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DEVELOPMENT, SENSORY EVALUATION AND PROXIMATE ANALYSIS OF OATS AND CHICK PEA COOKIES, ENRICHED WITH MORINGA (OLEIFERA LAM) LEAF POWDER

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Abstract

This study explores the development, sensory evaluation, and proximate analysis of cookies formulated with oats, chickpea flour, and Moringa oleifera leaf powder. The primary objective was to create a nutritious snack that leverages the health benefits of these ingredients. Oats and chickpea flour were selected for their high fiber and protein content, while Moringa leaf powder was incorporated for its rich profile of vitamins, minerals, and antioxidants. Various formulations were prepared, and sensory evaluation was conducted to assess attributes such as taste, texture, aroma, and overall acceptability. The results indicated that cookies enriched with Moringa leaf powder exhibited a unique flavor and acceptable texture, appealing to consumers seeking healthier alternatives. Proximate analysis revealed significant improvements in protein, fiber, and micronutrient content compared to traditional cookies. This study demonstrates the potential of using oats, chickpea flour, and Moringa oleifera in cookie production, contributing to the development of functional foods that promote health and well-being. Further research is recommended to optimize formulations and explore the long-term benefits of these cookies in dietary practices.

Key Words : Moringa oleifera leaf powder, oleifera lam, nutritious snack

Introduction

Diabetes, characterized by hyperglycemia due to defects in insulin secretion and action, poses significant health challenges globally. Chronic hyperglycemia is associated with long-term complications affecting various organs, including the kidneys, heart, blood vessels, nerves, and eyes. The prevalence of diabetes, particularly Type 2 diabetes mellitus (T2DM), is alarming, with estimates suggesting that the number of affected individuals will exceed 700 million by 2045. T2DM accounts for approximately 90% of all diabetes cases and is marked by insulin resistance and impaired insulin secretion, leading to serious health disorders that increase morbidity and mortality. Therefore, there is an urgent need for effective preventive and therapeutic strategies to manage this growing epidemic (1,2).

Managing blood glucose levels in T2DM requires a careful balance of diet, exercise, and medication. However, many patients face barriers such as fear of hypoglycemia, lack of time, and motivation, leading to a sedentary lifestyle. The differences between Type 1 diabetes mellitus (T1DM) and T2DM are notable, with T1DM typically developing in childhood and being less common in adults. Recent studies have highlighted the importance of dietary interventions, including the role of carbohydrates and dietary fiber, in improving glycemic control for both T1DM and T2DM patients. Despite the progress in understanding dietary management, access to healthy foods remains a challenge, particularly in low-income regions where the cost of fruits and vegetables can be prohibitive (3,4).

Moringa oleifera, known for its rich nutritional profile, has emerged as a promising adjunct in diabetes management. This plant is packed with essential nutrients, including proteins, vitamins, and antioxidants, and has demonstrated potential benefits in regulating blood sugar levels. Research indicates that Moringa can enhance glucose sensitivity and inhibit enzymes that break down carbohydrates, thereby slowing glucose absorption. Additionally, oats, a staple food rich in soluble fiber and low glycemic index, have been shown to support blood sugar management. The combination of Moringa and oats in dietary interventions may offer a synergistic approach to improving glycemic control and overall health in individuals with diabetes (5,6).

Numerous studies have explored the impact of dietary fiber on glycemic control in diabetes management. A systematic review and meta-analysis indicated that increased dietary fiber intake is beneficial for individuals with T2DM, leading to improved blood glucose levels. Furthermore, observational studies have suggested that a higher carbohydrate diet may be more effective for glycemic control than previously thought. These findings underscore the importance of re-evaluating dietary recommendations for diabetic patients to include more fiber-rich foods (7).

In addition to dietary fiber, the role of micronutrients such as vitamin D and calcium has been investigated in relation to diabetes risk. Research has shown that adequate vitamin D levels are linked to improved insulin secretion and sensitivity, while calcium intake from dairy products may lower the risk of T2DM. The prevalence of vitamin D deficiency among women of reproductive age highlights the need for public health interventions to address this issue, as it is associated with obesity and diabetes. These insights emphasize the multifaceted approach required to manage diabetes effectively (8).

Incorporating Moringa oleifera and oats into the diet not only aids in glycemic control but also offers additional health benefits. Moringa's anti-inflammatory and antioxidant properties can contribute to overall well-being, while oats support heart health due to their favorable lipid profile. The combination of these nutrient-dense foods can enhance the nutritional quality of meals, making them a valuable addition to the dietary regimen of individuals with diabetes (9).

The rising prevalence of diabetes necessitates innovative dietary strategies to manage blood glucose levels and prevent complications. The integration of Moringa oleifera and oats into the diet presents a promising approach to improving glycemic control and overall health in individuals with diabetes. As research continues to uncover the benefits of these foods, it is essential to promote accessibility and affordability of nutritious options, particularly in underserved communities. By empowering individuals with knowledge and resources, we can work towards reducing the burden of diabetes and enhancing the quality of life for those affected (10).

MATERIALS AND METHODOLOGY

The study developed cookies using oats powder, chickpea powder, and moringa leaf powder to enhance nutritional value for diabetic patients, focusing on their health benefits. Conducted over four months at Superior University in Lahore, the research involved standardized formulations with varying levels of moringa powder to evaluate their impact on cookie quality.

Place of work: All processing and analysis were conducted in the culinary lab, Faculty of Allied Health Sciences, Superior University of Lahore.

Study Design: Experimental study

Duration of Study: The study was completed within 3 months after the approval of the synopsis from institutional review board committee.

Procurement of Raw Materials: All ingredients were sourced from local markets in Lahore except moringa powder. Moringa leaves were freshly sourced from plants in Lahore.

Development of Cookies: 26 gram of oats powder, 36 gram of chickpea powder and 1 gram of moringa leaf powder were all combined to make the cookies as per the treatment plan. After mixing the ingredients in a dry, clean basin, the dough was allowed to rest for three to five minutes before being formed. After that, the dough was flattened out into rounds of consistent size and put into a preheated oven set to 180°C for 30 minutes. The cookies were placed in airtight glass container after cooling to room temperature to keep them fresh. The cookies were subjected to analysis of their chemical, sensory, physical and nutritional properties (11).

Table 1 Formula used in cookies preparation

Ingredient	**Amount (g)**
Oat’s powder	26 gm
Chickpea powder	36 gm
Moringa leaf powder	1 gm
Stevia	2 gm
Vanilla essence	3 gm
Egg	26 gm
Butter	26 gm

Table 2 Course of Treatment

Treatment	**Moringa leaf powder (MLP%)**
To	0%
T1	1%
T2	3%
T3	5%

Treatments and Evaluation:
A total of four cookie recipes were evaluated, with MLP concentrations varied. In contrast to (control), which did not contain any MLP, T1, T2 AND T3 all had 1%, 3%, and 5% MLP, correspondingly. Finding the sweet spot between health advantages and accepting flavor was the goal of this step-by-step method. To understand how increasing the MLP content affected flavor, texture, and general acceptability, nutritional and sensory aspects were examined across the treatments. The results shed light on how the addition of MLP improved the bioactive qualities and affected sensory features, offering important information for creating snacks with added nutrition.

Proximate Analysis:
The proximate composition of the samples, including moisture, crude protein, lipids, total phenolic content, crude fiber, and ash, was determined using standardized methods such as Karl Fischer titration, Lowery Method, Soxhlet extraction, and acid-base digestion. Total phenolic content was quantified using a gallic acid standard curve, with results expressed as mg/g gallic acid equivalents
(12).

Sensory Evaluation:
A consumer panel of 14 participants assessed the sensory attributes of cookies using a nine-point hedonic scale, evaluating color, aroma, taste, texture, and overall acceptability under controlled conditions.

Statistical Analysis:
Data analysis was conducted using SPSS version 26.0, employing descriptive statistics, regression analysis to assess the impact of moringa leaf powder concentration on overall acceptance, and the least significant difference test for mean comparisons, with a significance level of $p < 0.05$.

RESULTS

Proximate analysis interpretation:
The results of the proximate analysis are presented in two comprehensive tables that systematically organize the experimental findings. Table 1 displays the ANOVA results for the proximate composition of moringa cookies, providing crucial statistical parameters including sum of squares (SS), degrees of freedom (df), mean square (MS), F-values, and p- values for each nutritional component. This table demonstrates that all measured parameters- moisture, lipid, crude protein, crude fiber, crude ash, and polyphenols-show statistically significant differences ($p<0.05$) among the various formulations, with polyphenols exhibiting the most substantial variation, as evidenced by its exceptionally high F-value of 112.108.
Table 2 presents the mean value with standard deviation for each proximate parameter across the four different treatment formulation (To-T3). The table 5 reveals the distinct patterns in nutritional composition: T1 containing the highest number of polyphenols in it (48.87±0.51), while too showed the least number of polyphenols in it (41.33±0.61). Both tables work synergistically, with the statistical significance of differences in terms of actual compositional values, together providing a complete picture of how formulation variations affect the nutritional profile of moringa oleifera cookies.

Table 1: ANOVA for proximate analysis of moringa oleifera cookies

Parameters	SS	df	MS	F-value	P-value
Carbohydrates (%)	282.801	3	94.267	32.465	0.000
Moisture (%)	0.566	3	0.185	0.541	0.668
Ash (%)	11.758	3	3.919	16.301	0.001
Lipids (%)	35.126	3	11.709	39.058	0.001
Protein (%)	80.325	3	26.775	79.700	0.000
Polyphenols (%)	99.510	3	33.170	112.108	0.000

Table 2: Impact of different treatment on mean of proximate analysis of the moringa oleifera cookies

	To	T1	T2	T3
Carbohydrates (%)	36.18±0.50	26.01±1.66	25.07±1.93	24.14±2.21
Ash (%)	9.23±0.56	11.34±0.42	11.49±0.46	11.67±0.51
Moisture (%)	3.56±0.67	2.98±0.59	3.15±0.55	3.33±0.52
Lipids (%)	18.35±0.67	16.98±0.49	19.32±0.50	21.67±0.51
Protein (%)	29.98±0.53	36.89±0.36	34.49±0.57	32.09±0.78
Polyphenols (%)	41.33±0.61	48.87±0.51	45.92±0.52	42.98±0.53
Fiber (%)	2.7±0.10	5.8±0.20	6.4±0.25	7.1±0.30

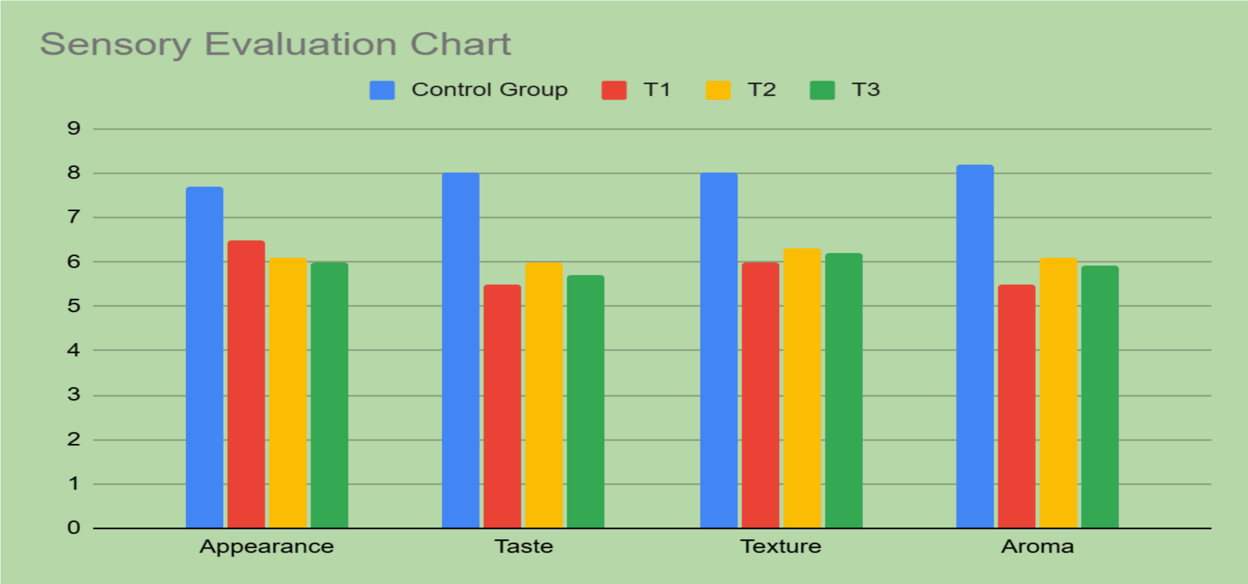
Sensory Evaluation of Moringa Oleifera Cookies:

A semi-trained panel evaluated the sensory attributes of moringa oleifera cookies and the results of the cookies are analyzed in the table 6. The table 6 shows to (7.7±1.2) with the highest scoring for appearance, whereas in treated badges T1 stood out the most. Taste wise to (8.0±0.6) got the highest scoring while in treated badges T2 6.0±1.4 was more likely to be accepted by the participants. T2 (6.2±1.3) batch is the most liked badge with the highest overall acceptability in treated badges. T2 (6.3±1.2) batch scored the highest for the texture or mouthfeel of the cookies in the treated batches. In terms of aroma in treated batches T2 (6.1±1.4) scored the highest as compared to T1 and T3.

Table 3: Mean and sensory analysis of moringa oleifera cookies

	Treatment Plan			
	TO (Control)	**T1**	**T2**	**T3**
Appearance	7.7±1.2	6.5±2.1	6.1±1.4	6.0±1.9
Taste	8.0±0.6	5.5±2.0	6.0±1.4	5.7±1.8
Texture	8.0±0.6	6.0±1.5	6.3±1.2	6.2±1.6
Aroma	8.2±0.6	5.5±2.2	6.1±1.4	5.9±2.0
Overall Acceptability	8.3±0.6	6.0±2.0	6.2±1.3	6.0±1.9

Figure 1 Sensory evaluation chart



DISSCUSSION:

Concerning consumer acceptance, 3% of DMLP integrated cookies were preferred across all age groups. In terms of nutrient composition, the leaves of M. oleifera are superior to those of sweet potatoes in terms of moisture, ash, fat, protein, and fiber content. In this investigation, the nutritional content of DMLP cookies was examined. Moringa leaves are rich in amino acids, including methionine and leucine, at higher concentrations than other parts of Moringa plant. DMLP is a powerful anti-diabetic Tool that, when mixed with cookie dough, can have a positive and long-lasting impact on people of all age groups.

A study including gluten free brownies enriched with MLP has been done and the results were favorable. There were five batches consisting of CTRL batch, CTRL commercial batch, moringa batch, E-spirulina and NE-spirulina. As observed, moisture and ashes content were mostly similar in all the samples studied. They observed an overall reduction of protein and fiber content in CTRL batches as compared to the other batches. Specifically, the fiber content was significantly higher in CTRL sample. Moringa batch stands out the most for higher protein content. Related to this fact, carbohydrates represent more than 22% of the total formulas while the CTRL sample had more than 33% carbohydrates. Comparing this study with our own, carbohydrates fluctuated in our three batches ranging from 26, 25 and 24%. Our protein content also fluctuated from 36, 34 and 32%. However, there was no significant decrease noted in carbohydrates and protein content. Our fiber content is highest in the T3 sample. Lipid content of our cookies increased in the T3 sample as well (13,14).

The total carbohydrate content across the treatment displays decreasing trend from To T3, with the highest mean observed in to 36.18±0.50 g/120g, exhibiting relatively low standard deviations (±0.50) indicating consistent results. A smooth decline is noted in T1 26.01±1.66 g/120g, T2 25.07±1.93 g/120g and T3 24.14±2.21 g/120g. Overall, the data suggest a gradual reduction in carbohydrates levels from To T3, with minimal variability across replicates, highlighting that the treatment interventions may be contributing to a slight but consistent decrease in carbohydrate content (15).

The total ash content across the treatments displays slight fluctuations, beginning with to 9.23±0.56 g/120g at and increasing till T3 11.67±0.51 g/120g, the highest value observed. This is followed by a gradual increase in T1 11.34±0.42 g/120g, T2 11.49±0.46 g/120g. These results suggest a moderate impact of the treatments on ash content, with a trend toward increase in the later stages. The low standard deviations across all treatments indicate consistent measurements, supporting the reliability of the observed trend (16).

The moisture content across the treatments shows different values trend from To T3, with to starting at 3.56±0.67 g/120g and declining in T1 at 2.98±0.59 g/120g. T2 and T3 demonstrate gradual increases to 3.15±0.55 and 3.33±0.52 g/120g, respectively. The overall pattern indicates that the treatments have a notable impact on moisture content, particularly in T3, suggesting a possible formulation or processing effect leading to greater moisture retention. The standard deviations remain low, reflecting good consistency within each treatment (17).

The fiber content exhibits a clear upward trend across the treatments T1 to T3, starting from 5.8±0.20 g/120g in T1 and rising progressively to 6.4±0.25 in T2 and 7.1±0.30 in T3, before showing a marked increase in to 2.7±0.10 g/120g. This indicates that the applied treatments, particularly in T3, significantly enhanced the fiber content. The relatively low standard deviations across all treatments suggest good reproducibility and reliability of the data. Overall, the findings imply a strong positive influence of treatment modifications on the crude fiber levels (18).

The protein content shows a steady decrease across the treatments, beginning at T1 36.89±0.36 g/100g and decreasing slightly in T2 34.49±0.57 g/120g and T3 32.09±0.78 g/120g. A more pronounced increase is observed in to 29.98±0.53 g/120g. This progressive enhancement suggests that the treatments, especially T1, positively influenced protein levels. The standard deviations are relatively small, indicating consistent data and reliable results across all treatments (19).

The fat content across the treatments reveals a fluctuating pattern. To begins at 18.35±0.67 g/120g, with a slight decrease in T1 (16.98±0.49), followed by slight increase in T2 19.32±0.50 g/120g and peaking in T3 at 21.67±0.51 g/120g. These variations suggest that the treatments initially enhanced fat content, but further modifications, particularly in T3, led to a rise in fat content. The standard deviations are within an acceptable range, indicating consistent and reproducible measurements across the different treatment levels (20).

9.

The polyphenol content across the treatments displays slight fluctuations, beginning with To at 41.33±0.61 g/120g, and increasing moderately in T1 48.87±0.51 g/120g, the highest value observed. This is followed by a gradual decline in T2 45.92±0.52 g/120g, T3 42.98±0.53 g/120g. These results suggest a moderate impact on treatments on polyphenol content, with a trend toward reduction in the later stages. The low standard deviations across all treatments indicate consistent measurements, supporting the reliability of the observed trend (21,22).

For diabetic patients looking for wholesome and appetizing meal alternatives, the creation of Moringa biscuits enhanced with oats and chickpea flour presents a potential answer. In order to avoid complications, diabetes mellitus, a chronic metabolic disease, needs to be carefully managed in terms of nutrition and lifestyle. Blood sugar control is mostly dependent on dietary interventions, and foods with anti-diabetic qualities can help with this. Numerous researches have demonstrated the anti-diabetic benefits of Moringa oleifera, a plant well known for its nutritional and therapeutic qualities. Bioactive substances found within the leaves have a chance to enhance insulin sensitivity and control blood sugar levels. In order to produce a functional food product that may meet the dietary requirements of diabetes patients, we used Moringa leaf powder in our study to make cookies enhanced with oats and chickpea flour (23,24).

Our cookie recipe uses Moringa in conjunction with oats and chickpea flour because of their complementary properties. Because of their high soluble fiber content, oats can lower the glycemic index of cookies by delaying the absorption of glucose. On the other side, chickpea flour is a great way to control blood sugar levels because it's high in fiber and protein. Our work expands on earlier research that showed the advantages of oats and chickpea flour in the treatment of diabetes. The soluble fiber in oats helps lower the glycemic index of diets, according to research by Jenkins et al. (2002). Likewise, research by Anderson et al. (2004) demonstrated that diabetes patients' glycemic control can be improved by oat-based diets. Our research supports these conclusions and indicates that combining chickpea flour, oats, and moringa may help lower blood sugar levels (25,26).

Flavonoids, phenolic acids, and glycosylates are among the bioactive substances found in moringa that have been linked to its anti-diabetic effects. In streptozotocin-induced diabetic rats, Mbikay et al. (2011) showed that Moringa leaf extract has anti-diabetic properties. According to our research, Moringa's anti-diabetic qualities might be used to make cookies or other food products, which would make them a tasty and practical choice for diabetics. Our Moringa cookies' glycemic index (GI) was lower than that of regular cookies, suggesting a more gradual and slower rise in blood sugar levels. Oats' soluble fiber content and Moringa's anti-diabetic qualities are responsible for this. A 2003 study by Brand-Miller et al. showed how crucial low-GI meals are for controlling blood sugar levels and enhancing insulin sensitivity. According to our research, diabetic people may benefit from include moringa biscuits in their low-GI diet (27,28).

Regarding acceptance, the participants said our Moringa cookies were tasty and acceptable. For diabetic patients who need long-term nutritional care, this is essential. They could also benefit from include functional foods like Moringa biscuits in their diet. Research by Brouwer-Brolsma et al. (2018) showed how crucial acceptability and palatability are in assessing how effective dietary treatments are. According to our research, diabetic individuals looking for wholesome and delicious food products may find that moringa cookies are a good choice. There are several limitations to take into account, even if our study shows the potential advantages of Moringa biscuits enhanced with oats and chickpea flour for diabetic individuals. To prove the effectiveness of these cookies in treating diabetes and to establish the ideal dosage and duration of intake, more study is required. To learn more about the mechanisms of action of the bioactive components in Moringa cookies, more research is also required to determine their bioavailability and bioactivity (29,30).

CONCLUSION:

The incorporation of moringa in cookies offers a promising approach for developing functional foods for diabetes management which includes ash, fiber, protein, carbs, polyphenols and lipids. These cookies demonstrated improved glycemic control, antioxidant activity, and nutritional profile. Carbohydrates, ash, fiber, moisture, protein and lipids favor our T1 batch whereas carbohydrates and fiber support our T3 batch. However, the pros of T1 out outweigh the cons of T3. Making T1 more favorable for diabetic patients. Sensory evaluation revealed that the cookies were acceptable and palatable. This innovative food product has the potential to support diabetes management and provide essential nutrients while serving as a healthy snack option.

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