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Nutritional Profiling and Characterization of Developed Cake Premix Using Finger Millets (*Eleusine coracana*) and Sweet Potato (*Ipomea batatas L.*)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Research in the areas of nutrition and health care, as well as the growing public knowledge of these subjects, support the potential of phytochemicals like dietary fibre on their health-beneficial properties. Finger millet (FM) rates higher in terms of nutritional composition than other cereal grains. When absorbed by the body, FM's nutritional composition lowers the chance of developing type 2 diabetes, hypertension, and gastrointestinal tract disorders. Due to the high levels of calcium

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(0.38%), dietary fibre (18%), and phenolic compounds (0.3–3%) in it, its usefulness in terms of nutrition is well understood. Additionally, they have been found to have anti-diabetic, anti-tumor, anti-atherosclerotic, antioxidant, and antibacterial activities. The study focused on the development, Physiochemical Analysis, Nutritional Profiling and Microbial analysis of Cake Premix using Finger Millet and Sweet Potato in Different Ratio. A porous shape of the premix powder was shown by Scanning Electron Microscope-Energy Dispersive Spectroscopy. The structure of the Premix was mainly pore-free, uniform, and compact. showed that the Premix's surface was also smooth. Presumption powder's Fourier-transform infrared spectroscopy (FTIR) spectra were essentially identical within the wave-number range of 4000–400 cm^{-1}. the six-month period's microbiological proliferation (count of mould and yeast). The findings showed that during the storage period, there was no discernible variation in the microbiological load (yeast and mould count) in the created goods, suggesting that they were safe for ingestion for up to six months. The objective of the present research was intended to develop Cake premix by using Finger Millet and Sweet Potato in different Ratio which could be utilized as nutritional supplement and also helps in lowering the risks of lifestyle disorders.

Keywords: Geminated finger millet; sweet potato; chia sees; nutritional profiling; SEM; FTIR; microbial analysis.

1. INTRODUCTION

The global food market is increasingly dominated by bakery items, which are widely consumed worldwide. One of the key items in the bakery field is cakes.

The word "millet" comes from the French word "mille," which means "thousand," and refers to the number of grains that may be found in a handful of millet [1]. A common cereal grain in various areas of the world with a low-income population is finger millet (*Eleusine coracana*), commonly referred to as tamba [1]. The grain has different colour variations (brown, white, and light brown cultivars), a high concentration of carbohydrates, dietary fibre, phytochemicals, and essential amino acids, the presence of vital minerals, and a gluten-free status. Because it includes the amino acid methionine, which is deficient in the diets of hundreds of millions of the poor who depend on starchy staples like cassava, plantain, polished rice, or maize meal, finger millet is particularly beneficial. Methionine and tryptophan, two essential amino acids, are abundant in the finger millet proteins, as are significant levels of all other essential amino acids, with the exception of lysine [2]. The high prevalence of iron deficiency anaemia in pregnant women and calcium deficiency rickets in young children [2]. The millet does, however, also contain phytates (0.48%), polyphenols, tannins (0.61%), trypsin inhibitory factors, and dietary fibre, due to their metal chelating and enzyme inhibition activities, were once referred to as "anti-nutrients" [3]. However, they are now known as nutraceuticals. It is also a good supplier of potassium, iron, copper, zinc, and other elements. It is a good source of pantothenic acid, thiamin, riboflavin, niacin, and vitamin B6. Smaller but nonetheless significant levels of vitamin E and K are also found. Due to its prominence among the few crop species that are widely farmed as staple food sources, wheat's nutritional content is crucial. Many health benefits of finger millet flour include its use in treating anaemia, reducing blood cholesterol, improving bone health, and helping people lose weight [4].

Sweet potatoes are known as "camote" in the local language of Mexico, Peru, Central America and come in a range of hues, including red, purple, yellow, pink, beige, orange, and white. Manganese, micronutrients, and vitamins B1, B2, and B6 are all abundant in them [5]. In addition to providing nutrients (carbohydrates, beta-carotene (provitamin A), minerals (Ca, P, Fe and K), sweet potato flour can also contribute natural sweetness, colour, flavour, and dietary fibre to processed food products [6]. Micronutrients are present in sweet potatoes in various forms. There are significant amounts of vitamin C, moderate amounts of thiamin (vitamin B1), riboflavin (vitamin B2), and niacin, small amounts of panthothenic acid (vitamin B5), pyridoxine (vitamin B6), folic acid, and satisfactory levels of vitamin E. Due to its high carotenoid content, sweet potato flour might be advertised as a healthier alternative to wheat flour in sweet baked goods [7]. Carotene and vitamin C both function as potent antioxidants in the body by removing free radicals.

Chia, a perennial herbaceous plant whose seeds have been eaten for thousands of years, is also known as *Salvia hispanica*. The Spanish word "chia" is an adaptation of the Nahuati word "chian" or "chien," which means "oily" [8]. The plant's seeds have received more attention recently because to its culinary usage and potential health advantages. In reality, seeds are a rich source of nutrients, especially polyunsaturated omega-3 fatty acids, which protect against inflammation, improve cognitive function, and lower cholesterol. Additionally abundant in antioxidant chemicals that shield the body from free radicals, ageing, and cancer are due to polyphenols generated from caffeine found in seeds [9]. Additionally, carbohydrate-based fibres, which are found in high concentration levels, are linked to lowering cholesterol, regulating intestinal function, and reducing inflammation [10]. The current research looks at the wide range of uses for finger millet as a significant dietary supplement with a number of health advantages in the Indian context.

2. MATERIALS AND METHODS

2.1 Material

The study was carried out at Food Science and Technology Laboratory (FSTL) of Babasaheb Bhimrao Ambedkar University's Lucknow, Utter Pradesh India. The nutritious vegan cake was formed using malted finger millets, sweet potato, chia seeds, soymilk powder, brown sugar, cocoa powder, and virgin coconut oil. Finger millet and chia seed were purchased from organic Gyan websites and other ingredients like brown sugar, cocoa powder, baking soda, virgin coconut oil was purchased from lulu mall in Lucknow.

2.2 Malted Finger Millet Flour Preparation

The most common way to germinate finger millet in India is by using water, and the nutrition profile of germinated finger millet is better measured than that of germinated maize and germinated sorghum [11]. To get rid of any undesirable particles, millet seeds were separated and thoroughly cleaned. Then, the seeds were immersed in water for a whole day. Five kilograms of weight were left on top of the mixture after extra water had been drained away and the seeds tied with muslin cloth. After germinating for 24 hours at 27°C, these seeds were dried for two days in the shade. The malted ragi seeds were ground into flour using an electric blender.

2.3 Sweet Potato Flour Preparation

The roots of sweet potatoes were cleaned and cut to remove any dirt, foreign substances, decaying parts, damage by insects, etc. These tubers were peeled and stored in tap water for 30 minutes to avoid enzymatic browning. Slices were then cut from the peeled samples with a knife. Using a tray dryer set at 65 °C for 24 hours, the slices were dried. The dried slices were ground into flour using a grinder, and the resulting sweet potato flour was sieved through an 80 micrometer-mesh screen [12].

2.4 Chia Seeds Flour Preparations

Chia seeds were cleaned and remove dirt particles after that cleaned chia seeds were ground into flour by using mixer.

2.5 Premix Powder Preparation

Premix Powder was made by combining Malted Finger Millet, Sweet Potato Flour, Chia Seeds Flour, Soymilk Powder, Brown Sugar, Baking Soda, and Coaca Powder. 30 parts by weight, 40 parts by weight, 50 parts by weight, and 60 parts by weight of composite flour, respectively. A bread sample made entirely of wheat flour served as the control. The flours were stored at room temperature and protected from light in polythene bags.

2.6 Cake Preparation

The flour samples were used to make cake, however somewhat differently than suggested [12]. This includes soymilk powder, flavour, brown sugar, virgin coconut oil, and composite flour. After 40 minutes of baking at 150°C in a preheated oven, the mixture was chilled and deplaned.

2.7 Determination of Proximate Composition of Raw Sample and Premix Powder

2.7.1 Moisture analysis

Using the oven method, the moisture content of the premix powder was ascertained. As per AOAC 2020, the oven's temperature was set at 105° C, which is a consistent temperature. 2 to 5 g of sample weight was added to the Petri dish, which was then left for 7 hours. The sample was weighed after cooling, and the results were recorded. As shown below, the moisture content was calculated.

Moisture (%) = $\frac{w1-w2}{w2}$

Whereas,

w1= before dried sample weight
w2= after dried sample weight

2.7.2 Ash content analysis

The ash content was calculated using the procedure outlined in AACC (2000) [13]. In this method, A 5g sample was weighed in an empty crucible and burned at 550°C in a muffle furnace for 8 hours until a grayish residue was left behind. A sample weighing 5g was placed in an empty crucible and burned for 8 hours at 550°C in a muffle furnace, leaving behind a brownish residue. Using the following formula, ash was calculated.

Total ash content (%) =$\frac{(W2-W1)}{(W1-W)} \times 100$

w = weight in gram of the empty crucible.
w1= weight in gram of the dish with dried material taken for test.
w2 = weight in gram of the dish with the ash.

2.7.3 Protein analysis

The protein content of samples was estimated by the Kjeldahl method. 5g of samples was introduced in digestion flask and to that 10 mL of concentrated H_2SO_4 and 5g of digestion mixture of K_2SO_4:$CuSO_4$: Na_2SO_4 (equal ratio) was added. The flask was stirred to fully combine the ingredients before being placed on a heater to begin digestion until the mixture became transparent (blue green in colour). The entire procedure took three hours to complete.

The resulting solution was brought to room temperature and put to a volumetric flask of 100 mL. Distilled water was used to top up the volume. Thereafter, ten milliliters of digest were gently added to the distillation tube, along with 10 ML of 0.5 N NaOH.

Due to the presence of NH_4OH, a yellowish tint emerged during distillation. The distillate was then titrated with a 0.25mol/L standard HCl solution until a pink colour was obtained. In order to determine how much titrant was utilized, the initial and final readings were recorded at this phase and marked as Vs. The nitrogen content of acetanilide or tryptophan after addition of 1 g of saccharose was determined at the titration stage for the blank, and the volume of titrant utilized was indicated as Vb. The %N in samples was calculated via the given formula followed by the calculation of % P by multiplying the %N with the protein factor (PF) that is 6.38 [14].

Protein % = $Vs - Vb \times F \times C \times f \times M(N)\ m \times 1000 \times 100$

Where,

Vs- volume of titrant used for sample
V_b - volume of titrant used for blank
F- molar reaction factor of titrant (HCl-1 and H_2SO_4 - 2)
C- concentration of titrant (mol/L) = 0.25mol/L
f- Factor of titrant = 1
M(N)- Molecular weight of Nitrogen = 14.007g/mol
m- sample weight
1000- conversion factor (mL into L)
%N- % weight of N

Fig. 1. Cake with premix powder

2.7.4 Fat content analysis

The Soxhlet technique was employed to determine the sample's fat content. A thimble is used to hold the sample; after heating the flask, the solvent evaporates and is transferred up to the condenser, where it is changed into a liquid and collected into the extraction chamber with the sample. The solvent removes the lipids from the sample as it moves through it and carries them into the flask. This extraction procedure normally takes six to twenty-four hours [15].

2.7.5 Carbohydrates content analysis

Total carbohydrates were determined using the following formula: 100 (%Moisture + %Crude protein + %Crude fat + %Crude fibre + %Ash) [16].

2.7.6 Crude fibre analysis

The method described in IS: 10226 (1982) was used to calculate the crude fibre content.

3. CHARACTERIZATION

3.1 SEM (Scanning Electron Microscope)

SEM (Model No. JSM 6610-LV) at x3000 magnification was used to examine the morphological characteristics of Premix flours. The gold palladium (60:40, g/g) auto fine coater, JEOL-JFC-1600, was used to coat the flour samples after mounting them on the aluminum stubs using double-backed cellophane tape.

3.2 FTIR (Fourier Transform Infrared Spectroscopy)

Cake premix samples were put into the Nicolet-6700 FTIR spectrometer, which was made available by Thermo Fisher Instruments, USA, to determine functional groups. The spectra were captured in the 400–4000 cm^{-1} wave number range, and the resulting spectra were analysed as described by Singh et al. [17].

3.3 Microbial Testing

The Cake Premix samples were subjected to the aerobic plate count utilising the Fawole and Oso, 1988 method. A sample of ten grammes was homogenized for about two minutes in a blender (Philips Type HR 2815i) with 90 mL of sterile distilled water after being taken aseptically. In test tubes, 9 mL of sterile, distilled water were used to create serial dilutions using 1 mL of homogenates. Using plate count agar (PCA, oxoid), one millilitre of the dilution was pour plated in sterile Petri dishes and incubated at 37°C for 24-36 h. Log cfu/g sample was used to express counts of the visible colonies.

4. RESULTS AND DISCUSSION

Studies were done on the development and quality assessment of a healthy vegan cake using different ratios of flours, such as Malted Finger Millets Flour, Sweet Potato Flour, and Chia Seeds Flour. Physical and chemical properties such as moisture content, ash content, fat content, protein content, crude fibre content, carbohydrates content, and pH were used to assess the quality of the vegan cake.

4.1 Proximate Analysis of Raw Material

Table 1 shows the % composition of Malted Finger Millet Flour, Sweet Potato Flour, and Chia Seeds. Comparable to other cereals including rice, wheat, maize, and millet, malted finger millet grains have a high carbohydrate content of 74.81%, protein 6.36%, crude fibre 0.46%, and mineral content (Table 1). Finger millet has a significantly greater crude fibre content than wheat (1.2% fibre) and rice (0.2% fibre). Amylopectin makes up about 80–85% of the finger millet starch, whereas amylose makes up the remaining 5–20% [18]. Essential amino acids make up the majority of protein's quality. In finger millet, 44.7% of the amino acids are considered to be necessary [19]. The highest concentrations of calcium (344 mg%) and potassium (408 mg%) are found in finger millet, compared to all other cereals and millets. More than any other regularly eaten cereal grain, finger millet has a total ash percentage that ranges from approximately 1.7 to 4.13%. Calcium and iron are both found in good amounts in finger millet. As the richest source of calcium and iron, finger millet is essential to our diet since it could prevents anaemia and bone with tooth disorders caused by iron and calcium deficiencies.

Table 2 displays the sweet potato flour's moisture, ash, fibre, fat, carbs, and proteins. The moisture content of the sweet potato flour was discovered to be within the permitted range, or values less than 13% [20]. ANVISA (ordinance 354/96) recommends a maximum ash content of 2.0 to 2.5%. Values above that are considered to be external pollutants. The values observed in this experiment are therefore consistent with the norm. However, the sweet potato flour has 74.81% carbohydrates. Protein concentration was made possible by the drying process, which prevented the protein content from deteriorating. Approximately 6.16 percent of sweet potatoes contain protein. To make the cookies and reduce the amount of sugar used, sweet potato flour was used in place of wheat flour.

The approximate chemical composition of chia seeds is shown in Table 2. Like what was discovered by other authors. Chia seeds have a high quantity of proteins and lipids). The Value Observed in this Experiment was 23.60 [21]. Because moisture levels influence physicochemical and microbiological traits, understanding moisture levels in food products is very important. The chia seeds Contain 4.31 moisture content 23.60fat, 18.70 percent Carbohydrates, and 18 percent crude fibre.

The information indicated that the Composite Flour is a rich source of fibre and protein. It was discovered that germination-processed millet had higher levels of protein, fat, and ash than wheat flour. The buildup of proteins and generation of certain extra amino acids in the samples as a result of germination was the cause of the germinated millet sample's highest crude protein values. The increase in protein content of the germinated grains may be the result of a quantitative decrease in antinutritional elements (tannin, and phytic acid), as well as other grains' components such starch.

4.2 Proximate Analysis of Premix Powder

Protein levels in cake premix flour were examined. Premix powders are regarded as having a high nutritional value, in part because of their high protein, crude fibre, and carbohydrate content (Table 4). About 11.25 g of protein, 72.68 g of carbohydrates, and 6.25 g of fat are present in the premix.

4.3 Proximate analysis of Cake

The protein content for each treatment decreased while the cake cooked, as seen in Tables 4 and 5. Premix flour provides 11.25% protein, which decreases to 10.73% when cooked. When ingredients are cooked into a Cake that contains protein, the effect of heat temperature on the contents results in a denaturation process, which lowers the protein level. The addition of water during the cooking process makes the material heavier than premix flour, which lowers the protein composition of the cake. The results of the investigation of a premixed cake are shown in Table (6). The amount of crude fibre, moisture content, and cake components all increased up. However, there was a decrease in the protein, calorie, and carbohydrate content of the composite cakes. Nutrient deterioration may have occurred as a result of the batter's high temperature and prolonged heating. The heat that was applied is the cause of this.

4.4 SEM (Scanning Electron Microscope)

SEM was used to assess the morphologies of the Premix flour samples at various levels of magnification (500(A), 1000(B), 2000(C), and in Fig. (2). The Premix's structure was compact, homogenous, and largely free of pores. demonstrated that the Premix's surface was smooth as well.In the Premix powder micrographs, many elemental particles could be seen (Fig. 2). Additionally, the ratio of $CaCO_3$, SiO_2, and Pt atoms in the Premix was disclosed by the EDS analysis.

4.5 FTIR (Fourier-Transform Infrared Spectroscopy)

The detection of functional components in the produced Cake premix formulations was carried out using FTIR spectroscopy. The FTIR spectra peaks of the control Cake premix formulations are shown in Fig. 2. The flour samples with CO14 and CO15 IR spectra showed that the peaks had slightly shifted and did not indicate any variations in the functional groups [22]. The major peaks observed in the IR-Spectra was 3387.3 cm^{-1}, 3337.5 cm^{-1}, 1053.6 cm^{-1}, 999.1 cm^{-1}, 2930.0 cm^{-1}, 3558.6 cm^{-1}.

4.6 Microbial Testing

Using the clear zone of the circular film disc, the inhibitory impact was evaluated. The film disc's diameter was taken into account when measuring the exact zone diameter; as a result, the results were consistently higher when a clear zone was present. The diameter was given a value of zero if there is no inhibitory zone and no surrounding clear zone. The disc's surrounding area has a clear inhibitory zone. Against yeast, Premix Powder has a significant amount of antibacterial action.

Table 1. Composition of premix powder

Type of cake	Ingredient									
	Wheat flour (g)	**Malted finger millets flour (g)**	**Sweet potato flour (g)**	**Chia seeds flour (g)**	**Soymilk Powder (g)**	**Brown sugar (g)**	**Baking powder (g)**	**Coeca Powder (g)**	**Virgin Coconut Oil (g)**	**Water**
Control	100	____	_____	____	15	70	4	10	20	105
T1	-------	60	35	5	10	50	3	5	10	100
T2	-------	50	40	10	10	60	3	6	10	105
T3	-------	40	50	10	15	80	4	8	10	105
T4	-------	30	60	10	15	70	4	10	20	105
T5	-------	60	30	10	15	70	4	10	20	105

Table 2. Proximate composition of malted finger millet

Nutrient	Malted Finger Millet Flour
Moisture	14.29
Ash	1.21
Protein	6.36
Fat (g)	3.33
Crude Fibre	0.46
Carbohydrates	74.81
Energy	354.65

Table 3. Proximate composition of raw material

Nutrient	Sweet Potato Flour	Chia Seeds Flour
Moisture	6.29	4.31
Ash	2.34	4.61
Protein	6.16	23.60
Fat (g)	0.76	29.80
Crude Fibre	1.99	18
Carbohydrates	88.75	18.70
Energy	386.1	537kcal

Table 4. Proximate composition of premix powder

Moisture	5.85
Ash	3.70
Protein	11.25
Fat	6.52
Crude Fiber	0.98
Carbohydrates	72.68
Energy	394.04

Table 5. Proximate composition of malted ragi cake

Moisture	31.84
Ash	3.40
Protein	10.73
Fat	3.81
Crude fibre	1.52
Carbohydrates	50.22
Energy	278.09

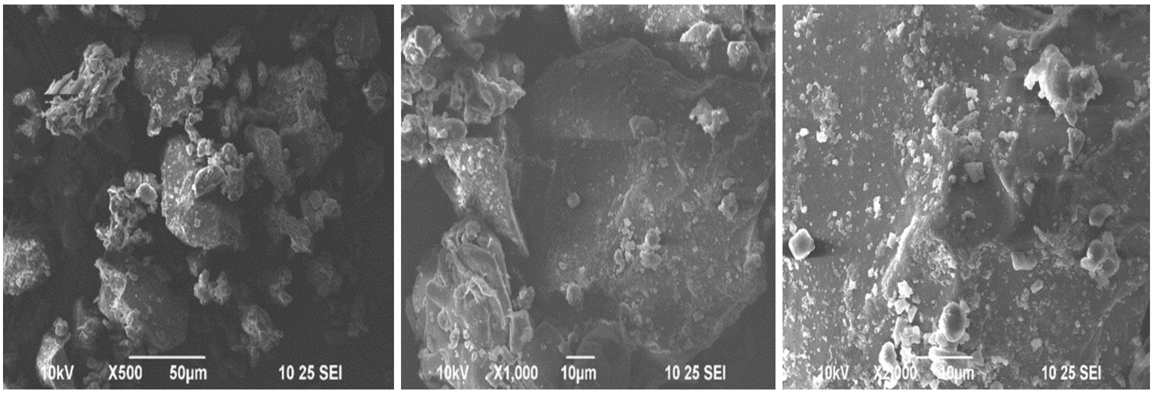

Fig. 2. SEM images of Premix Powder at X500, X1000 X2000 level magnification

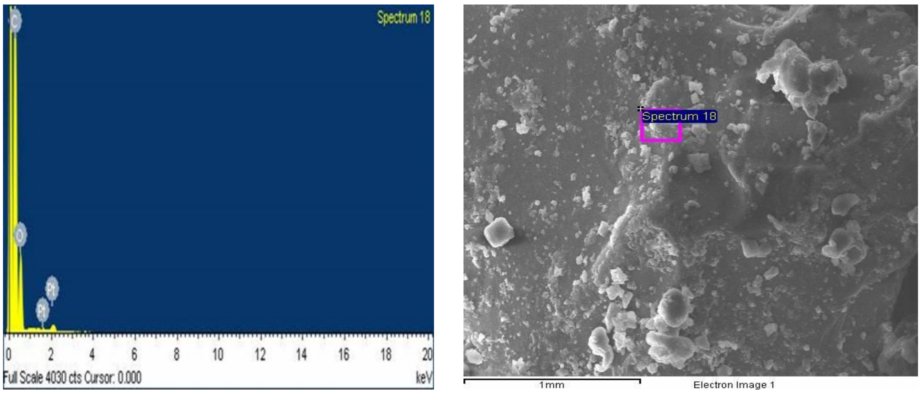

Fig. 3. EDS spectrum for premix powder

Table 6. EDS spectrum for premix powder

Element	Weight (%)	Atomic (%)
C K	63.98	70.70
O K	35.26	29.25
Pt M	0.76	0.05
Total	100.00	

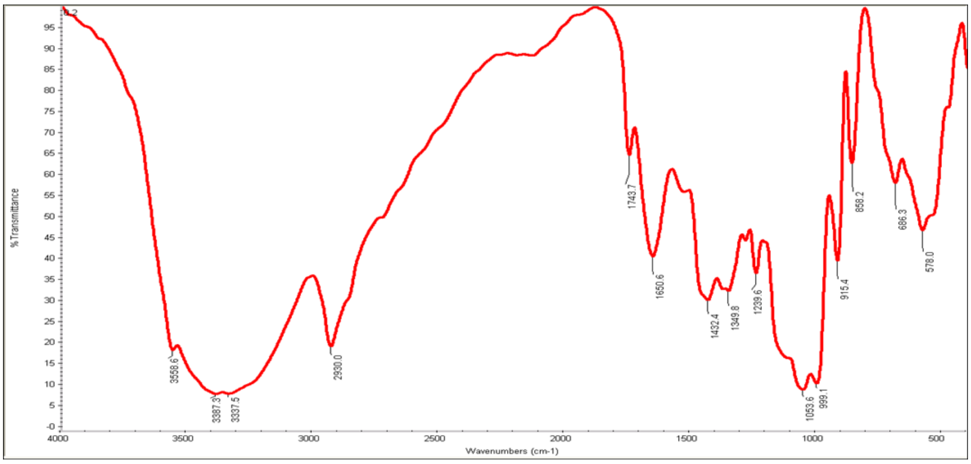

Fig. 4. FTIR of premix powder

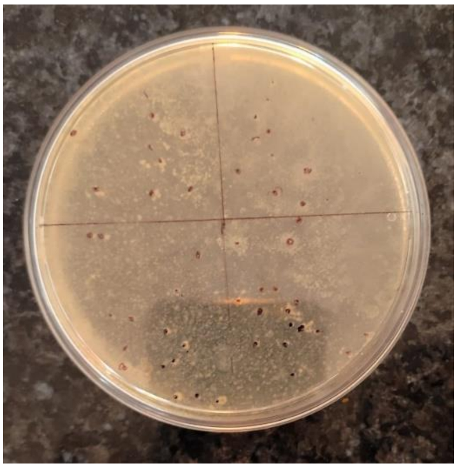

Fig. 5. Inhibition zones of the premix powder

5. CONCLUSION

A cake with a reduced gluten level that included germinated finger millet flour was successfully developed. When replacing wheat flour in different bakery goods with sweet potato and chia seed flour, you can boost the intake of vital nutrients in the diet of people by doing so. The functional qualities of the flour blends were significantly impacted. Compared to wheat cake control, cake has a higher protein, calorie, and fat content. Physical investigation also revealed that there are higher and lower hardness levels. The majority of millet's dietary fiber is composed of non-starchy polysaccharides, which also provide a number of health advantages, such as slowing down the absorption of nutrients, increasing fecal volume, and reducing blood lipid levels. The study shows that the irradiation of finger millet cake samples did not show much difference when compared with the control.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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