Volume 3, Issue 10, 2025

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

THERAPEUTIC EFFECTS OF FOX NUT (*EURYALE FEROX*) BASED MILK-CAKE IN MANAGING TYPE II DIABETES MELLITUS

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DOI: https://doi.org/10.5281/zenodo.18160448

Keywords

Fox Nut, Type 2 Diabetes Mellitus, Tannins, Flavonoids.

Article History

Received: 30 October 2025
Accepted: 18 December 2025
Published: 31 December 2025

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Abstract

Background: *This research focuses on the impact assessment of milk cake made from Fox Nut (Euryale Ferox) on sensory properties and various health parameters over twelve weeks, including blood glucose levels, HbA1c, and anthropometrical changes like BMI.*

Objective: *The study aims to evaluate Fox Nut as a dietary ingredient for managing diabetes.*

Methodology: *A consumer acceptability test through organoleptic analysis slightly differentiated between T_0, T_1, and T_2, with T_2 exhibiting the highest acceptability.*

Results: *In T_2, the Fox Nut Milk Cake helped reduce fasting blood glucose (FBG) levels from 120.35 ± 1.53 mg/dL to 117.65 ± 0.99 mg/dL, a difference not observed in T_0 and T_1. This suggests that T_2 might be the most effective in lowering fasting blood glucose levels. Like T_1, T_2 also showed the greatest improvement in random blood glucose (RBG) after 12 weeks, decreasing from 190.1 ± 6.37 mg/dL to 177.1 ± 4.33 mg/dL, indicating improved glycolytic control. HbA1c levels in T_2 decreased from T_0 (6.1 ± 0.11%) to T_1 (5.87 ± 0.1%), demonstrating that Fox Nut helps manage chronic high blood sugar better than T_0 and T_1. Anthropometric assessments revealed the highest reduction in weight and BMI in T_2, with statistically significant results ($p < 0.05$). T_2 also led to a notable decrease in waist circumference (WC), emphasizing its benefits for central obesity.*

Conclusion: *Fox Nut-based Milk Cake in T_2 significantly improved FBG, RBG, and HbA1c levels, highlighting its potential as a therapeutic food for diabetes management. Rich in tannins, flavonoids, and pentacyclic triterpenes, with a low glycemic index, Fox Nut may support improved glycemic control and overall metabolic health in diabetic patients.*

INTRODUCTION

In recent times, Type 2 diabetes (T2DM) has emerged as one of the most common non-communicable diseases in high as well as in low and middle-income countries (Seuring et al., 2015). According to the WHO, T2DM was the largest cause of mortality in 2019, claiming 1.5 million lives. As per the International Diabetes Federation (IDF) Atlas 2021, 10.5% of the adult global population (20-79 years) has diabetes. Furthermore, by 2045, 783 million adults will be diabetic (one in eight adults), as per IDF projections. The dynamics of this disease are

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ISSN: (e) 3007-1607 (p) 3007-1593

changing. It is estimated that globally, T2DM accounted for 12% of health expenditure in 2010 at $376 billion and is expected to reach $490 billion in 2030 (Zhang et al., 2010). T2DM is one of the fastest-rising public health concerns in Asian countries, mainly due to lifestyle changes associated with economic transitions, globalization, and urbanization (Taimur et al., 2024). The total number of diabetic patients in Pakistan is 6.6 million, with the age group of 20 to 79, according to the international diabetes federation (IDF). So, if we calculate the total economic burden of diabetes mellitus in Pakistan, the average cost of diabetes management is rupees 5542. The total cost is Pakistan Rupees 36,577,200,000 per month, which is a tremendously high economic burden of diabetes in Pakistan (Hussain M et al.,2014). Pakistan is a low-middle-income country located in South Asia. According to the second National Diabetes Survey of Pakistan NDSP, the weighted prevalence of diabetes was 26.3%. (28.3% in urban areas and 25.3% in rural areas), while the prevalence of pre-diabetes was 14.4% (Abdul et al., 2018). Pakistan is the 5th most populous country in the world. The most recent IDF Atlas estimated that 33 million people are living with diabetes in Pakistan, which constitutes 3rd third-largest diabetes population globally (Sun et al., 2022). An additional 11 million adults have impaired glucose tolerance, while 8.9 million with diabetes remain undiagnosed, making it a major public health concern in the country (Bhutta et al., 2022). The high prevalence can be attributed to the poor state of non-communicable disease risk factors in the country, such as unhealthy diet, physical inactivity, increasing trends of tobacco consumption, overweight, and obesity (Rafique et al., 2018). Diabetes results from high blood sugar levels due to insufficient insulin production by the pancreas or the body's ineffective use of insulin. It can impact individuals of any age but is manageable with medication and lifestyle adjustments. The primary energy source for the body, glucose, is derived from carbohydrates. Type 2 diabetes, which is the most prevalent form of diabetes, happens when the body either doesn't produce sufficient insulin or becomes less responsive to it. This condition can impact individuals of all ages, including adults and children.

Euryale ferox seeds (EFS), called fox nuts, makhana, or gorgon nuts, have numerous health benefits and should be best consumed when a person is hungry (Yang et al., 2022). It is obtained from *Euryale ferox*, a water plant found in India, Bangladesh, Myanmar, New Zealand, Russia, Thailand, some parts of East Asia, and other places. *Euryale ferox* Salisbury, which has other common names such as fox nut, gorgon nut, prickly water lily, or makhana, is the only plant of this group. This is an aquatic plant found in South and Southeast Asia, particularly in the areas of East Asia. It mainly grows on lakeshores and other shallow water bodies. Its main growing region is in Northern Bihar, particularly the Koshi and Mithila divisions. The plant's edible seeds are considered valuable and consumed as a snack akin to popcorn (Kumari et al., 2016). This plant is an herbaceous plant without a stem, having a thick root with some features of a spiny plant. The submerged leaves can be oblong or circular, up to 6-100 cm in diameter. Makhana seeds are also referred to as the black diamonds of wetlands. Bihar accounts for an 85% share of the total production of India with an annual production of about 20000 MT, as highlighted by Arvind Kumar et al (2017). Makhana crops also need a considerable amount of effort, human energy, and resources, which implies considerable investment in human capital. These seeds are nutritional, with magnesium, potassium, and phosphorus content. They have low levels of saturated fats, cholesterol, and sodium. The weighed proximate composition analysis of popped makhana is as follows: moisture (11.92%), Dry weight (100 g) Popcorn makhana, 75.94% Carbohydrate, 9.8% Protein, 0.2% Fat, 2.32% Crude fiber, 3.36% Ash According to Nath & Kumar a study made on the seeds showed that they contain calcium (0.02%), phosphorous (0.9 %) and iron (0.0014%). Similar research indicates that popped makhana contains phosphorus of 0.0532 percent, iron of 0.0014 percent, and approximately 358 Kcal/ 100 g. While the overall

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ISSN: (e) 3007-1607 (p) 3007-1593

nutritional value of makhana shows that it contains 10-12% protein, it is considered better than many plant and animal products and is easy to digest. (Nath et al., 1985; Kumar et al., 2011; Kumar et al., 2017). The essential amino acid of unprocessed makhana seeds is found to be higher (93.63%) than in popped seeds (89.95%), and it is even more valuable than many other plant-based foods. The seeds also contain other minor ingredients like copper, sodium, calcium, iron, and magnesium, which however, are reduced during the process of starch purification, especially calcium and magnesium (Bilgrami et al., 1983). Fox nuts (makhana) are rich in Carbohydrates, Proteins, Essential Amino Acids, Flavonoids, Cyclic Dipeptides, Lipids, and Vitamin E. They offer antioxidant, antidiabetic, and anti-aging benefits and act as activators and adsorbents. Fox Nut (*Euryale Ferox*) helps protect the pancreas by increasing antioxidant enzyme levels, which shield the insulin-producing β-cells from damage caused by harmful molecules known as reactive oxygen species (ROS). This protection helps reduce the detrimental effects of diabetes on the body. Fox Nuts' anti-inflammatory properties can reduce pancreatic β-cell damage, promote glucose absorption and utilization, and improve insulin resistance, making them effective in diabetes management (Jiang et al., 2023). The pentacyclic triterpenes in fox nuts stimulate insulin release and improve lipid profiles, aiding in managing type 2 diabetes. Additionally, alkaloids in fox nuts enhance insulin secretion and improve glucose uptake in cells. Fox Nuts are classified as low glycemic index (GI) foods. Their slower digestion of carbohydrates results in a gradual and steady release of glucose into the bloodstream, which helps keep blood sugar levels more stable (Gupta, Sonawan, Bhushette, & Dabade, 2021). Type 2 Diabetes Mellitus (T2DM) is a rapidly increasing global health issue, requiring effective dietary interventions for better glycemic control. Conventional management strategies, including medications and lifestyle modifications, often have limitations, making functional foods a promising complementary approach. Fox Nut (Euryale Ferox) is a nutrient-dense food rich in tannins, flavonoids, and pentacyclic triterpenes, which exhibit antioxidant, anti-inflammatory, and anti-diabetic properties. It also has a low glycemic index (GI), making it suitable for diabetic patients. However, despite its strong nutritional profile, limited research has been conducted on its direct role in diabetes management, especially when incorporated into functional foods like milk cakes. This study aims to develop a Fox Nut-based Milk Cake and evaluate its therapeutic potential in managing T2DM by assessing its effects on fasting blood glucose (FBG), random blood glucose (RBG), HbA1c levels, BMI, and waist circumference. By providing scientific evidence on the health benefits of Fox Nut in a palatable and accessible form, this research could contribute to the development of natural, functional foods for diabetes management, reducing reliance on synthetic treatments and improving overall metabolic health.

Material and Methods

Procurement of Raw Material

Fox nuts were purchased from small shops in Lahore markets. Each fox nut was thoroughly cleaned with keenness, and ensured that all dust and dirt were well wiped off from the nuts. Then nuts with fur were subjected to a cleaning process, and after that, ground into a fine powder. This powder was then sieved out to remove any larger particles not in keeping with the fine powder status. If there were any large particles, the coarse particles were ground again for a uniform and consistent size of the powder produced. After grinding was done, the fine powdered fox nuts were put in a jar or a bowl, depending on the storage place, which should be clean and dry to avoid any spoiled fox nut powder (Nehal et al., 2015).

Volume 3, Issue 10, 2025

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ISSN: (e) 3007-1607 (p) 3007-1593

Product Development

Table: 1 T_o: Control Group, T_1: Treatment Group, T_2: Treatment Group

Groups	Wheat Flour (gm)	Fox Nut Flour (gm)	Milk (ml)	Stevia (gm)	Ghee (gm)
T_o	18	0	75	1.5	0.25
T_1	3	15	75	1.5	0.25
T_2	0	18	75	1.5	0.25

The control group was administered a milk cake made without fox nut flour supplement but with wheat flour in the amount of 18 grams. This helped establish a benchmark for other researchers to assess the qualities of a traditional milk cake. In Treatment Group 1, the milk cake was prepared by adding fox nut flour 15g and wheat flour 3g. This combination was developed to investigate the effects of replacing wheat flour partially with fox nut flour; the effects on the texture and taste of the cake were the variables of interest. Like in Treatment Group 1, Treatment Group 2 was served a milk cake in which fox nut flour was used to replace wheat flour in its entirety at 18 grams, as given in Table 1

The procedure of Fox Nut (Euryale Ferox) based Milk cake



Milk cake is prepared using 100 grams of fox nut flour, combined with 500 ml of milk, ½ teaspoon of ghee, and ¼ teaspoon of cardamom powder, with stevia added to taste. This recipe yields 10 pieces of milk cake. To prepare the milk cake, pure ghee is melted in a thick-bottomed pan. Low-fat milk is then added and brought to a simmer. Fox nut flour is gradually stirred in and cooked over low heat for 15–20 minutes until the mixture thickens. The sweetener and cardamom powder are then incorporated, and cooking continues until the mixture further thickens and begins to pull away from the pan. The thickened mixture is then poured onto a greased plate, spread evenly, and garnished with chopped nuts. After cooling to room temperature, it is refrigerated to set before being cut into pieces (Khandagale, Joglekar, Chauhan, Bainwad & Thombre, 2007).

Sensory evaluation

Each panelist is provided with samples of milk cake and scoring sheets featuring the 9-point Hedonic Scale. They are instructed to evaluate each sample based on sensory attributes, including appearance, aroma, taste, texture, and overall liking (Wichchukit & O'Mahon, 2015).

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ISSN: (e) 3007-1607 (p) 3007-1593

Treatment plan

Table 2: T_0 (Control Group), T_1 (Treatment Group), T_2 (Treatment Group)

Groups	Wheat Flour(gm)	Fox Nut Flour (gm)
T_0	18	0
T_1	3	15
T_2	0	18

In this efficacy trial, a total of 60 participants were divided into three groups of 20 each: Control Group T_0, Treatment Group T_1, and Treatment Group T_2. One control group was given a milk cake prepared using wheat flour at 18 grams without adding fox nut (Euryale ferox), which acted just like a baseline against which to evaluate the effects of traditional wheat flour on the participants. Treatment T_1 was milk cake prepared with 3 grams of wheat flour and 15 grams of fox nut flour. This was to study the effect of fox nut flour on different cake properties, along with the participants' responses. Treatment Group T_2 was fed a milk cake prepared with only 18 grams of fox nut flour to assess the findings on fox nut flour as the only type of flour, as given in Table 2. The research was designed in such a way that each group received a different formulation of milk cake, which could allow for direct comparison of the various recipes concerning acceptability and effects induced. This is structured to provide meaningful insight into the benefits that could be accrued from incorporating fox nut flour into traditional recipes, enhancing understanding of its effectiveness and nutritional value.

Study Design and Sample Size

An experimental study design was used to evaluate the effect of fox nut (Euryale ferox) based milk cake in managing Type II Diabetes. For this purpose, 60 participants, both male and female, aged between 35 and 55 years, were carefully selected to represent as wide a cross-section of the targeted demographic group as possible. In this respect, participants were divided into three groups of 20: the Control Group T_0, the Treatment Group T_1, and the Treatment Group T_2. This structure allowed for a systematic assessment of how different milk cake recipes were collectively influencing the management of Type II Diabetes (Nazari et al., 2021).

Ethical Consideration

Before the actual study and exposure of the product to participants, permission had been obtained from the Institution's Ethical Committee. The consent confirmed that the research was in agreement with ethical guidelines focusing on protection and safety for participating individuals.

Inclusion criteria and Exclusion criteria

The selection was based on a category of age: males and females aged between 35 and 55 years old. All the participants had HbA1c levels that ranged from 5.7% to 6.4%. Other participants included those with fasting blood sugar levels of between 110 and 125 mg/dL and those with random blood sugar levels of between 140 and 199 mg/dL. This was a sampling criterion used to ensure participants met the required health standards in assessing the effect of the intervention on Type II Diabetes management. Exclusion criteria included subjects below the age of 35 or above 55 years. In contrast, subjects with HbA1c below 5.7% or above 6.4%, having a fasting blood sugar less than 110 mg/dL or greater than 125 mg/dL, and having a casual blood sugar less than 140 mg/dL or greater than 199 mg/dL, were excluded from this study. Those with known allergies, those pregnant or lactating, and anyone who had taken part in any other intervention were excluded. This kind of exclusion ensured persons with serious conditions did not take part in the study and thus left the cohort with the much-needed

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ISSN: (e) 3007-1607 (p) 3007-1593

specific health criteria to study the effects of the intervention.

Anthropometric Measurements

Anthropometric data included height, weight, body mass index, and waist circumference. These anthropometric parameters analyze the participant's physical characteristics concerning the outcomes (Aamir et al., 2019).

Biochemical test

The blood glucose levels have been assessed in both pre- and post-biochemical tests for Type II Diabetes regarding HbA1c, FBS, and RBS. These represent key assessments to establish participants' glycemic control and understand the dietary interventions affecting their blood glucose regulation throughout the study. The study was designed to assess the efficacy of fox nut-based milk cake as a dietary intervention for Type II Diabetes management using a food-based approach and adding knowledge to the sections of nutritional science and diabetes management (Jeppsson et al., 2022).

Data Analysis

Data analysis was conducted using IBM SPSS Clementine Version. Statistical significance was set at a level below 5% ($p < 0.05$). The study utilized appropriate statistical methods, including analysis of variance (ANOVA). Results were presented in tables, charts, and graphs to effectively communicate findings and enhance understanding. This systematic approach to data analysis allowed for robust conclusions regarding the impact of dietary interventions on participants (Ahmad, Kumar, Verma, Shukla & Sharma, 2015).

Result and Discussion

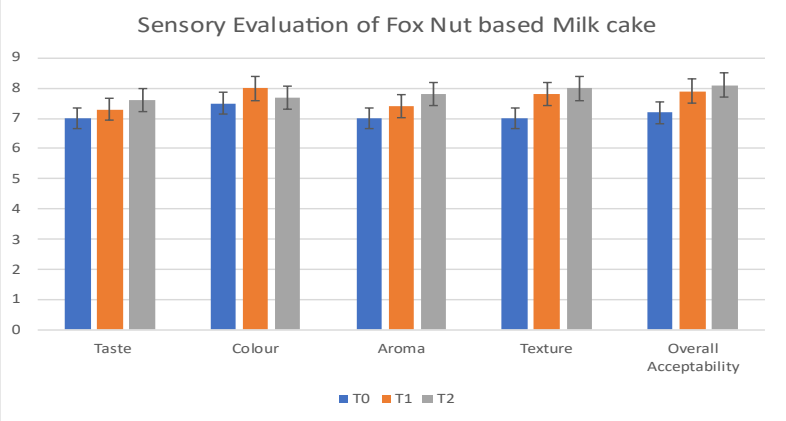


Figure: Sensory Evaluation

Sensory Evaluation

The analysis of the Milk Cake's mean square for sensory evaluation indicated no significant differences in taste, color, aroma, texture, and overall acceptability. The variations in treatments did not significantly affect the sensory characteristics, particularly aroma, taste, color, and overall acceptability. According to the Figure, a declining trend was observed in taste, color, aroma, texture, and overall acceptability from T_o to T_2.

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Table 3: Impact of Fox Nut (Euryale Ferox) based Milk Cake on Weight (kg)

Treatments	T0	T1	T2
Before	87.45±5.82	91.9±4.06	90.95±4.62
After	88.05±5.3	90.9±4.06	88.8±4.01

Weight: From the analysis regarding the effect of Fox Nut (Euryale Ferox)-based milk cake on weight, the findings indicate different results for each treatment. Treatment T_o (control) showed a slight weight gain from 87.45±5.82 kg pre-treatment to 88.05±5.3 kg post-treatment. In Treatment T_1, the patients recorded a slight decrease in weight, from 91.9±4.06 kg pre-treatment to 90.9±4.06 kg post-treatment. On the contrary, Treatment T_2 recorded the highest reduction in initial weight of 90.95±4.62 kg to 88.8±4.01 kg after the intervention, as given in Table 3. Therefore, Treatment T2 is the best among the treatments tried as far as losing weight is concerned, compared to T_o and T_1. The present study shows that the addition of Fox Nut (Euryale Ferox) to the diet reduces weight gain and improves metabolic parameters. Dietary supplementation with Fox Nut, therefore, coupled or not with calorie control or increased physical exercise, further enhances the synergistic action on body weight reduction and insulin sensitivity. This underscores that dietary modifications combined with heightened exercise significantly amplify the advantages of Fox Nut (Euryale Ferox) in tackling obesity and related metabolic issues.

Table 4: Impact of Fox Nut (Euryale Ferox) based Milk Cake on Waist Circumference (inches)

Treatments	T0	T1	T2
Before	38.4±0.82	40.1±2.79	39.47±2.36
After	40.2±1.11	39.3±1.75	36.7±0.98

Waist Circumference: Examining the effects of Fox Nut (Euryale Ferox) based milk cake on waist circumference, the results indicate varying impacts across treatments. In the control group (T0), there was an increase in waist circumference from 38.4±0.82 inches at baseline to 40.2±1.11 inches following the intervention. For Treatment T1, a small decrease in waist circumference was noted, dropping from 40.1±2.79 inches before to 39.3±1.75 inches afterward. However, Treatment T2 exhibited the most notable reduction, with waist circumference decreasing from 39.47±2.36 inches initially to 36.7±0.98 inches after the intervention, as given in Table 4. Hence, Treatment T2 proved to be the most effective in reducing waist circumference, indicating it had the greatest beneficial effect among the treatments.

Table 5: Impact of Fox Nut (Euryale Ferox) based Milk Cake on Body Mass Index (kg/m^2)

Treatments	T0	T1	T2
Before	27.99±3.97	30.4±3.61	29.87±3.57
After	28.14±3.87	30.07±3.58	29.16±3.35

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Body Mass Index: The effects of the Fox Nut (Euryale Ferox) milk cake on Body Mass Index (BMI) indicate different outcomes across the various treatments. In the control group (T0), BMI experienced a slight increase from 27.99±3.97 kg/m² before the intervention to 28.14±3.87 kg/m² afterward. Treatment T1 also reflected a minor decrease in BMI, dropping from 30.4±3.61 kg/m² before to 30.07±3.58 kg/m² after the intervention. In contrast, Treatment T2 exhibited a more significant decrease, with BMI lowering from 29.87±3.57 kg/m² to 29.16±3.35 kg/m² following the intervention, as given in Table 5. Overall, Treatment T2 proved to be the most effective in terms of reducing BMI, indicating that it had the most favorable impact among the evaluated treatments.

Blood Glucose Profile

Table 6: Impact of Fox Nut (Euryale Ferox) based Milk Cake on Fasting Blood Glucose Levels (mg/dL)

Treatments	T0	T1	T2
Before	120.55±1.73	120.6±1.62	120.35±1.53
After	120.25±1.62	119.3±1.56	117.65±0.99

Fasting Blood Glucose: In Treatment T0, the fasting blood glucose level showed a slight decline from 120.55±1.73 mg/dL to 120.25±1.62 mg/dL after the consumption of the milk cake (Wheat Flour), indicating a minimal reduction. Treatment T1 experienced a more pronounced decrease (Wheat Flour + Fox Nut), with blood glucose levels falling from 120.6±1.62 mg/dL to 119.3±1.56 mg/dL. The most significant reduction, however, was noted in Treatment T2, where the fasting blood glucose level decreased from 120.35±1.53 mg/dL to 117.65±0.99 mg/dL, as given in Table 6. Among these three treatments, T2 provided the strongest effect in terms of reducing terminal fasting blood sugar levels, outlining that this treatment may be the most efficacious. Such a decrease in T2 treatment is much more pronounced than that of T0 and T1 treatment, which reflects the greater effect of the Fox Nut-based Milk Cake in this treatment group in controlling the FBG level. Each treatment group's blood glucose levels were measured before and after the intervention.

Table 7: Impact of Fox Nut (Euryale Ferox) based Milk Cake on Random Blood Glucose Levels (mg/dL)

Treatments	T0	T1	T2
Before	190.5±5.65	190.9±5.13	190.1±6.37
After	187.55±5.05	184.8±4.42	177.1±4.33

Random Blood Glucose: Table 7 demonstrates the effects of Fox Nut (Euryale Ferox) based Milk Cake on random blood glucose levels (mg/dL) across three treatment groups: T0, T1, and T2, both before and following the intervention. Each treatment group exhibited a decrease in blood glucose levels, indicating a beneficial impact of the Fox Nut-based Milk Cake on blood glucose management. In Treatment T0, the random blood glucose level experienced a slight reduction from 190.5±5.65 mg/dL before the intervention to 187.6±5.05 mg/dL afterward, reflecting a minimal change. Treatment T1 displayed a more significant reduction, with levels decreasing from 190.9±5.13 mg/dL before the intervention to

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ISSN: (e) 3007-1607 (p) 3007-1593

184.8±4.42 mg/dL following it, suggesting a more effective response compared to T0. The highest effect was again recorded in Treatment T2, with a reduction of random blood glucose levels from 190.1±6.37 mg/dL to 177.1±4.33 mg/dL after the Fox Nut-based Milk Cake intake of the three treatments, T2 showed has highest decrease in random blood glucose level; hence it was most effective. This pronounced decrease suggests that the possible actions in glucose metabolism, as well as the random blood sugar reduction of the Fox Nut-based Milk Cake formulation used for T2, might be most effective among other treatments studied. Studies have shown that Fox Nut (Euryale Ferox) contains a good number of antioxidants and dietary constituents that help to reduce the random blood sugar levels. The α, β, and δ-Tocopherol forms of Vitamin E work as powerful antioxidants.

Table 8: Impact of Fox Nut (Euryale Ferox) based Milk Cake on HBA1c (%)

Treatments	T0	T1	T2
Before	6.11±0.13	6.12±0.12	6.1±0.11
After	6.08±0.14	6±0.12	5.87±0.1

HbA1c: Table 8 presents an in-depth analysis of the effects of Fox Nut (Euryale Ferox) based Milk Cake on HbA1c (%) levels across three treatment groups: T0, T1, and T2, measured before and after the intervention. HbA1c levels, which indicate the average blood glucose over the preceding two to three months, serve as a crucial marker for long-term glucose regulation. In Treatment T0, HbA1c levels experienced a slight decrease from 6.11±0.13% before the intervention to 6.08±0.14% afterward. While this change is modest, it still signifies a minor enhancement in long-term glucose management. Treatment T1 decreased from 6.12±0.12% to 6±0.12%. Thus, treatment T0 increased much less than treatment T1. The most pronounced decline in the level amongst all the subjected treatments was in Treatment T2, which went down from 6.1 ±0.11% pre-intervention to a low of 5.87±0.1% post-intervention. This reduction indicates a significant improvement in glucose management over the period and thus places the Fox Nut-based Milk Cake formulation used in T2 as particularly effective in bringing down the HbA1c level. Overall, all three treatments showed positive effects on HbA1c levels, although the most considerable enhancement was shown for Treatment T2, suggesting a potential benefit on long-term blood sugar control. These findings represent the possible efficacy of Fox Nut (Euryale Ferox) as a nutritional intervention for long-term glucose management and reduction in HbA1c levels. The study determined that the fat content of fox nuts is lower on a moderate level and thus can be considered a favorable option. On the contrary, their carbohydrate content is quite high, which raises problems for people having diabetes and metabolic syndrome. Besides these nutritional elements, some medicinal attributes of fox nuts can be found in the ancient Chinese and Indian medical literature. In addition to these major and micronutrients, which can be found in fox nuts, phenolic compounds and antioxidant properties provide exclusive health benefits. Flavonoids and phenolic compounds act as key components when assessing the antioxidant capacity and nutritional value of food products. Their importance in the management of different diseases has been substantiated in several studies (Lee et al., 2002; Lin et al., 2016).

Conclusion

Fox Nut (Euryale Ferox) is a nutrient-rich aquatic plant that is supposed to have a wide range of health benefits, most predominantly beneficial for diabetes and general well-being. Since it has low-calorie content, it provides a significant

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ISSN: (e) 3007-1607 (p) 3007-1593

amount of all the essential nutrients and can be an excellent diet for nutrition-oriented individuals. Besides, Fox Nut is very rich in dietary fiber, which guarantees good digestion and helps to stabilize blood sugar levels, which is particularly valuable for people suffering from diabetes. The presence of polyphenolic compounds enhances their health properties by delivering strong antioxidant effects that help fight oxidative stress and reduce inflammation. Besides, the anti-inflammatory properties of Fox Nut itself may reduce symptoms related to many inflammatory conditions and hence support metabolic health and improve insulin sensitivity. With all these properties, Fox Nut is a helpful dietary component for the maintenance of metabolic health and the reduction in the risk of chronic diseases. In other words, sensory analysis of Fox Nut-based milk cake indicated that variation in treatment application across different treatments had no serious effects on fundamental attributes such as taste, color, aroma, texture, and overall acceptability. Hence, the Mean Square analysis from this indicated no statistical differences among the treatments, though the results showed that T1 and T2 treatments had accorded flavor and aroma as well, and retained desirable texture and color. Notably, the treatment T2 demonstrated the highest reduction both in fasting and random blood glucose levels among the three treatment groups, while the noted reduction in HbA1c level further highlights the potential of Fox Nut-based milk cake to encourage long-term blood sugar regulation. Also, Treatment T2 accordingly provided the maximum reductions in both weight and waist circumference, therefore underscoring its potential for use in aiding body weight reduction and improving the metabolic profile. In the broader perspective, the results show that the incorporation of Fox Nut into milk cake formulation is of potential benefit to subjects with a desire for the management of blood sugar levels and for living a healthy life. The general health benefits and practical applications of this new food might be further investigated.

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