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Formulation and analysis of modified food product: 'Namkeen crackers' for type 2 diabetes mellitus

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Abstract

Introduction: Diabetes is an autoimmune chronic disease with steadily increasing prevalence. Managing diabetes with nutrition is the core of its management process. The main aim of the study was to develop nutritious 'Namkeen Crackers' enriched with cereals and seeds as a healthy snack option for diabetic's population. The objectives of the study were to standardize the therapeutic product, to conduct sensory evaluation to check the acceptability of the product, to evaluate the nutritional parameters of the product and to perform the microbial analysis to study the shelf life of the product.

Methodology: The study consisted of four phases including standardization of the product, followed by the sensory evaluation, next the nutritional parameters of the product were evaluated, and lastly microbial analysis of the product was performed.

Results: The 'Namkeen Crackers' were golden brown in colour with a crunchy texture and a delicious aroma. The panel approved the taste and texture of the crackers. The nutritional evaluation showed high dietary fibre and protein content which is beneficial for diabetics. The microbial analysis revealed that the product can be stored for up to 30 days in an airtight container.

Conclusion: Namkeen crackers were a nutritious snack alternative for diabetic individuals. The combination of cereals & seeds enriched the food with dietary fibre and protein, thereby reducing craving & promoting satiety. Additionally, these crackers besides being nutrient dense, were free of preservatives, additives, and artificial colour without compromising taste or texture.

Keywords: Diabetes, crackers, cereals, seeds, high fibre, high protein

Introduction

Diabetes is a chronic condition brought on by either insufficient insulin production by the pancreas or insufficient insulin utilisation by the body. A hormone called insulin controls blood sugar levels. Uncontrolled diabetes frequently causes hyperglycaemia, also known as high blood glucose or raised blood sugar, which over time can seriously harm many different bodily systems, including neurons and blood vessels. (WHO, 2022) [15]

There are three main types of diabetes: type 1, type 2, and gestational diabetes (diabetes while pregnant). Type 1 diabetes is thought to be caused by associate reaction (the body attacks itself by mistake). This reaction prevents your body from producing insulin. T1DM affects approx. 5-10% of all diabetics. Diabetes symptoms usually appear quickly. It is diagnosed in children, teenagers, and young adults. Individuals with type 1 diabetes must rely on regular insulin dosage to survive. With type 2 diabetes, body does not use hormones properly and cannot maintain normal blood glucose levels. Type 2 diabetes affects approximately 90-95% of diabetics. It develops over time and is sometimes diagnosed in adults (but increasingly in children, teenagers, and young adults). & a gestational condition characterised by an elevated blood glucose level during pregnancy that usually resolves after the birth. If diabetes is not treated, it has the potential to cause serious health problems such as nephrosis, vision loss, & cardiovascular disease over time depending on the type of diabetes.

Diabetes, along with respiratory illnesses, cancer, and cardiovascular disease (CVD), is one of the most serious global health issues of the 21st century. According to the (WHO), non-communicable diseases killed 74% of people worldwide in 2019; diabetes was responsible for 1.6 million of those deaths, making it the 9th leading cause of death worldwide. Diabetes is expected to kill nearly 592 million people by 2035. T2DM, previously thought to be a disease of the wealthy "Western" nations, has spread globally and is now a leading cause of disability

and mortality for increasingly younger age groups.

Diabetes mellitus can be managed with healthy eating, regular exercise, weight loss, possibly, diabetes medication or insulin therapy & Blood sugar monitoring. These steps will help to keep blood sugar level closer to normal, which can delay or prevent complications. (Soliman, 2019) [13]

As previously stated, the role of diet in the aetiology of T2DM was proposed by Indians who observed that the disease was almost entirely confined to wealthy people who consumed excessive amounts of oil, flour, and sugar. Whereas few studies have found a strong link between T2DM and a high carbohydrate and fat intake. Many studies have found a link between a high sugar intake and the development of T2DM. After controlling for dietary, demographic, anthropometric, and lifestyle factors, it was discovered that the frequency of obesity increased with each additional serving of carbonated drinks consumed. Food intake has been strongly linked to obesity, not only in terms of volume but also of diet composition and quality. Consumption of red meat, sweets, and fried foods increases the risk of insulin resistance and T2DM.

In contrast, an inverse relationship was found between functional food consumption and T2DM. because they are high in nutrients, fibre, and antioxidants, which act as a protective barrier against the disease. (Sami *et al.*, 2017) [16] Functional foods contain biologically active ingredients that have been linked to physiological health benefits in the prevention & management of chronic disease (T2DM). A daily consumption of practical foods may even be linked to increased antioxidant, medication, hypoglycaemic agent sensitivity, and anti-cholesterol functions, all of which are thought to be important in the prevention and management of T2DM. Fruits, vegetables, oily fish, olive oil, and tree nuts are examples of sensible foods because of their natural content of nutraceuticals such as polyphenols, terpenoids, flavonoids, alkaloids, sterols, pigments, and unsaturated fatty acids.

Studies have shown that Fatty fish helps fight inflammation, omega-3s in fish-oil supplements increase adiponectin levels within the blood, a hormone that supports glucose regulation. polyunsaturated fatty acid fatty acids will facilitate lower the degree of triglycerides & stop the hardening of the arteries. (Alkhatib *et al.*, 2017) [11]

Moth beans were discovered to have the highest phenolic content and antioxidant activity of any known antioxidant. Underutilized food legume moth beans have potential as nutraceuticals, especially for diabetic individuals since they are high in nutritional fibre and have a low glycaemic index. Consuming moth bean thus provides important nutraceuticals that are advantageous to human health. As a result, including protein from moth bean legumes in the creation of functional meals with enhanced therapeutic potential is a huge step toward enhancing health and well-being.

Both flax seeds & fenugreek have been shown to have a positive effect on diabetes, as they may improve many of its risk factors, Due to their high fibre content, are thought of a low-glycaemic food. This implies that intense them won't spike your glucose levels & promoting glucose management. This is due in part to their soluble fibre content, specifically mucilage gums, which slow food digestion and reduce the absorption of certain nutrients such as sugar. Flax seeds contain high amounts of lignan, which acts as a powerful antioxidant. Antioxidants are believed to improve insulin sensitivity and slow the development of diabetes (Goyal *et al.*, 2014) [6]. Research showed that fenugreek seeds decreased the glucose absorption rate. If fenugreek will cut back the

absorption of high glucose levels within the intestine, it's going to facilitate lower the chance of symptom. (Saadh, 2020) [10] (Gromova *et al.*, 2021) [5]

Thus, a snack option containing goodness of antioxidants, protein, good quality fats and dietary fibre providing functional foods were utilised to develop Namkeen Crackers which can prove to be healthy snack option for diabetics.

Aim and Objectives

Aim

To develop nutritious 'Namkeen Crackers' enriched with cereals and seeds as a healthy snack option for diabetic's population.

Objectives

- To standardize the therapeutic product - Namkeen crackers for diabetic population.
- To conduct sensory evaluation to check the acceptability of the product.
- To evaluate the nutritional parameters of the product
- To perform microbial analysis on the product to study the shelf life of the product.

Methodology

Phase 1

Standardization of the Product

Collection of Ingredients

In the present study, the Namkeen Crackers were developed using the following ingredients, moth bean flour (25g), gram flour (15g), semolina (10g), flaxseeds (10g), fenugreek seeds (10g), ajwain (to taste) and oil (2.5g).

Procedure

Firstly, sprouted fenugreek seeds were dried and ground to powder. Then, all ingredients were combined in a deep bowl and knead into a soft dough with enough water. The dough was then allowed to rest for 10-15 mins. Meanwhile, oven was set to preheat. The dough was then divided into equal portions. Each portion was rolled into a big circle like a *chapati*. A cookie cutter was used to cut them into a desired shape and size. A toothpick was used to make holes all over the base. Lastly, they were placed on a baking tray and brushed lightly with oil. Crackers were baked for around 15-25 mins at 10 °C till they turned golden brown. Crackers were cooled completely and stored in an airtight container.

Phase 2

Sensory Evaluation of the Product

The Namkeen Crackers were prepared as described above and given for sensory evaluation.

For this study, the panel included 4-5 females. The product was presented to them, and they were asked to taste it and then evaluate based on 6 different characteristics as follows, appearance, taste, aroma, texture, innovation, and overall acceptability. The scores were recorded on a sensory score card using the 5- point Likert scale and the panellist were asked to comment and score on the overall acceptability of the product.

Phase 3

Evaluation of the Nutritional Parameters of the Product

The nutritional content of the ingredients present in these Namkeen Crackers were analysed using the Indian Food Composition Tables (IFCT) Book (2017).

Phase 4

Microbial Analysis of the Product

Microbial analysis was conducted to study the shelf life of the product. It was conducted using the pour plate method, which is the method of choice for counting the number of colonies forming bacteria present in a specimen.

Procedure

All the instruments, flasks, and media that were required for the procedure were sterilized. The sample was then suspended in sterile water to prepare a liquid solution. For inoculation, 1 ml of the diluted sample was poured from the petri-dish. 15-18 ml of molten agar was heated and poured onto the sample. The lid of the dish was then closed and swirled slowly. The plate was left to solidify. Lastly, the plate was inverted and incubated at an optimal temperature (usually 37 °C) for 24-48 hours. After incubation, the plates were observed for viable colony counts.

Results and Discussions

Phase 1

Standardization of the product

Table 1: Standardization

Ingredients	Amt (g/ml)
Matki flour (moth bean)	25
Besan	15
Semolina	10
Fenugreek seeds	10
Flaxseeds	10
Oil	2.5

The following table implicates the proportion of each ingredients used to develop the product. The table indicates total 1 whole serving which delivers approx. 12-15 crackers.

The United States Department of Agriculture (USDA) defines a standardized recipe as one that has been tried, adapted, and retried several times for use by given foodservice operation and has been found to produce the same good results and yield every time when the exact procedures are used with the same type of equipment and the same quantity and quality of ingredients.

The advantages of standardization to a food service include the same consistency of food prepared every time and nutrient content with the food cost and inventory controlled. Moreover, product taste and appearance will be the same from cook to cook. In addition to these, efficient purchasing will be done as the cook will know how much quantity is required for a certain product and guesswork will be eliminated. It will also help in minimizing the effects of employee turnover on food quality. It aids in portion and yield control, cost control and consistent nutrient content.

Phase 2

Sensory Evaluation of the Product

The crackers formulated for diabetic specific populations appeared to be golden brown in color which was quite appetizing with a crunch in texture and had a delicious aroma making the product appealing yet nutritious.

In addition to this the crackers appeared to be in circle and had sharp edges which gives them unique and attractive shape similar to biscuits. The taste of the crackers was salty which makes it a perfect snack option and can be used as a combination with a sip of tea or any other beverages.

In addition to this the aftertaste according to the evaluators was a slight bitter due to the presence of fenugreek seeds. However, it did not much affected as there was no hard bitterness found during aftertaste because there were no chemical leavening agents used like baking powder, baking soda, etc. which can add even more bitterness to the crackers. The crispiness of the crackers was appreciated by most of the panelists. Majority of the panelists found the product to be innovative due to its shape, texture and taste and thereby serving as a great snack alternative for diabetics.

Phase 3

Evaluation of the Nutritional Parameters of the Product.

Table 2: Nutritional Composition

Ingredients	Amt (g/ml)	Energy (kcal)	Carbs (g)	Protein (g)	Fats (g)	Fibre (g)
Moth bean flour	25	77	13	4.96	0.44	3.78
Gram flour	15	58	8.67	3.36	1	1.62
Semolina	10	33	6.84	1.14	0.11	0.97
Fenugreek seeds	10	24	1.06	2.54	0.57	4.76
Flaxseeds	10	44	1.1	1.86	3.57	2.62
Oil	2.5	22	-	-	2.5	-
Total		258 Kcal	30.67 g	13.84 g	8.19 g	13.75
% Distribution		100%	48%	23%	29%	

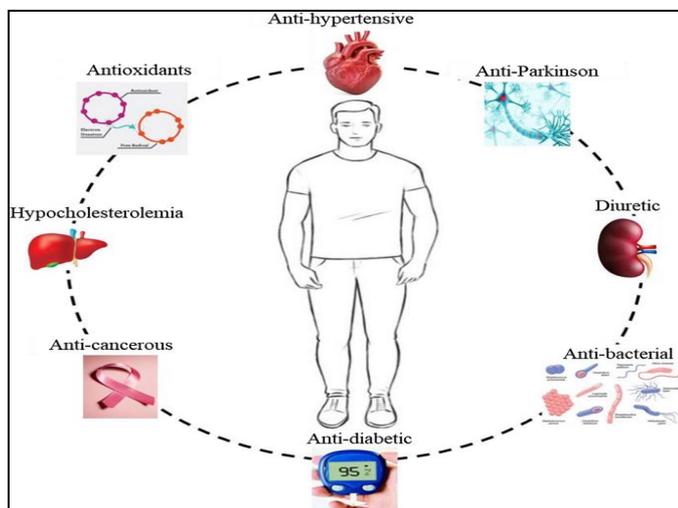
The Nutrients that were examined under Nutritional Composition included energy, proteins, carbohydrates, fats, Fibre. Each crackers provided 17 kcal of energy, 2 g of carbohydrates, 1 g of protein, 0.5 g of fats and 1 g of fibre.

The product provides 258 kcal as energy, 30.67 g of carbs, 13.84 g of protein, 8.19 g of fats and 13.75 g of fibre. Overall, the product constitutes 23 percent of protein and fibre and thereby contributing to better glycemic control especially in diabetics.

Matki flour is the main base ingredient of the developed product which is prepared from moth beans serve abundant food protein source besides carbohydrate, fatty acids, minerals and vitamins. Additionally, the level of antioxidant and polyphenol contents in moth beans are substantial. Moth bean legume has several health benefits capable of preventing cardiac diseases, diabetes and obesity to humans, if consumed regularly.

Moth bean is a food legume belongs to family Fabaceae. Agronomically, it prospers in tropical environment and cultivated on infertile soil too. Consequently, it is grown and consumed in South-East Asia. Rajasthan state of North Central India leads major moth bean producing regions due to crop supporting climatic conditions. Moth bean is predominantly a Kharif crop, cultivated and harvested in Indian subcontinent's monsoon season, which last from June to November. Moth bean seems a versatile pulse crop and provide a source of food, fodder, feed and green manure for animal husbandry. It constitutes an economical source supplement for protein deficiency.

Findings recognized moth bean as an alleged source of nutrition both by way of macro and micro micronutrients and certain bioactive components showing antioxidant, anti-diabetic, antihypertensive activities. Seeds of moth bean are appreciated due to high protein contents and carbohydrates associated with an adequate amount of minerals (Ca, Mg, Fe, Zn, and Mn), vitamins (niacin and ascorbic acid), essential amino acids and unsaturated fatty acids.



Source: Bhadkaria *et al.*, 2022^[2]

Fig: Pharmacological effects of matki flour on human health

Gram flour, commonly called besan, is a staple flour in the Indian kitchens. It is made from dried garbanzo beans that have been ground into a fine powder. This is due to its high protein and fibre content, which may help prevent insulin resistance, a condition that impairs your body's ability to regulate blood sugar levels efficiently. It also has a naturally dense texture and strong binding properties, making it a great vegan and gluten-free substitute for wheat flour. Interestingly, gram flour is sans gluten, which makes it an ideal choice for the weight watchers too.

Research carried out at Harvard has associated consumption of legumes with a lower GI. The high fibre content in besan also lowers absorption of blood sugar, which is the core of diabetics. Hence besan is now quoted as the superfood which can even help lower sugar levels even in Type-2 diabetic people.

Semolina is a coarse flour made from durum wheat, a hard type of wheat. Semolina is high in protein and fiber B vitamins like thiamine and folate, which have many important roles in your body, including helping convert food into energy. Additionally, semolina is a good source of iron and magnesium. These minerals support red blood cell production, heart health, and blood sugar control. Semolina may improve blood sugar control due to its high levels of magnesium and dietary fiber. Maintaining healthy blood sugar levels is an important factor in reducing your risk of type 2 diabetes and cardiac complications. Magnesium improves blood sugar control by increasing your cells' response to insulin, a hormone that regulates your blood sugar levels.

According to studies, magnesium-rich diets have been associated with up to a 14% reduced risk of diabetes. Semolina is also rich in fiber, a nutrient essential for blood sugar control. Studies have revealed that Fiber slows the absorption of carbs into your bloodstream, helping control blood sugar spikes after a meal. It can also lower fasting blood sugar levels in people with diabetes. Additionally, diets rich in fiber may reduce hemoglobin A1c levels in people with diabetes by up to 0.5 percent

According to studies, Fenugreek seeds (*Trigonella foenum graecum*), a commonly used condiment in Indian homes, were evaluated for hypoglycemic property and it was found that incorporation of fenugreek produced a significant fall in fasting blood glucose levels and an improvement in glucose tolerance test. Insulin responses were significantly reduced. There was a 64 percent reduction in 24 hr urinary glucose

excretion with significant alterations in serum lipid profile. Serum total cholesterol, LDL and VLDL cholesterol and triglyceride levels decreased without any alteration in HDL cholesterol fraction with fenugreek diet.

Another study concluded that a daily dose of 10 grams of fenugreek seeds help control type 2 diabetes and the following crackers contains 10g of fenugreek thereby leading to better blood glucose management.

Flaxseed contains 32 percent to 45 percent of its mass as oil of which 51 percent to 55 percent is α -linolenic acid. Flax lignan complex and secoisolariciresinol diglucoside (SDG) have been isolated from flaxseed. Flaxseed and its components have antioxidant, hypolipidemic and hypoglycemic effects. These are mostly due to the SDG content. Oxidative stress has been implicated in both type 1 and type 2 diabetes. Flaxseeds aids in prevention from oxidative stress and thereby induces anti diabetic properties.

Phase 4

Microbial Analysis of the Product

Microbial Analysis of the following developed product was performed through pour plate method. This method often is used to count the number of microorganisms in a mixed sample, which is added to a molten agar medium prior to its solidification. It is a plating technique that is commonly used for obligate and anaerobic bacteria. This technique is used to isolate microbial colonies by serial dilution and then counting the colony forming units (CFUs).

After incubation of the sample, the plates were observed for viable colony counts. The total count of colonies obtained were 25 CFU/ml and also was not reported as - too numerous to count (TNTC) and no repetition was required for dilution.

The shelf life of the product was also studied. Shelf-life is the length of time a food can be kept under stated storage conditions while maintaining its optimum safety and quality. The shelf-life analysis revealed that the product can be stored for up to 30 days in an airtight container so that it doesn't gets exposed or affected by the environmental factors and gets deteriorated in quality. Thereby, retaining all the sensory characteristics of the developed crackers.

Biscuit/crackers consumption is considered one of the top ten daily consumed foods and most of the marketed products contains high trans and saturated fats which is proven not to be beneficial for diabetic people and can lead to further complications and also can give rise to other metabolic disorders. Thus, the objective was the overall acceptability of these crackers as diabetic friendly snack option.

Conclusion

Diabetes is an autoimmune chronic disease with steadily increasing prevalence. In the world's diabetes epidemic, India is in second place to China with 77 million diabetics. Although managing diabetes mellitus requires combining many different aspects, the approach to nutrition is ultimately at the core of the process. Achieving glycemic control while limiting hyperglycemia and weight gain requires careful attention to nutrition. For diabetic individual, it might be challenging to select healthful snacks. It's important to select snacks that are rich in fibre, protein, and good fats. The current study was conducted to develop a therapeutic product – 'Namkeen Crackers', a combination of cereals, legumes & seeds that enriches the product with protein and dietary fibres, thereby reducing craving & promoting satiety.

The study was conducted in four phases wherein firstly, the product was standardised followed by phase two, where

sensory evaluation was conducted based on various sensory characteristics – appearance, taste, smell, colour and texture. The product so developed was golden brown in colour making it appealing to the panels. The aroma of freshly baked herbs and crispiness of the crackers were also well appreciated by evaluators. Sensory evaluation resulted in positive overall acceptability of the product by the panels. Thirdly, the nutritional parameters of the product were calculated. In this phase all the significant macronutrients along with dietary fibre were calculated using IFCT nutritional composition. One serving of the snack contained 15 crackers that provided 258kcal, 13.84g protein, and 13.75g dietary fats. Thus, it was safe to claim that the product was rich in protein and fibre. Along with these nutrients, phytochemicals, antioxidants and other bioactive components present in moth beans, sprouted fenugreek seeds and flaxseeds may aid to maintain normal plasma glucose levels and reduce the risk of developing diabetes. Lastly, microbial analysis was conducted using pour plate method which revealed that the product was safe to consume and had the shelf of 30-40 days when stored in an air-tight container. Therefore, at the end, it was inferred that the Namkeen Crackers so created were nutrient-dense and free of additional preservatives, additives, and artificial colour without compromising taste or texture. Thus, 'Namkeen Crackers' serves as a perfect snack for diabetic individuals.

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