Development of curry leaf-based bites for diabetic patients

[1]Firdous Fatima, [2]Sumaiyya Fatima

[1]Student, M.Sc. Nutrition and Dietetics
[2]Lecturer & Research Guide, Department of Nutrition and Dietetics
St. Joseph's Degree and PG College for Women, Hyderabad, India
[1]firdoushamda7@gmail.com

Abstract—**Diabetes is a growing public health concern in India, necessitating novel and accessible approaches to manage the condition effectively. Curry leaves (Murray koenigii), traditionally used in Indian cuisine, potential benefits were noticed in managing diabetes because of their anti-diabetic, antioxidant, and their anti-inflammatory properties. Scientific studies suggest that bioactive compounds found in curry leaves, like alkaloids and flavonoids, may help lowering blood sugar levels and improving overall metabolic health. Purpose: This study developed curry leaf bites, a nutritious and flavorful snack harnessing the health benefits of curry leaves, intended to offer a functional food solution for individuals at risk of or living with diabetes.Method: The snack was formulated into three variations and faculty members from St. Joseph's Degree & PG College evaluated the product using a "nine-point hedonic rating scale" to assess sensory attributes such as appearance, taste, aroma, texture and overall acceptability. The AOAC and spectrophotometry methods were used to analyze comprehensive nutritional content, including essential nutrients and mineral composition. Statistical analysis was performed with the help of ANOVA and t-test, enabled comparisons between the formulations. Result:Sample A was identified as the most accepted variant, with optimal flavor and texture profiles. Per 100g, it contained 3.113 mg of iron and 574.8 mg of calcium, reflecting significant nutritional benefits. Statistical evaluation confirmed the panel's preference for sample A, with significant differences observed in sensory parameters. The product also demonstrated stable shelf-life under refrigerated storage conditions. Further research is needed to determine the effect of curry leaf bites on blood glucose levels.**

Keywords: Murraya koenigii , Bioactive ,Alkaloids ,Flavonoids ,Hedonic, AOAC ,ANOVA, Sensory attributes.

I. INTRODUCTION

Among the oldest illnesses, diabetes mellitus (DM) affects people all over, regardless of race, religion, or financial background. Type 2 Diabetes Mellitus is defined by high blood sugar levels, insulin resistance, and impaired insulin production. The development of this condition is shaped by interplay of genetic, environmental and lifestyle factors. Especially in underdeveloped settings such as certain parts of Africa, T2DM increases the overall risk of short and long-term consequences, often resulting from delayed decisions. T2DM can cause vivid microvascular disorders (MVC) including neuropathy, nephropathy, and retinopathy. Neuropathy might cause ulcers and pain that could impact amputation; nephropathy could cause organ failure; retinopathy could cause vision loss. Maintaining strict glycemic control-targeting HbA1C levels under 7 or, indeed, 6.5-helps to mitigate these pitfalls and thereby improves quality of life and relieves strain on healthcare systems. Though results have varied, evidence suggests that by 2025, blood sugar lowering microvascular problems are working ferociously. (1)

The global burden of diabetes Is substantial and continually rising, with developing countries like India experiencing particularly rapid increases. This trend is primarily driven by growing rates of overweight and obesity, as well as unhealthy lifestyle habits. Type 2 diabetes accounts for most diabetes cases and can lead to complications that impact various organs. There are two main categories of complications: microvascular and macrovascular. These complications significantly contribute to premature illness and death among individuals with diabetes, reducing life expectancy and imposing heavy financial and personal burdens on both patients and the healthcare system. (2)

Ingredients:

Curry Leaves (Murraya koenigii)

Research on "curry leaves (Murraya koenigii)" has highlighted their potential antidiabetic properties, showcasing their ability to manage blood glucose levels and diabetes-related complications through various mechanisms. Preclinical studies have consistently demonstrated that curry leaf extracts can lower fasting blood sugar and enhance insulin sensitivity in diabetic models. Notably, studies on diabetic rats have shown that aqueous and ethanolic extracts of curry leaves can reduce blood glucose levels by up to 48%, enhance glycogen storage, and protect pancreatic cells, thereby promoting insulin secretion. (3)

The antidiabetic effects are largely attributed to bioactive phytochemicals such as carbazole alkaloids (e.g., mahanimbine, koenimbine), flavonoids, and phenolic compounds. These compounds block carbohydrate-digesting enzymes, such as α-glucosidase and α-amylase, which slows down carbohydrate breakdown and reduces post-meal glucose spikes. The antioxidant activity of curry leaves mitigates oxidative stress, a key factor in β-cell dysfunction and insulin resistance, by scavenging free radicals and enhancing endogenous antioxidant enzymes. This antioxidant effect also contributes to renal protection, as evidenced by reductions in serum urea and creatinine in diabetic rats treated with curry leaf extracts, suggesting nephroprotective benefits. (4)

Sesame Seeds (Sesamum indicum)

Sesame seeds ability to lower blood sugar levels is linked to their distinct bioactive compounds. Lignans like sesamin and sesamolin play a central role by enhancing insulin sensitivity, reducing oxidative stress, and inhibiting enzymes involved in glucose production. These compounds also protect pancreatic beta cells from damage caused by chronic high blood sugar.

Additionally, the high fiber content in sesame seeds slows carbohydrate digestion, preventing sudden glucose spikes after meals. The seeds are also rich in magnesium, a mineral critical for regulating insulin function and glucose metabolism. Antioxidants like sesamol also fight inflammation and oxidative stress, which can lead to insulin resistance. [5]

Oats (Avena sativa)

Oats have been extensively studied for their beneficial effects on diabetes management, particularly type 2 diabetes, due to their unique nutritional components such as betaglucan, a soluble fiber known to improve glycemic control and lipid profiles. Oats also aid in weight management, an important factor in diabetes control. The fiber in beta-glucan promotes feelings of fullness, slows digestion, and can lead to reduced calorie intake and improved insulin sensitivity. A 2022 meta-analysis found that beta-glucan supplementation lowered both fasting and post-meal blood sugar levels in middle-aged adults having type 2 diabetes, underscoring its benefits for glucose control. [6]

Nuts

Chronic inflammation is closely linked to the development of atherosclerosis, they also increase the risk of cardiovascular diseases and diabetes. Inflammatory markers like interleukin-6 (IL-6) and C-reactive protein (CRP) are predictive of these conditions. Given that certain composites set up in nuts can help modulate inflammation, regular consumption may give defensive benefits against insulin resistance, a common concern for those with diabetes. Rich in colorful macro and micronutrients – including magnesium, fiber, nascence- linolenic acid, antioxidants, and monounsaturated adipose acids (MUFA) – nuts are well-equipped to combat inflammation and bolster insulin perceptivity. High magnesium input is linked to lower situations of systemic inflammation and bettered insulin response, while salutary fiber helps regulate postprandial blood sugar situations. The healthy unsaturated fats present in nuts also contribute appreciatively to metabolic health. Also, the antioxidants set up in nuts may play a vital part in regulating seditious processes, thereby reducing the threat of habitual conditions. Overall, the substantiation underscores the significance of including nuts in the diet for individualities with diabetes, as they can help improve inflammation and reduce associated health pitfalls. [7]

Quinoa (Chenopodium quinoa)

Quinoa is increasingly recognized as a beneficial food for aids in diabetes management due to its low glycemic index (GI) and rich nutrient profile, and bioactive compounds that support blood glucose regulation and metabolic health. With a GI of approximately 35–53, quinoa causes a slower, steadier rise in blood sugar compared to higher-GI staples like rice and wheat, helping to prevent sharp postprandial glucose spikes that challenge insulin regulation in diabetes Quinoa's high fiber content, especially insoluble fiber composed of galactose, xylose, and glucose, slows carbohydrate digestion and enhances satiety, thereby helping regulate blood sugar and reduce hunger. [8]

Pearl Millet (Pennisetum glaucum)

Hyperglycemia can induce chronic inflammation and increase reactive oxygen species (ROS), resulting in vascular dysfunction. Consequently, heightened oxidative stress and inflammation further compromise insulin sensitivity and secretion. Controlling the overproduction of reactive oxygen species (ROS) is crucial for delaying the onset of diabetes and preventing cardiovascular complications. Pearl millet contains bioactive compounds like polyphenols, flavonoids, and phenolic acids, which have potent antioxidant and anti-inflammatory properties, helping to reduce oxidative stress and inflammation, thereby providing potential health benefits and supporting overall well-being. By harnessing the anti-inflammatory and anti-oxidant effects of pearl millet's bioactive compounds, individuals may be able to reduce their risk of developing diabetes and cardiovascular disease.[9]

Coconut Powder (Cocos nucifera)

Renowned for its versatility, the coconut tree (Cocos nucifera L.) holds immense value due to its wide array of nutritional and medicinal benefits. The coconut plant is entirely utilized, with every part – including tender coconut water, kernel, copra, oil, cake, toddy, shell, wood, leaves, and coir pith – finding diverse applications, particularly in traditional coconut-growing areas. This widespread use highlights the coconut's essential role as a natural resource, not only providing vital nutrients in the human diet but also supplying important compounds used in the production of medicines and a range of industrial products.[10]

Dates (Phoenix dactylifera)

Dates have demonstrated notable benefits for diabetes management, as supported by both animal and human studies. The polyphenolic and flavonoid content in dates and date palm pollen has been shown to exert hypoglycemic effects, improve lipid profiles, and offer antioxidant protection. For example, a study on alloxan-induced diabetic rats found that supplementation with date palm pollen or its extracts significantly reduced serum glucose levels, improved lipid profiles, and enhanced renal and liver function. These outcomes are linked to the high levels of polyphenols, flavonoids, and essential minerals such as magnesium, zinc, and selenium, which play key roles in insulin action, glucose uptake, and antioxidant defense. The mechanism is thought to involve a multi-faceted approach, including inhibiting key enzymes involved in digesting carbohydrates (alpha-glucosidase and alpha-amylase) to slow down glucose release, stimulating insulin secretion to regulate blood sugar levels, and protecting pancreatic β-cells from oxidative stress and injury to preserve their function and support long-term glucose health.[11]

II. METHODOLOGY

A.Formulation of the recipe

Curry leaf bites were created as a standard product by collecting fresh curry leaves, washing, and air-drying them. The curry leaves were then roasted in ghee, cooled, and ground. Separately, oats, almonds, cashews, coconut powder, dates, and sesame seeds were roasted, cooled, and ground individually. All the ingredients were then mixed together and shaped into cubes.

Two variations of the product were created:

Variation 1 by replacing oats with Pearl millet.

Variation 2 by replacing oats with Quinoa.

Table 1: List of formulations prepared

INGREDIENTS	SAMPLE A	SAMPLE B	SAMPLE C
Curry leaves	8g	8g	8g
Oats	30g	-	-
Pearl millet	-	30g	-
Quinoa	-	-	30g
Almonds	14g	14g	14g
Cashews	16g	16g	16g
Sesame seeds	30g	30g	30g
Coconut powder	20g	20g	20g
Dates	30g	30g	30g
Ghee	5ml	5ml	5ml

DEVELOPMENT OF BITES:

Assemble the required ingredients

↓

Measure ingredients precisely

↓

Prepare the curry leaves

(wash, dry, light roast)

↓

Gently roast all items

↓

Grind each item individually

↓

Allow to cool and combine ingredients

↓

Mold the Mixture into elegant little cubes

↓

Storage

Figure 1: Process flow chart for preparing curry leaf bites

B.SENSORY EVALUATION

Sensory evaluation involves rating food items using a hedonic rating scale, which requires participants to rate how much they like or dislike a product on a scale from "dislike extremely" to "like extremely". This method helps determine the overall consumer preference for a product based on personal enjoyment.

The sensory evaluation was carried out on three developed products of curry leaf bites: Sample A, Sample B, and Sample C, with one serving as a control. The panelists included 100 participants, comprising faculty members from various departments, including the Faculty of Nutrition and Dietetics, as well as students from different departments of St. Joseph's Degree and PG College.

The attributes evaluated included appearance, color, flavor, texture, taste, and overall acceptability. Each attribute was rated on a 9-point hedonic scale, with scores ranging from 9 (Like Extremely) to 1 (Dislike Extremely): Like Extremely (9), Like Very Much (8), Like Moderately (7), Like Slightly (6), Neither Like nor Dislike (5), Dislike Slightly (4), Dislike Moderately (3), Dislike Very Much (2), and Dislike Extremely (1).

C.PHYTOCHEMICAL ANALYSIS

Estimation of Phytochemicals in Curry Leaves

Test for Alkaloids,Flavonoids,Saponins,Phenols,Tannins:

Procedure:

To test for the presence of alkaloids, take 1 mL of the curry leaf extract in a test tube, add a few drops of Mayer's reagent to the extract, and observe the mixture for any precipitate formation.To test for the presence of flavonoids, take 1 mL of the curry leaf extract in a test tube, add a few drops of 10% H2SO4 (sulfuric acid) to the extract, and then add 1 mL of ammonia solution to the mixture.To test for the presence of sapnins, take 2 mL of the curry leaf extract in a test tube, add water to the extract, and then shake the mixture vigorously.To test for the presence of phenols, take 1 mL of the curry leaf extract in a test tube and add a few drops of Ferric Chloride ($FeCl_3$) solution to the extract.To test for the presence of tannins, take 1 mL of the curry leaf extract in a test tube and add a few drops of 5% Ferric Chloride ($FeCl_3$) solution to the extract.(12)

D.NUTRITIONAL ANALYSIS

Estimation of moisture and ash content

Procedure:

To determine moisture content, accurately weigh 50-100g of the curry leaf bites sample and transfer it into a pre-weighed moisture dish, spreading it evenly. Then, dry the sample in a hot air oven at 125°C for 3 hours. After drying, cover the dish and cool it in a desiccator for 30 minutes. Finally, weigh the dish rapidly and record the weight.To determine ash content, weigh a suitable amount of the curry leaf bites sample into a crucible of known weight. Then, set the muffle furnace to 600°C and place the crucible in the furnace using metal tongs. Incinerate the sample for 2 hours and repeat the process until a constant weight is achieved, indicating complete ashing.

ESTIMATION OF IRON CONTENT OF FOODS BY WONGS METHOD

Procedure:

The iron content of foods was estimated using Wong's method, a spectrophotometric technique.

The procedure for Estimation of Iron involves preparing 7 test tubes: a Blank with 6.5 mL distilled water, Std 1-5 with 1-5 mL standard solution and decreasing amounts of distilled water (5.5 to 1.5 mL), and a Sample with 6.5 mL ash solution. All tubes receive 1 mL of 30% H_2SO_4, 1 mL of 7% Potassium persulphate, and 1.5 mL of 30% potassium thiocyanate solution.

Measurement of Absorbance

To measure absorbance for iron estimation, measure the red color developed within 20 minutes at 540 nm in a calorimeter after zeroing with the blank. Record absorbance (O.D values) of standard and sample solutions. Construct a calibration curve by plotting iron concentration on the x-axis and absorbance at 540 nm on the y-axis. Compute the iron concentration in the sample from the calibration curve. Calculate the iron content per 100g of sample considering the dilution factor of the ash solution and the sample weight.(13)

ESTIMATION OF CALCIUM BY TITRIMETRY METHOD

Procedure:

Take 2 ml of the sample solution into a graduated glass centrifuge tube (15 ml. Capacity). Add, 2ml of deionized water followed by 2ml Of ammonium oxalate solution and mix thoroughly and leave overnight. The next day, mix the contents and centrifuge for 5 minutes at 1500 rpm. Discard the supernatant without disturbing the precipitated. Drain the residual supernatant by inverting the tube on a rack (care should be taken not to disturb the precipitate). Wipe the mouth of the centrifuge tube with a piece of filter paper. Stir the precipitate and wash the sides of the tubes with 3ml of dilute ammonia. Centrifuge again and drain as before. Wash the precipitate once more with dilute ammonia to ensure the Complete removal of ammonium oxalate. To the washed precipitate, add 2ml of in H_2SO_4 and mix. Place the tube in boiling water bath. until all the precipitated is dissolved and then titrate the hot solution with standardized potassium permanganate solution taken in a micro burette to a pale pink end point that persist at least for a minute also conduct a blank titration using in h_2 so4 (2ml) against 0.01n kmno4 solution to a definite pink color persisting for at least 1 minute.

E.STATISTICAL ANALYSIS

The study employed statistical analysis to evaluate product quality and consumer perception, utilizing Analysis of Variance (ANOVA) to compare sensory attributes such as appearance, color, taste, texture, flavor, and overall acceptability among three product samples. This analysis helped identify significant differences and possible interactions among factors. Furthermore, t-tests assuming unequal variances were conducted to quantitatively assess the differences between the Basic sample and Variable 1, and between the Basic sample and Variable 2, providing insights into whether observed variations were likely due to real differences or merely random chance, thereby determining the statistical significance of the differences between the samples.

IV.RESULTS AND DISCUSSION

A.SENSORY EVALUATION RESULTS OF THE DEVELOPED PRODUCT

Figure 2:picture of the food product

APPEARANCE

In the case of the curry leaf product, the mean appearance scores were observed to be 8.7 for Sample A, 8.4 for Sample B, and 8.19 for Sample C. The superior score of Sample A suggests that its visual attributes were more favored, possibly due to a more vibrant colour or better consistency in shape and size.

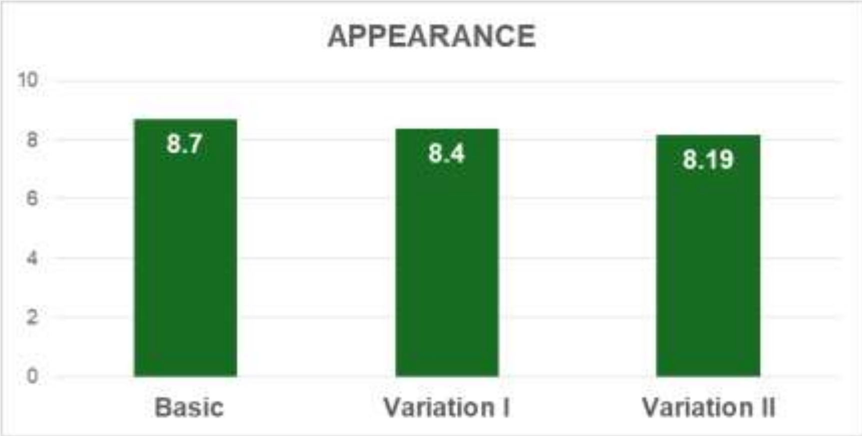

Figure 3: Mean appearance scores of curry leaf product samples

COLOUR

In the sensory assessment of colour for the curry leaf-based product, the mean scores were 8.53 for Sample A, 8.34 for Sample B, and 8.17 for Sample C. The relatively higher score for Sample A suggests superior colour quality, which may be attributed to optimal formulation or processing, resulting in a more appealing hue.

Figure 4 :Mean colour scores of curry leaf product samples

TASTE

For the curry leaf product, the mean taste scores were 8.45 for Sample A, 8.17 for Sample B, and 7.83 for Sample C, resulting in an overall average score of 8.15. The superior taste score of Sample A suggests that it possessed a more favorable and balanced flavor profile, likely due to optimal formulation..

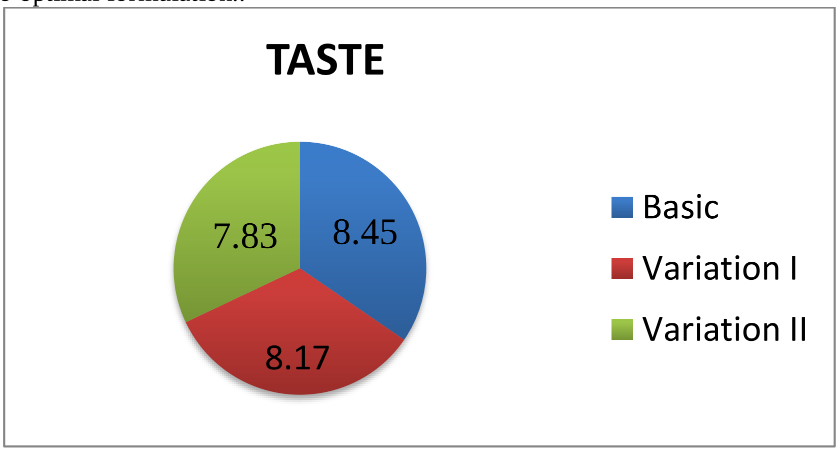

Figure 5: Mean taste scores of curry leaf product samples

TEXTURE

For the curry leaf-based product, the mean texture scores were 8.44 for Sample A, 8.16 for Sample B, and 7.90 for Sample C, with an overall average of 8.16. The higher score for Sample A suggests it offered a more desirable texture that was well received by the panelists.

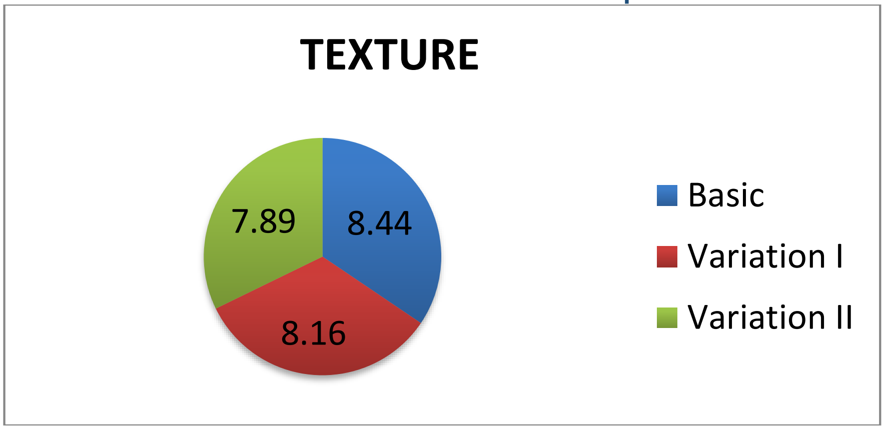

Figure 6: Mean texture scores of curry leaf product sample

FLAVOUR

. In this study, the curry leaf-based product had mean flavour scores of 8.67 for Sample A, 8.37 for Sample B, and 8.24 for Sample C, making the average score 8.43. The slightly higher score for Sample A suggests that it offered a more balanced and enjoyable flavour, likely because of how the curry leaves and other ingredients complemented each other.

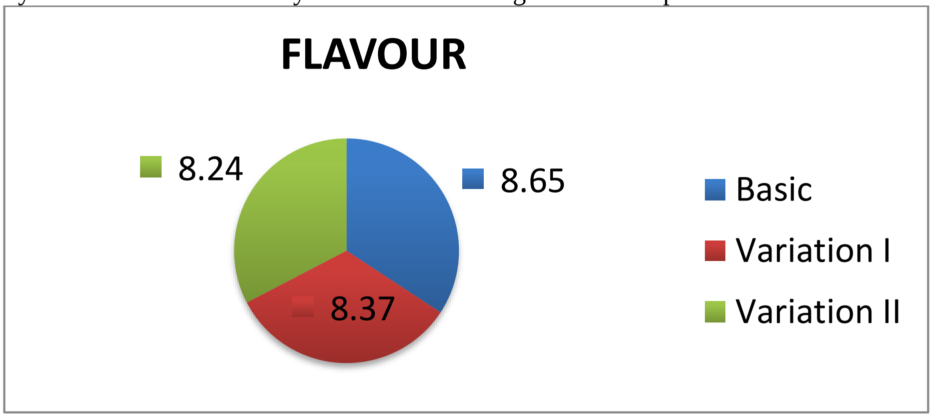

Figure 7: Mean flavour scores of curry leaf product samples

OVERALL ACCEPTABILITY

Overall acceptability is a comprehensive measure that reflects how appealing a product is to consumers based on their combined sensory impressions. For the curry leaf-based product, the mean scores for overall acceptability were 8.57 for Sample A, 8.29 for Sample B, and 8.07 for Sample C, with an average score of 8.31. The highest score for Sample A indicates that panelists found it most satisfactory in terms of appearance, taste, texture, and flavour. The slightly lower scores for Samples B and C suggest that these variations were less preferred, possibly due to subtle differences in formulation or sensory attributes that made them less appealing as a whole.

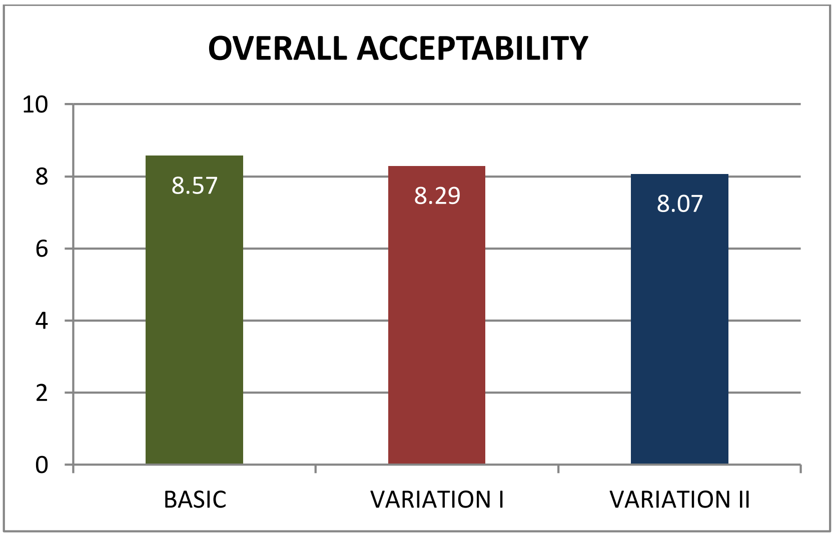

Figure 8: Mean overall acceptability scores of curry leaf product samples

B.SHELF LIFE OF THE PRODUCT

Shelf life refers to the duration of time a product remains safe to consume, retains its desired sensory, chemical, physical, and microbiological characteristics, and complies with any label declaration of nutritional data when stored under recommended conditions. It is a crucial factor for food products as it directly impacts quality, safety, and consumer satisfaction.

The curry leaf bites product was stored under two different conditions: refrigerated and non-refrigerated, to evaluate its shelf life and quality retention over a period of 2 months. Under refrigerated conditions, the product maintained its texture, taste, and aroma consistently throughout the storage period. In contrast, non-refrigerated storage resulted in a noticeable change after one and a half months, characterized by a loss of shine, resulting in a lighter appearance, although the taste and aroma remained relatively stable, highlighting the importance of refrigeration in preserving the product's quality attributes.

C.ANALYSIS OF IRON AND CALCIUM CONTENT IN FOOD SAMPLES

Estimation of moisture

Table 2: Moisture Content in Food Sample

Food sample	Moisture content percentage
A	2%
B	5%
C	7%

The moisture content analysis reveals that the three food samples have varying levels of moisture. Sample A has the lowest moisture content at 2%, while Sample C has the highest at 7%. Sample B falls in between with a moisture content of 5%. This information is crucial in understanding the shelf life and storage requirements of these food samples.

Estimation of ash content

Table 3: Ash Content in Food Sample

Food sample	Ash percentage
A	21.8%
B	36.6%
C	21.4%

The ash content analysis shows that the three food samples have different levels of ash content. Sample B has the highest ash content at 36.6%, indicating a higher mineral content. Samples A and C have relatively similar ash content, with 21.8% and 21.4%, respectively.

ESTIMATION OF IRON

Table 4: Iron Content in Food Sample

Sample	Iron content (mg / 100g)
A	3.11
B	5.76
C	4.57

The results indicate that Sample B has the highest iron content, followed by Sample C, and then Sample A. This suggests that Sample B is the richest source of iron among the three samples analyzed.

ESTIMATION OF CALCIUM

Table 5: Calcium content in food samples

Food sample	Calcium content (mg /100g)
A	574.8
B	537.33
C	662.3

The results indicate that Sample C has the highest calcium content, followed by Sample A, and then Sample B. This suggests that Sample C is the richest source of calcium among the three samples analyzed.

D.PHYTOCHEMICAL ANALYSIS

TABLE 6: Phytochemical analysis results of standard sample

Phytochemical Constituents	Presence / Absence
Alkaloids	+
Flavonoids	+
Saponins	+
Phenols	+
Tannins	+

The phytochemical analysis results show that the curry leaf bites product contains a diverse range of bioactive compounds. The analysis reveals that Alkaloids, Flavonoids, Phenols, Saponins, and Tannins are all present. This suggests that the product has potential medicinal or nutritional value due to the presence of these compounds. The presence of these phytochemical constituents can contribute to the product's antioxidant, anti-inflammatory, and other beneficial properties. Overall, the results highlight the key findings and implications for the potential health benefits of the curry leaf bites product.

E.STATISTICAL ANALYSIS RESULTS

Table 7: Mean scores of sensory evaluation of all three samples

SENSORY ATTRIBUTES	STANDARD	VARIATION I	VARIATION II
Appearance	8.7	8.4	8.19
Colour	8.53	8.34	8.17
Taste	8.45	8.17	7.83
Texture	8.44	8.16	7.89
Flavor	8.66	8.37	8.24
Overall acceptability	8.57	8.29	8.07

Table 8: ANOVA Results

SOURCE OF VARIATION	Df	F ratio	P value	F critical	P value interpretation
Columns	5	17.47	0.000117	3.325	Significant

The sensory evaluation scores of Curry Leaf Bites were statistically a analyzed using two-way ANOVA, which revealed a significant difference between the mean scores of the three samples, as indicated by a p-value less than 0.05, as shown in the table above.

STATISTICAL COMPARISON OF SENSORY ATTRIBUTES BETWEEN BASIC AND MODIFIED PRODUCT SAMPLES USING T -TEST

The results of the t-test comparing the sensory attributes of Sample 1 (Basic) and Sample 2 (Variation 1) are presented below.

Table 9: Statistical analysis of sensory attributes (basic vs. Variation I)

PARAMETER	BASIC	VARIATION I	P VALUE(ONE TAIL)	P VALUE (TWO TAIL)	STATISCALLY SIGNIFICANT (P<0.005)
Mean	8.56	8.29	0.0008	0.0012	Yes
Variance	0.011	0.010			

Table 10: Statistical analysis of sensory attributes (basic vs. Variation II)

PARAMETER	BASIC	VARIATION II	P VALUE(ONE TAIL)	P VALUE (TWO TAIL)	STATISCALLY SIGNIFICANT (P<0.005)
Mean	8.56	8.07	0.00015	0.00030	Yes
Variance	0.011	0.028			

The t-test analyses presented in both the tables consistently showed statistically significant differences between the two product samples across sensory attributes. In both the specific attribute (e.g., appearance) and the overall sensory evaluation, the p-values (both one-tail and two-tail) were well below the 0.05 threshold, demonstrating that the modifications in the Variation sample resulted in perceptible and statistically meaningful changes as compared to the Basic sample

F.COMPARISON OF IRON AND CALCIUM CONTENT OF THE FOOD PRODUCT TO THE NUTRITIVE VALUE OF THE PRODUCT

TABLE 11: Comparison of calculated and IFCT values of iron and calcium across three variations

S.no	Variation	Iron (calculated mg)	Iron (IFCT VALUE)	Calcium (calculated mg)	Calcium (IFCT VALUE)
1.	**Basic**	3.11	9.99	574.8	519.6
2.	**Variation I**	5.76	10.78	537.33	512.8
3.	**Variation II**	4.57	11.1	662.3	564.0

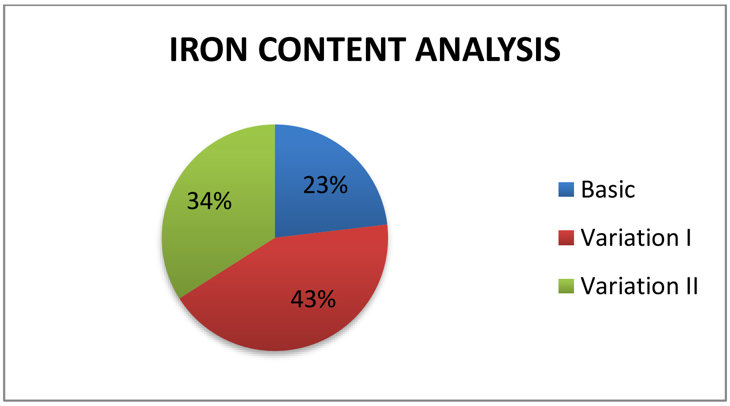

Figure 9: Distribution of Iron in different samples

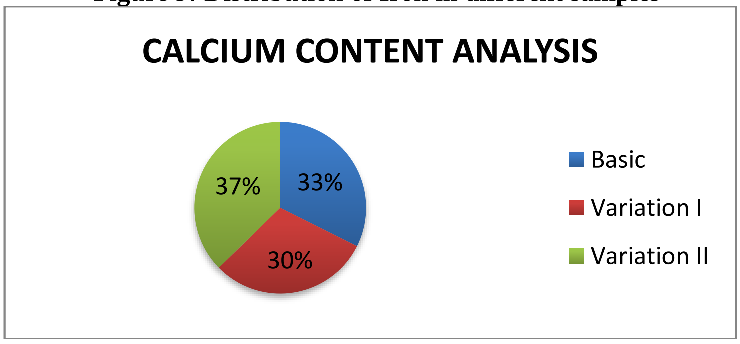

Figure 10:Distribution of Calcium in different samples

The template is used to format your paper and style the text. All margins, column widths, line spaces, and text fonts are prescribed; please do not alter them. You may note peculiarities. For example, the head margin in this template measures proportionately more than is customary. This measurement and others are deliberate, using specifications that anticipate your paper as one part of the entire proceedings, and not as an independent document. Please do not revise any of the current designations.

V.CONCLUSION

The development of Curry Leaf Bites, a nutritious snack incorporating the health benefits of curry leaves, shows promise as a healthy snack option. While its optimal flavor, texture, and nutritional profile make it appealing, the true potential of Curry Leaf Bites in managing diabetes remains unexplored due to the lack of clinical trials with diabetes patients. Although the curry leaves used in the snack have recognized anti-diabetic properties and the product is rich in iron and calcium, its efficacy in supporting blood sugar management can only be confirmed through rigorous clinical trials. Further research is necessary to investigate the optimal dosage and formulation of curry leaves, conduct sensory evaluations across diverse groups, and most critically, conduct clinical trials with diabetes patients to validate its health benefits. Until such trials are conducted, the full potential of Curry Leaf Bites as a nutritious complement to diabetes management remains speculative.

VI.ACKNOWLEDGEMENT

I am thankful to the almighty ALLAH for his grace, and to the principal, Mrs.Sridevi Sangani of St.Joseph's College, for providing me with the opportunity to complete this work.I would like to extend my special thanks to my guides, Ms. Sumaiyya Fatima, Mrs.Sadath Fatima and Ms.Sadiya kauser as well as my mother ,family and friends ,for their constant support and guidance.

REFERENCE

[1] Ekoru, K., Doumatey, A., Bentley, A. R., Chen, G., Zhou, J., Shriner, D., Fasanmade, O., Okafor, G., Eghan Jr, B., Agyenim-Boateng, K., Adeleye, J., Balogun, W., Amoah, A., Acheampong, J., Johnson, T., Oli, J., Adebamowo, C., Collins, F., Dunston, G., Adeyemo, A., & Rotimi, C. (2019). Type 2 diabetes complications and comorbidity in Sub-Saharan Africans. EClinicalMedicine, 16, 30–41. https://doi.org/10.1016/j.eclinm.2019.09.001

[2] Pradeepa, R., & Mohan, V. (2021). Epidemiology of type 2 diabetes in India. Indian Journal of Ophthalmology, 69(11), 2932–2938. https://doi.org/10.4103/ijo.IJO_1627_21

[3] Papule, P. P., Khandagale, D., Sonawane, N. S., & Randive, P. S. (2024). Review on Murraya koenigii (curry leaf) for antidiabetic activity. International Journal of Current Science and Pharmacy, 14(1), Article IJCSP24C1011. https://rjpn.org/ijcspub/papers/IJCSP24C1011.pdf

[4] Rekha, U. V., Bhuminathan, S., & Ravi Shankar, P. (2021). Anti–Diabetic Activity of Murraya koenigii – A Comprehensive Review. Journal of Pharmaceutical Research International, 33(58B), 462–470. https://doi.org/10.9734/jpri/2021/v33i58B34226

[5] Yargholi, A., Najafi, M. H., Zareian, M. A., Hawkins, J., Shirbeigi, L., & Ayati, M. H. (2021). The effects of sesame consumption on glycemic control in adults: A systematic review and meta-analysis of randomized clinical trials. Evidence-Based Complementary and Alternative Medicine, 2021, Article 2873534. https://doi.org/10.1155/2021/2873534

[6] Chen, V., Zurbau, A., Ahmed, A., Khan, T. A., Kendall, C., & Sievenpiper, J. L. (2022). Effect of oats and oat ß-glucan on glycemic control in diabetes: A systematic review and meta-analysis of randomized controlled trials. BMJ Open Diabetes Research & Care, 10(1), e002686. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9438016/

[7] Casas-Agustench, P., Bulló, M., & Salas-Salvadó, J. (2010). Nuts, inflammation and insulin resistance. Asia Pacific Journal of Clinical Nutrition, 19(1), 124–130. https://apjcn.qdu.edu.cn/19_1_9.pdf

[8] Marak, N. R., Das, P., Das Purkayastha, M., & Baruah, L. D. (2024). Effect of quinoa (Chenopodium quinoa W.) flour supplementation in breads on the lipid profile and glycemic index: An in vivo study. Frontiers in Nutrition, 11, 1341539. https://doi.org/10.3389/fnut.2024.1341539

[9] Pei, J. J., Umapathy, V. R., Vengadassalapathy, S., Hussain, S. F., Rajagopal, P., Jayaraman, S., Veeraraghavan, V. P., Palanisamy, C. P., & Gopinath, K. (2022). A review of the potential consequences of pearl millet (Pennisetum glaucum) for diabetes mellitus and other biomedical applications. Nutrients, 14(14), 2932. https://doi.org/10.3390/nu14142932

[10] DebMandal, M., & Mandal, S. (2011). Coconut (Cocos nucifera L.: Arecaceae): In health promotion and disease prevention. Asian Pacific Journal of Tropical Medicine, 4(3), 241-247. https://doi.org/10.1016/S1995-7645(11)60078-3

[11] ElHayani, A. A., Ahmed, A. E., ElSayed, M., & Farahat, M. (2021). Effect of Egyptian Date Palm Pollen (Phoenix dactylifera L.) and Its Hydroethanolic Extracts on Serum Glucose, Lipids Profile, and Renal-Hepatic Functions in Alloxan-Induced Diabetic Rats. Scientia Pharmaceutica, 89(1), Article 107267. https://www.scirp.org/journal/paperinformation.aspx?paperid=107267

[12] Sophiyamole, L., Reshma, J. K., Prabhachandh, R. S., & Babychan, N. (2017). Phytochemical analysis of Murraya koenigii in urban and coastal area. Journal of Emerging Technologies and Innovative Research (JETIR), 4(10), 238–242. http://www.jetir.org/papers/JETIR1710037.pdf

[13] AOAC International. (2005).Official Methods of Analysis(18th ed.). AOAC International https://www.aoac.org/official-methods-of-analysis/