Due to the thermally induced chemical oxidation and water-soluble flavonoid leaching, the contents of flavonoids were decreased in the banyan fruit powder through sun drying and microwave oven drying (Karmakar *et al.,* 2020).

3.2.3 Antioxidant activity

DPPH, or 2, 2-diphenyl-l-picrylhydrazyl, is a commonly used reagent in food analysis to evaluate the antioxidant activity of food and plant extracts. It measures the reduction of DPPH by antioxidants, which results in a color shift from purple to yellow (Gulcin, 2020). This test gives useful information regarding the free radical scavenging capability of dietary components, assisting in the evaluation of their total antioxidant activity. The findings of DPPH tests are crucial for identifying the quality, nutritional contents, and possible health benefits of food items, allowing the development of functional foods with increased antioxidant characteristics (Gulcin *et al*., 2023). The values of DPPH free radical scavenging activity of banyan fruit dried through microwave oven drying, sun drying, and hot air oven dried samples were recorded as 61.7867 ± 3.41, 47.7633 ± 2.65 and 38.8867 ± 1.32, respectively. Between these three techniques, the banyan fruit dried through microwave showed the highest values of DPPH whereas the banyan fruit dried through sun drying and hot air-drying technique showed a decreasing value for radical scavenging activity. Microwaves retain the antioxidant activity due to shorter processing time (Yıldız and Çağındı, 2023).

Due to higher temperatures and longer drying time in hot air drying and exposure to sun for drying may also result in the reduction of DPPH scavenging activity. This decrease in DPPH scavenging activity in hot air-dried banyan might be due to oxidation or loss of ascorbic acid and total phenolic contents during high temperatures, which are responsible for antioxidant activity. Due to its simplicity of operation and rapidity in drying, the microwave could be an effective technique in releasing the antioxidant compounds from agricultural products. Longer processing times eventually lead to a significant reduction in the nutritional properties and antioxidant activity.

3.2.4 Total Saponin Contents

Total saponin contents are the amount of saponin present in a particular plant material (Bot *et al.,* 2022). Saponin is a group of naturally occurring compounds that have a bitter taste. It is a plant-based glycoside and has more than 100 species belonging to wild, cultivated, and marine species. Saponins have a wide range of biological effects and have been used throughout history in various applications. It consists of hydrophobic aglycone and sugar molecules bound together by easter linkage and form a chain. They exhibit different biological activities depending on their structure (Oakenfull and Sidhu, 2023). Several antibacterial, antiviral, antifungal, and anti-parasitic activities have been described for saponins, including immunostimulatory, hypocholesterolemic, antitumor, anti-inflammatory, antibacterial, antiviral, antifungal, antidiabetic and anti-parasitic effects. Their consumption may produce different health benefits, including cholesterol-lowering activity, blood sugar-lowering effect, and anti-inflammatory effect (Oleszek and Oleszek, 2020). The total saponin content of the sample dried by hot air oven, sun drying sample, and microwave oven drying sample was 152 ± 11.2, 149.16 ± 1.56 and 148.32 ± 4.91 g/kg of banyan fruit powder, respectively.

In Microwave oven drying, electromagnetic radiation is used to heat water molecules within the food, causing rapid drying. While faster, this method exposes food to higher temperatures (often exceeding 100°C) for shorter bursts. This can lead to partial degradation of saponins due to the heat. While the sun drying relies on sunlight and ambient air for drying. It is the most energy-efficient as it exposes food to fluctuating temperatures and extended drying times. This combination can lead to significant saponin loss due to prolonged exposure to sunlight and potential enzymatic breakdown at higher daytime temperatures, particularly ultraviolet (UV) radiation. The hot air-drying method uses consistent, controlled heat (typically 50-70°C) to remove moisture. It's generally considered the most saponin-preserving method. The moderate and constant temperature minimizes the degradation of these heat-sensitive compounds (Nguyen *et al.,* 2018).

3.3 Vitamin C

Vitamin C, also known as ascorbic acid, is a vital nutrient that our bodies can't produce on their own. It is a water-soluble vitamin that has an antioxidant capacity (Dosedl *et al.,* 2021). We need to obtain it from our diet to maintain good health. This water-soluble vitamin plays a multitude of roles in our body's functioning, making it a true essential. It is famous for its ability to fight off and cure the common cold. Vitamin C plays a vital role in many bodily functions such as collagen formation, wound healing, immune system function, antioxidant activity, and iron absorption (Mousavi *et al.,* 2019). The amount of vitamin C contents present in the treatments dried through microwave oven drying, hot air oven drying, and sun drying

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were 5.846 ± 0.292, 8.769 ± 0.292, and 11.692 ± 0.292 mg/100, respectively. The amount of vitamin C contents s was decreased in the microwave oven-dried sample (25.20 ± 0.89 mg/100 g) as compared to the hot air oven-dried sample (59.50 ± 0.78 mg/100 g) and freeze-dried sample (92.50 ± 1.33 mg/100 g). This is because vitamin C is a water-soluble and heat-sensitive vitamin (Mieszczakowska *et al.,* 2021). Due to an increase in temperature, the vitamin C present in food was denatured and destroyed.

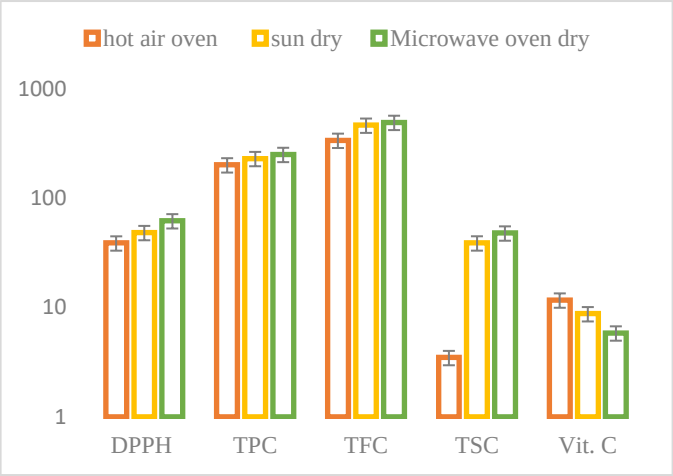

Fig 2. Proximate Composition of *Ficus Benghalensis* Fruit Powder dried under different Drying Method

3.4 Efficacy results

3.4.1 Body weight

Worldwide diabetes has been declared a serious public health issue as it is connected with chronic diseases along with an increased risk of complications. Diabetes type 2 results in severe weight loss. Thus, weight management during diabetes could provide an easy way to manage hyperglycemia. It is an important parameter in the treatment of diabetes mellitus and, the improvement of quality of life and overall health (Shaheen, 2017). In this study, the body weight of rats was measured on 0, 7th, 14th, 21st, and 28th days by using weight balance. The body weight of rats was measured and the change in weight after administration of banyan fruit powders in set concentrations was calculated. Table 2 shows the mean values of body weight on 0, 7th, 14th, 21st, and 28th day of study.

3.4.2 Blood glucose levels

Blood glucose is referred to as blood sugar level. It is the main sugar that circulates in our bloodstream and is the primary source of energy for your body's cells (Parker 2020). Blood glucose levels were enhanced in all of the diabetic-treated rats compared to control rats. The blood sample was collected from fasting subjects to determine the amount of glucose circulating in the blood (Shivkar and Joglekar, 2020).

In this study rats were given the banyan fruit powder and after 2-3 hours of powder administration, blood sugar level was checked. Blood glucose level was checked on 0, 7th, 14th, 21st, and 28th day by snipping the tail vein with a pin and using a glucometer strip for measurement and expressed in mg/dl. The statistical results regarding blood glucose in diabetic rats were influenced by different treatments during the period of study. The mean glucose values are presented in Table 3.

Fig. 3 Blood sugar checking of diabetic rats in all groups

The results showed a significant relationship between the treatment group and the time interval of the study. The reduction in blood sugar level of rats treated with banyan fruit powder was due to the presence of saponin an anti-nutrient bioactive compound present in banyan fruit powder (Siddaiah 2019). The saponin can inhibit the enzymes responsible for the breakdown of complex carbohydrates into simple ones. By inhibiting these enzymes, saponin helps in slow down the absorption of glucose in blood and thus control the sudden rise of blood sugar levels. Saponin also improves insulin secretion and insulin sensitivity which also helps in controlling the blood sugar level of the body (Jabbar *et al.,* 2023).

3.5 Conclusion

The study indicates that banyan fruit, when processed into a powder form, effectively change the proximate values in different drying and reduced blood sugar levels in diabetic rats. The study further suggests that the anti-diabetic effects are dose-dependent, with higher doses demonstrating more significant blood sugar reduction. While the study focused on type 2 diabetes, the results are promising and warrant further investigation to confirm these findings in human subjects. Additionally, identifying the specific compounds responsible for the anti-diabetic effects would contribute to the development of targeted therapies.

Table 2. Changes in Body Weight of Rats over 28 Days Following Treatment with Varying Concentration of *Ficus Benghalensis* Fruit Powder

Group	Days					
	0	**7th**	**14th**	**21st**	**28th**	**% Change**
G_0	147.33 ± 8.71 ^{abc}	170.33 ± 16.53 ^{abc}	180 ± 18.02 ^{abc}	183 ± 12.76 ^{abc}	185.2 ± 14.79 ^{abc}	+11.44
G_1	163.67 ±7.02 ^{abc}	159 ± 36.63 ^{abc}	153 ± 34.29 ^{abc}	152 ± 19.00 ^{abc}	149 ± 8.65 ^{abc}	-4.48
G_2	180.4 ± 27.02 ^{abc}	180.5 ± 26.98^{c}	184 ± 33.94 ^{c}	181.5 ± 28.99 ^{bc}	188.5 ± 27.57 ^{bc}	+2.17
G_3	163.67 ±7.02 ^{abc}	159 ± 36.63 ^{abc}	168.33 ± 41.28 ^{abc}	168.33 ± 47.38 ^{abc}	164.67 ± 40.20 ^{abc}	+3.04
G_4	200 ± 29.62^{ab}	200.33 ± 29.86 ^{ab}	211.33 ± 40.20 ^{a}	212.67 ± 36.96 ^{a}	214.6 ± 34.53 ^{a}	+3.91

The table presents the body weight (in grams) of different groups of rats (G_0, G_1, G_2, G_3, and G_4) measured at baseline (Day 0) and at weekly intervals for 28 days. Values are expressed as mean ± standard deviation. Different superscripted letters (a, b, c) within the same column indicate statistically significant differences ($p<0.05$) between the group at that specific time point. The "% change" column represents the percentage change in body weight from day 0 to day 28 for each group.

Table 3. Changes in Blood Sugar Level of Rats over 28 Days Following Treatment with Varying Concentration of *Ficus Benghalensis* Fruit Powder

Group	Days					
	0	**7th**	**14th**	**21st**	**28th**	**%Change**
G_0	104.33 ± 2.52 ^{cde}	120.66 ^{cde}	97.66 ± 6.02 ^{de}	96.33 ± 7.76 ^{de}	103.33 ± 5.0 ^{cde}	-7.74%
G_1	103.0 ± 7.81^{cde}	218.66 ± 6.02 ^{abcd}	326 ± 152 ^{a}	324 ± 129.98 ^{a}	362 ±202.51 ^{a}	+24.83%
G_2	120.33 ± 10.69 ^{cde}	131.5 ± 2.56 ^{cde}	113 ± 1.42 ^{de}	121 ± 8.48 ^{de}	120.5 ± 6.36 ^{e}	-4.36%
G_3	97.0 ± 4.58 ^{cde}	288.33 ± 14.23 ^{ab}	240.67 ± 16.78 ^{abc}	238 ± 17.87 ^{abc}	229 ± 17.95 ^{abcd}	-11.47%
G_4	118.0 ± 6.24 ^{cde}	156 ± 14.01 ^{bcde}	138 ± 12.52 ^{bcde}	136 ± 12.76 ^{cde}	122 ± 15.39 ^{cde}	-12.23%

The table presents the blood sugar level (in mg/dl) of different groups of rats (G_0, G_1, G_2, G_3, and G_4) measured at baseline (Day 0) and at weekly intervals for 28 days. Values are expressed as mean ± standard deviation. Different superscripted letters (a, b, c) within the same column indicate statistically significant differences ($p<0.05$) between the group at that specific time point. The "% change" column represents the percentage change in blood sugar level from day 0 to day 28 for each group.

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Data Availability statement

The data used in this study is available upon request from the author

Conflict of interest

The authors declare no conflict of interest.

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