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Ranking of the Novel Food Product Millet Cake Developed from Banana Pseudo Stem (*Musa acuminata*) through MAPH and TOPSIS Method

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ABSTRACT

Background: In today's world people are consuming sweets and cakes that are loaded with lots of sugar and refined flour which leads to various diseases such as PCOS, diabetes, obesity, hypertension, atherosclerosis, chronic kidney diseases, *etc.* The primary objective of this research is to develop a nutrient-rich food product, assess its sensory attributes using a 9-point rating scale, the ranking procedure by MAHP (Means of Analytical Hierarchy Process) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS).

Methods: Procurement and standardisation were done for the raw materials and product is developed. Through the implementation of banana pseudo stem powder, pearl millet flour, ragi flour, dried blueberries and sunflower seeds as the primary raw ingredients, supplemented with eggs, date powder, vanilla extract, milk powder, baking powder, figs, almonds and cashews, a healthy food product (millet cake) is developed without using sugar to satisfy the cravings of eating sweet desserts and the main goal was to enhance both flavour and nutritional value of the product.

Result: Sensory evaluation was done for four different samples and it has been observed that sample D containing (45 g pearl millet flour, 10 g ragi flour, 10 g banana pseudo stem powder, 20 g egg and 15 g dry fruits along with seeds and berries) surpasses the other samples across all parameters. The results of MAHP and TOPSIS also shows that the sample D is best rank. In this research a gluten-free, nutritionally fortified food product is developed that is rich in dietary fiber (14.28 g), contains high amount of protein (12.18 g) and (458 kcal) calories. As per the RDA 2020 the developed product is a rich source of minerals such as iron and calcium.

Key words: Diabetes, Metabolic disorders, Obesity, Pearl millet, TOPSIS.

INTRODUCTION

In this modern era, people are more inclined towards the consumption of junk food or desserts that are unhealthy and lead to various diseases. Diseases such as obesity, diabetes and PCOS are becoming the major epidemic crises in the world (Sharma and Sharma, 2024). Obesity develops as a result of hormones and neurotransmitters. Obesity is pervasive worldwide, as evidenced by rises in body mass index that approach unbearable levels in both men and women (Kannaa *et al.,* 2024). Obesity, which is frequently associated with socioeconomic problems, is the main cause of the development of the main components of the metabolic syndrome (Janssen, 2021).

Among other health concerns, millets are small-seeded grains in the Poaceae family that have gained popularity recently because of their health benefits and advantageous nutritional profile (Fang *et al.,* 2023). Millets include nutraceutical antioxidants that reduce blood pressure, heart disease risk, cancer and cardiovascular disease prevention, diabetes and tumor incidence (Bhat *et al.,* 2018). The rising trend of health-conscious eating is also encouraging the general population to choose gluten-free items. A nutrient-rich food product is developed to assess its sensory attributes using a 9-point rating scale and determine its ranking using the Technique for order of preference by similarity to ideal solution (TOPSIS) and MAHP helps to identify the best product from a list of in which different options are available.

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Millet

Millets are small seeds which are highly nutritious and grown across the world generally cultivated in semi-arid areas as they do not require much attention and are known as poor crops. There are many types of millet such as foxtail millet, pearl millet, ragi, proso millet, *etc.* (Mokal, 2024).

Pearl millet (*Pennisetum glaucum* L.) flour

Pearl millet is a nutritious millet that contains high energy along with proteins, carbohydrates, vitamins like A and B and fat (Kulthe *et al.,* 2022). It is also a rich source of iron,

calcium, potassium and zinc along with other minerals (Satyavathi *et al.,* 2021). It is gluten free and superior to rice and maize and has higher protein than wheat (Rodge *et al.,* 2024). Insoluble dietary fiber content is high in this grain which slows down the release of sugar in blood which has shown beneficial effects on diabetic patients due to its low glycemic index (Pei *et al.,* 2022). Millet flour is prepared by various methods (Verma *et al.,* 2018) such as milling, traditional methods like dry milling which is common in villages, or mechanical methods to prepare various food products like bhakri, roti and gruel (Selladurai *et al.,* 2023). Practices like popping and roasting of millets are also common in some places (Hema *et al.,* 2022).

Finger millet (Ragi, *Eleusine coracana* L.) flour

Finger millet which is commonly known as ragi is the ancient millet that contains the highest amount of calcium, 344 mg along with 408 mg of potassium (Sahoo *et al.,* 2023). It has been a great source to provide dietary fiber along with many minerals (Chaudhury and Choudhury, 2024). It has various health-related benefits and is also effective in maintaining blood glucose, wound healing, lowering cholesterol and ant ulcerative (Kaur *et al.,* 2024).

Banana pseudo stem

The Banana pseudo stem is considered to have high fiber along with total carbohydrates and cellulose. It helps to lose weight and also help to prevent kidney stones as it is a rich source of fiber that also acts as a detoxifier in the body and helps to relieve constipation Ma (2015). Obesity is regarded as the main factor that leads to serious diseases and mortality and individuals whose BMI is More Than 25 kg/m^2 have higher chances of developing serious comorbidity (Sharma *et al.,* 2024) and banana pseudo stem contains a high amount of fiber that helps to reduce weight in obese people. Nutritional content of banana pseudo stem powder (100 g) is shown in Table 1 (Thorat and Bobade, 2018).

Dried blueberries (*Vaccinium corymbosum* L.)

Blueberries (Vaccinium) are perishable fruits consumed across the world as they are rich sources of antioxidants and help to benefit health (Martins *et al.,* 2023). It is a rich source of phenolic compounds or antioxidants like the presence of anthocyanins helps to prevent various diseases such as cancer, heart disease, memory loss, aging and vision problems (Silva *et al.,* 2020). To dry blueberries techniques like hot air drying, microwave vacuum and drying by freezing are used to retain their nutritional value (Jakubczyk *et al.,* 2025). The most commonly used method is drying to improve and extend the shelf life of blueberries (Bezerra *et al.,* 2024).

Sunflower (*Helianthus annuus*) seeds

Seeds are becoming the centre of attraction these days as they grab all the attention due to their links with many health-related benefits. Sunflower seeds contain a good amount of protein that has a favourable distribution of amino acids and it also contains vitamins, tocopherols and minerals in adequate amounts. It has numerous health benefits due to low sodium concentration along with saturated fats and is high in fiber, magnesium and potassium (Li *et al.,* 2024).

Aims and objective of developing the product

- To develop a nutritionally balanced gluten-free food product from sources loaded with carbohydrates, proteins, dietary fiber, fats, energy, Iron and Calcium.
- To evaluate the organoleptic properties of the developed food product by standardizing variations.
- To rank the product that is developed using different statistical analysis methods like mean, standard deviation, MAHP and TOPSIS.

MATERIALS AND METHODS

Procurement of raw materials

All materials were purchased from a shop near my house Sadar Bazar, New Delhi. High quality and sufficient quantity were ensured while purchasing the food items for the product development to make 4 samples of the product. Weighing of each raw material was also done separately. The entire research has been conducted at Nutrition Lab Amity University Haryana. During the year of 2023-2024.

Standardization of food product

The recipes for the cake were standardized using the following ingredients-

Egg, Pearl millet flour, Ragi flour, Banana pseudo stem powder, Dried blueberries, Sunflower seeds, Dates powder (10 g), Figs, Almonds, Cashew, milk powder (5 g), baking powder (a pinch), Eno (a pinch), Vanilla extract (4-5 drops).

Preparation method of millet cake

The method followed to develop the cake was -

- Preheat oven to 180°C. Line a 4.5-inch round cake pan with parchment paper. Grease the slides and set aside.
- Take egg in a bowl. Use an electric beater to whip till fluffy.
- Start adding date powder a little at a time and keep blending till stiff peaks are formed.
- Now using a sieve sift the pearl millet flour, ragi flour and 15 g banana pseudo stem powder in and fold very gently.
- Add in milk powder, vanilla extract and baking powder and fold gently.
- Mix a handful of dried blueberries, almonds, cashews, sunflower seeds and figs.
- Spoon this into the prepared pan and bake for 30 to 35 minutes till the cake is done.
- Once the cake is cooked, remove from oven and set aside for 10 minutes to cool.
- Now use the knife to release the cake from the sides gently.
- Unmold the cake from the mold. Cool completely in a wire rack.
- Slice and serve.

Sample variation

In all the four samples variation was done in the quantity of Pearl millet flour and Ragi flour by using these as basic ingredients.

Sample A- This sample contains 30 g of Pearl millet flour along with 25 g of Ragi flour.

Sample B- This sample contains 35 g of Pearl millet flour along with 20 g of Ragi flour.

Sample C- This sample contains 40 g of Pearl millet flour along with 15 g of Ragi flour.

Sample D- This sample contains 45 g of Pearl millet flour along with 10 g of Ragi flour.

Sample variation according to percentage and amount of ingredients is shown in (Table 2).

These variations were considered to make the 4 samples of cake to assess their sensory attributes using a 9-point rating scale and determine its ranking using the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). Images of developed product are shown in (Fig 1) and steps involve in preparation are shown in (Fig 2).

Nutritional analysis

By using the AOAC 2005 method the product's nutritional analysis was done. The energy content of sample weighing 100 g was calculated including carbohydrate, protein, fats, moisture and ash. The nutritive value result of the newly developed cake is described in (Table 6).

Estimation of carbohydrate was done by the Micro-Kjeldahl method and the estimation of proteins was done by the Antrone method, whereas, estimation of fats was done by the Soxhlet apparatus method for the respective product.

Calculation of energy was done by multiplying proteins as well as carbohydrates by four and multiplying fats by nine, the individual values of the three were added.

Enzymatic- Gravimetric method was used to calculate the dietary fiber.

The crude fat- The fat extraction method was followed by AOAC 1995. Micro Kjeldahl Method is used to calculate the content of protein.

Micro Kjeldahl method was used to estimate the various flours as described in A.O.A.C. (2000).

The formula that was used is as follows.

$$N\ (\%) = \frac{1.4(V2 - V2)\ \text{Normality of HCl} \times 250\ (\text{dilution})}{\text{Weight of sample}}$$

Where,

(V2 -V1) = Volume made of the digest.

Protein % = N% × Conversion factor (6.25).

RESULTS AND DISCUSSION

After the sensory evaluation was conducted, the samples were analysed statistically using their mean and standard de*via*tion which are as follows:

Interpretation of the sensory evaluation scores

After the preparation of the millet cake, the sensory evaluation on a 9-scale hedonic scale was done. A hedonic test is a sensory evaluation that measures how much a person likes or dislikes a product. For each variable 20 semi-trained panel of judges from the Department of Dietetics and Applied Nutrition done the sensory evaluation. Each member of the panel was presented with 4 variants of the sample and told to evaluate the sample based on various characteristics that were of taste, colour, texture, firmness, crispiness and acceptability.

Each member of the panel provides the ratings using which the statistical analysis was done by calculating their mean and standard deviation of the sensory evaluation by



Fig 1: Images of the developed product.

the 20 panellists based on 9-point hedonic test for all the variables such as taste, colour, texture, firmness, crispiness and overall acceptability and has been depicted in the Table 3.

Sample D is the most preferred sample with overall acceptability 7.15±1 followed by Sample C with acceptability 6.9±0.99, Sample B with acceptability 6.8±1 and Sample A with acceptability 6.6±1.26.

TOPSIS for millet cake

Calculation of weights by MAHP (Means of analytical hierarchy process)

MAHP helps to identify the best product from a list of in which different options are available. For the ranking procedure, a pair-wise comparison scale was used.

Analytical hierarchy process technique

Letting the set of the criteria be A= {Aj},
Where,
j= 1, 2, 3 ..... n.

The pair-wise comparison of a matrix Z of 'n' number of criteria can be drawn as (n X n) matrix. Each element in (n X n) matrix is 'ij'.

Where,
i, j = 1, 2, 3 ..... n.
Pair-wise comparison matrix for n number of criteria.

AHP calculation

Step 1: The first step is to draw a '4*4' matrix for four different samples and calculations were done.
4*4' matrix for four different samples.

Step 2: After drawing the matrix, calculation of 4^{th} root was done.

4^{th} root for A= $(1* 0.50* 0.33* 0.25)^{1/4}$=0.45; B= $(2* 1* 0.5* 0.33)^{1/4}$=0.76; C= $(3* 2* 1* 0.5)^{1/4}$=1.32; D= $(4* 3* 2*1)^{1/4}$=2.21

Step 3: After calculating individual 4th root, sum of all the 4^{th} roots were done, which was found to be 4.74.

Step 4: Then, the calculation of PV for each group was done. For calculation of PV, divide 4^{th} root for each sample by the sum of 4^{th} root. Repeat the steps for all the four variables.

Step 5: Then the calculation of sum PV for each variable was done.

Sum PV for A= 0.10* 10 = 1; Repeat the steps for all four variables.

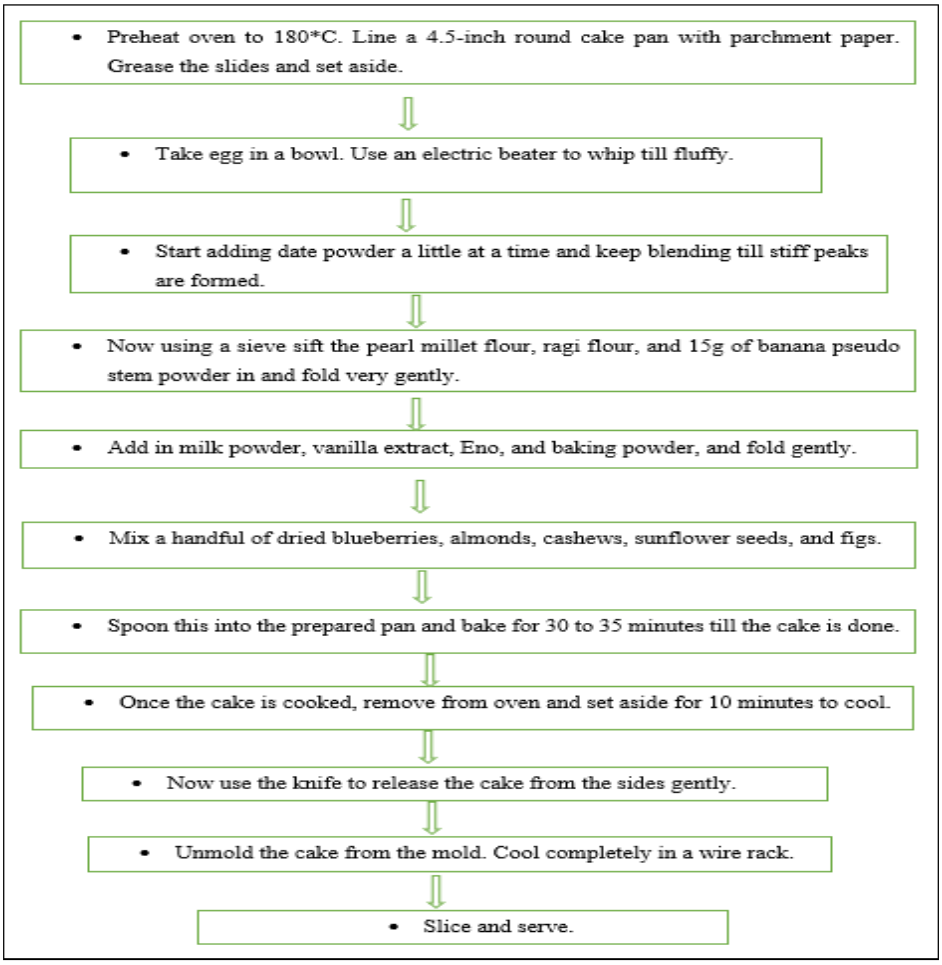


Fig 2: Steps involve in preparation.

Step 6: Then the calculation of Total for Sum PV= λ(max) {Lambda- max} was done.

$$\lambda(max)= \sum (PV (A, B, C, D) = 4.03$$

Step 7: Then the next step is to calculate CI value (Consistency index). It is calculated using the formula given below.

$$CI = \frac{[\lambda(max) - n]}{(n-1)}$$

Where,
n = Number of systems/variables being compared.
CI (Consistency index) = 4.03-4/3 = 0.01.

Step 7: Then finally, the CR (Consistency ratio) value was calculated by dividing CI (Consistency index) by RI value.

Where,
RI = Random index. Values of RI.

In our study, total 6 criteria were compared, so, n= 6. RI for 6 is used to calculate CR value. CR= 0.01/ 1.24= 0.0072 The CR is the indicator of the consistency of the various samples. A consistency ratio of less than 0.1 is acceptable. A matrix is said to be consistent and acceptable if the consistency ratio is less than 0.1. if the Consistency ratio comes to more than 0.1, then the sample is corrected using various correction measures.

The calculated consistency ratio of the study is 0.0072, which is less than 0.1, so our pair-wise comparison test was found to be consistent and no corrective actions were required for the comparison.

TOPSIS for ranking the samples

TOPSIS is a method in which solutions are identified from the various sets of options as it a multi-criteria decision-making technique. Mean scores for all the 6 attributes for each sample were used in the TOPSIS method, along with the calculated weights value from AHP method. 6 different attributes used were taste, colour, texture, firmness, crispiness and overall acceptability. Mean scores obtained from sensory evaluation and calculated weights from the AHP technique are shown in Table 4.

Test results of the 9-scale Hedonic rating were then analysed, mean and standard de*via*tion was calculated. All four samples were ranked using TOPSIS.
m= Varieties of sample = 4.
n= Number of attributes = 6.

Table 1: Banana pseudo stem powder (100 g).

Nutrients	Contents (%)
Protein	2.5
Fat	1.7
Free sugar	3.4
Soluble dietary fiber	1.4
Insoluble dietary fiber	27.4
Starch	27.3
Ash	0.3
Moisture	15.1

Thorat and Bobade 2018.

Table 2: Sample variation according to percentage and amount of ingredients.

Samples	Pearl millet flour (g)	Ragi flour (g)	Banana pseudo stem powder (g)	Egg (g)	Dry fruits, seeds and berries (g)
A	30	25	10	20	15
B	35	20	10	20	15
C	40	15	10	20	15
D	45	10	10	20	15

Table 3: The sensory evaluation of four samples (Statistical analysis of 9 Point hedonic test).

Parameters	Sample A	Sample B	Sample C	Sample D
Taste	6.2±0.91	7±0.94	6.8±1.10	6.9±1.11
Colour	6.9±1.19	7.3±0.94	7.1±0.87	7.2±1.03
Texture	5.9±1.28	6.7±1.05	6.8±1.31	6.95±1.21
Firmness	6±1.49	6.5±1.16	6.9±1.37	7.1±1.28
Crispiness	6.5±1.50	6.6±1.17	6.8±1.24	7.1±1.28
Overall acceptability	6.6±1.26	6.8±1	6.9±0.99	7.15±1

Table 4: Mean scores obtained from sensory evaluation and calculated weights from the AHP technique.

	Taste	Colour	Texture	Firmness	Crispiness	Overall	Weight age
A	6.2	6.9	5.9	6	6.5	6.6	0.1
B	7	7.3	6.7	6.5	6.6	6.8	0.16
C	6.8	7.1	6.8	6.9	6.8	6.9	0.28
D	6.9	7.2	6.95	7.1	7.1	7.15	0.47

Step 1: Calculation of $(\sum x^2_{ij})^{1/2}$ for each row

Calculation of $(\sum x^2_{ij})^{1/2}$ for each row**.**

Step 2: Calculation of r_{ij}.

To calculate r_{ij} for each attribute, divide the mean score for every attribute by $(\sum x^2_{ij})^{1/2}$ for every sample. r_{ij} value for each attribute.

Positive and Negative Ideal Situation.

Where,

V+ = Positive ideal solution.

V- = Negative ideal solution.

Step3: Then the Positive and Negative Ideal Solutions are determined.

Positive ideal solution is the highest value for each attribute, while the lowest value for each attribute is considered as the Negative Ideal Solution.

Step 4: Then the separation from Positive ideal solution as well as Negative Ideal Solution is determined. Si = $[S(v_j^*-v_{ij}^*)2]$ 1/2 Si+ and Si-negative values were calculated for all the samples.

Si+ = Separation from the Positive Ideal Solution.

Si- = Separation from the Negative Ideal Solution.

Step 5: Then the relative closeness to the ideal solution was calculated using the formula:

$$Ci = \frac{(Si-)}{\{(Si+) + (Si-)\}}$$

Si values and Ci values for each sample. Ranks of different samples are shown.

Sample A with Si+ and Si- is 0.48 and 0 for sample A respectively, for sample B the Si+ and Si- is 0.40 and 0.08 respectively, for Sample C the Si+ and Si- is 0.25 and 0.23 respectively and for Sample D the Si+ and Si- is 0 and 0.48 respectively.

The Ci value for sample A is 0, for sample B is 0.16, for sample C is 0.48 and for sample D shown in (Table 5).

Ranking

Sample D, which contains 45 g of pearl millet flour, 10 g of ragi flour, 10 g of banana pseudo stem powder, 20 g of egg and 15 g of dry fruits along with seeds and berries, has shown to be the most favorable among the four samples according to all parameters measured. Following Sample C and Sample B also performed well, whereas Sample A was found to be the least acceptable across all evaluated criteria.

According to the TOPSIS AND MAHP ranking was done for all the four samples that shows Sample D stands on rank 1, followed by sample C on rank 2, sample B stands on rank 3 and sample A on rank 4 as per the ranking it is shown in (Table 5).

Table 5: Si values and Ci values for each sample ranks of different samples.

	Si+	Si-	Ci	Rank
A	0.485324	0	0	4
B	0.403129	0.082525	0.169926	3
C	0.251821	0.233586	0.481216	2
D	0	0.485324	1	1

Table 6: Nutritional content of developed millet cake per 100 g.

Nutrient	Amount (per 100 g)
Energy	458 Kcal
Carbohydrates	65.63
Proteins	12.18
Fats	8.67
Dietary fiber	14.28
Moisture	8.62
Ash	6.43
Iron	11 mg
Calcium	654 mg

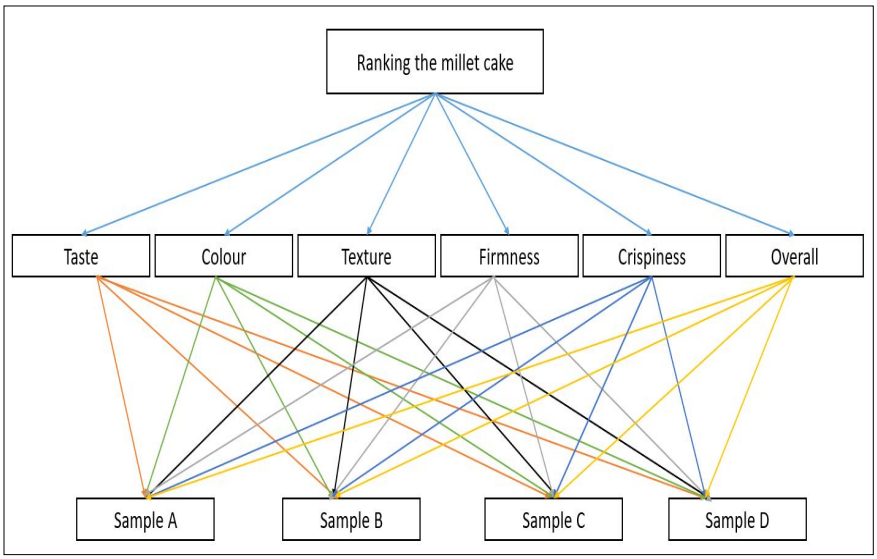


Fig 3: Hierarchical structure.

Hierarchical structure

Hierarchical Structure is shown in Fig 3.

Nutritional analysis of newly developed product

Nutritional analysis for the best preferred sample (Sample D) was done by using the AOAC method, 2005. The newly developed product is a good source of dietary fiber, protein, iron and calcium as it contains energy value 458 kcal per 100 g, 65.63 g of carbohydrate, 12.18 g of protein, 8.67 of fat, 14.28 of Dietary Fiber, 8.62 of Moisture, 6.43 of ash per 100 g and as per the RDA 2020 the developed product is a rich source of minerals such as Iron and Calcium as well as it contains 11 mg of Iron and 654 mg of calcium as shown in Table 6.

CONCLUSION

A nutrient-rich food product is developed in this research paper to assess its sensory attributes using a 9-point rating scale and to determine its ranking using MAPH that helps to provide the best product from the list that are available and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). TOPSIS is a technique in which solutions are identified from the various sets of options as it a multi-criteria decision-making technique. According to the TOPSIS and MAHP ranking was done for all the four samples that shows Sample D stands on rank 1 and best sample among the others, followed by sample C on rank 2, sample B stands on rank 3 and sample A on rank 4 as per the ranking. The developed millet cake is a good source of dietary fiber and protein and provide a healthy dessert option with health various benefits as it is loaded with nutrients that helps to maintain weight. However, TOPSIS method can be widely used in identifying the best sample and to make comparison between the alternatives of food products as this method eases the comparison and decision in the developed food products.

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Conflict of interest

The authors declare no conflict of interest.

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