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Development of a Breakfast Cereal Using Sprouted Mung Bean (Vigna radiata) and Roasted Flaxseed (Linum usitatissimum)

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Abstract— This study was conducted to develop a nutritious cereal blend using different compositions of sprouted green beans (SMB) powder, roasted flaxseed (RFS) powder and corn flour. The main objective was to create a functional cereal enriched with essential nutrients while maintaining good sensory properties. The proximate composition of the cereal was analyzed, and the following key results were revealed. Moisture was 8.39±0.19%, indicating good shelf stability; Ash content was 2.66±0.28%, reflecting essential minerals such as calcium and potassium. Crude protein was 20.66±0.57%, mainly contributed by SMB. Crude fiber was 12.96±0.25%, which promotes digestive health; and crude fat was 12.66±0.57%, which was mainly from omega-3 rich flaxseed. Carbohydrate content was 42.64±0.67%, which provided a balanced energy source. In addition, total soluble solids (TSS) content was 4.06±0.15%, which suggested a reasonable amount of soluble solids, and antioxidant activity was 44±0.05%, which was attributed to bioactive compounds in flaxseed and green beans. This study aimed to develop a nutritious cereal blend
using sprouted green bean (SMB) powder, roasted flaxseed (RFS) powder, and corn flour. The
goal was to create a functional food rich in essential nutrients with good sensory appeal.

Index Terms— Color analysis; Legume-based snack bar; Proximate composition; Sensory evaluation; Texture analysis

1 INTRODUCTION

This study focuses on developing a nutritious breakfast cereal using sprouted green beans (Vigna radiata) and flaxseed (Linum usitatissimum) and evaluating its potential for consumer acceptance. Other objectives are to develop a breakfast cereal by incorporating sprouted green beans and flaxseed.To identify the best formulation through a sensitivity analysis.To evaluate the nutritional composition and physicochemical properties of the developed breakfast cereal.To analyze the shelf life of the breakfast cereal.It also examines
the factors that push consumers towards specific cereals such as gluten-free, high-fiber,protein-rich and sugar-free options. The above objectives are achieved through this study. The goal was to create a functional food rich in essential nutrients with good sensory appeal. The optimized blend (T3: 60% SMB, 25% RFS, 5% corn flour) showed favorable results: moisture(8.39%), ash (2.66%), protein (20.66%), fiber (12.96%), fat (12.66%), and carbohydrates (42.64%), with notable antioxidant activity (44%) and TSS (4.06%). These components contribute to digestive health, energy, and heart benefits. The formulation was developed using Taguchi's L-4 (4) design, with sensory testing confirming T3 as the most acceptable. This study demonstrates the potential of ingredient optimization in developing nutrient-rich, functional cereal products.

2.METHODOLOGY

This section outlines the methods used for sample collection, cereal breakfast development and subsequent analysis.

3.Raw Material

Sprouted mungbean,Roasted,Flaxseed,Dried dates,Cornflour were purchased from Moneragala, Sri Lanka local markets.

3.Development of Cereal Breakfast

Four formulations (T1–T4) were developed using different proportions of sprouted mung bean powder (SMB), roasted flaxseed powder (RFS), and corn flour. The optimal blend (T3) had 60% SMB, 25% RFS, 5% corn flour

Table 1: Ingredient formulation of Breakfast cereal expressed in percentage (%)

Ingredient	SMB	RFS	Corn flour	Sugar	Salt	Dried dates
T1	50	25	2.5	0	2	8
T2	50	30	5	10	2	8
T3	60	25	5	0	2	8
T4	60	30	2.5	10	2	8

4.Sensory evaluation

A five-point hedonic test was conducted using 30 semi-trained panelists to evaluate the samples. In both sensory evaluations, 5 sensory parameters (Appearance, Color, Aroma,Taste, and Overall acceptability) were analyzed.

1.Color

2.Aroma

3.Mouthfeel

4.Taste

5.Overall Acceptance

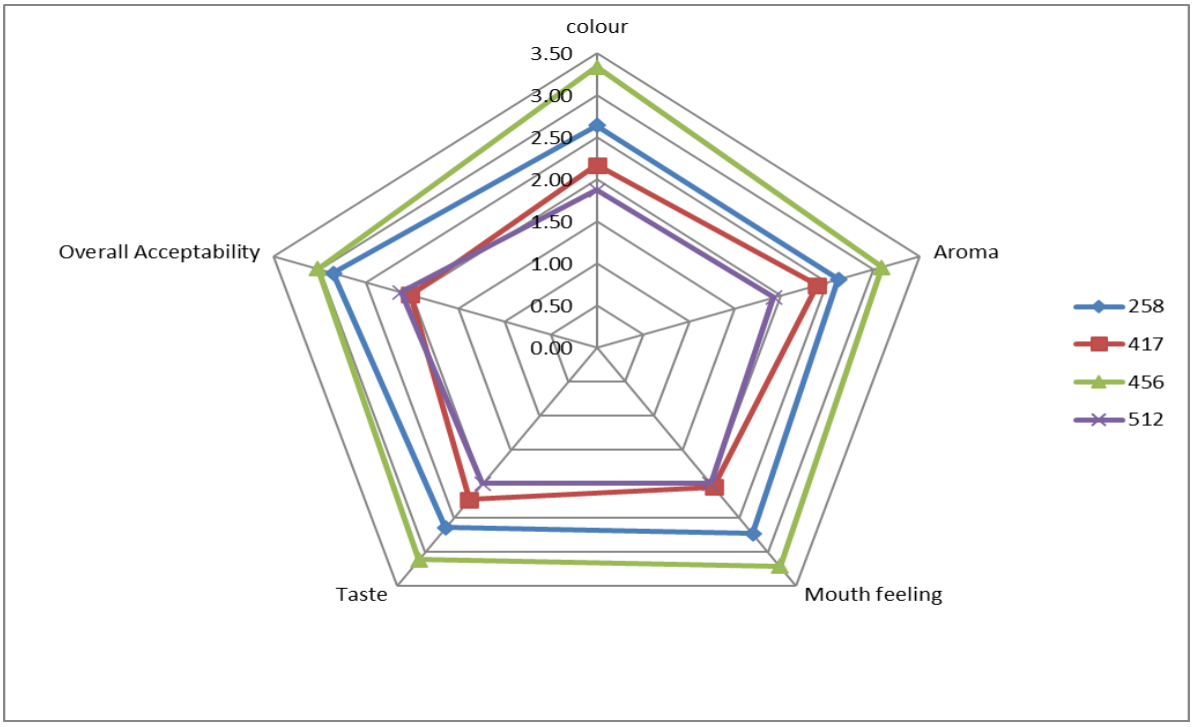

Fig 1: spider chart

The spider chart (or radar chart) visually compares the performance of four treatments (Treatment 1, Treatment 2, Treatment 3, and Treatment 4) across five attributes (Five point Hedonic).

5.Proximate analysis

Moisture, protein, fat, and ash contents of the selected sample from the sensory analysis were determined using AOAC (2000) methods 925.10, 920.87, 920.85, and 923.03, respectively. The carbohydrate content was calculated by difference [15].

6.Shelf-life analysis.

During the shelf-life study, the samples were stored in glass containers at room temperature (27 °C, 60% relative humidity) until all analyses were performed. The shelf life of cereals were evaluated based on microbial counts.

7.Statistical analysis

Data were analyzed using Minitab 19 software, employing one-way ANOVA, ,Experimental design and linear regression analysis with 95% confidence interval as mean ± SD.

8.Sensory analysis

Mean sensory scores for different attributes of the Cereal breakfast formulations are presented in Table 2.

Formulation	SMB	RFS	Corn flour	Sugar	salt
258	2.63	2.62	2.73	2.65	2.85
417	2.17	2.38	2.05	2.23	2.02
456	3.33	3.08	3.22	3.12	3.02
512	1.87	1.92	2.00	2.00	2.12

Table 2: Mean sensory scores for different attributes

This table shows how different **formulations (258, 417, 456, 512)** performed based on ingredient-related scores (**SMB, RFS, corn flour, sugar, salt**). Here's a simple explanation:

Formulation 456 demonstrated the highest values across almost all evaluated categories, with scores ranging from approximately 3.0 to 3.3, indicating that it performed the best overall in terms of quality, taste, or general acceptability. In comparison, formulation 258 showed moderate values between 2.6 and 2.8, suggesting an average level of performance that is acceptable but not outstanding. Formulation 417 recorded lower scores, around 2.0 to 2.3, reflecting a below-average performance. Meanwhile, formulation 512 had the lowest values, ranging from 1.8 to 2.1, making it the least preferred and weakest formulation among the four..

Overall conclusion:

456 > 258 > 417 > 512

- 456 is the best formulation
- 512 is the worst formulation

If these are sensory or quality scores, it means formulation 456 would likely be the most acceptable product.

Here is your data clearly organized into a clean

ANOVA table:

Sum of Squares (ANOVA)			df	Mean Square	F	Sig.
Color	Between Groups	22.733	3	7.578	14.012	0.000
Within Groups		62.733	116	0.541		
Total		85.467	119			
Aroma	Between Groups	13.100	3	4.367	12.395	0.000
Within Groups		40.867	116	0.352		
Total		53.967	119			
Taste	Between Groups	20.225	3	6.742	12.075	0.000
Within Groups		64.767	116	0.558		

Total		84.992	119			
Mouthfeel	Between Groups	9.933	3	3.311	7.175	0.000
Within Groups		53.533	116	0.461		
Total		63.467	119			
Overall acceptability	Between Groups	14.200	3	4.733	8.904	0.000
Within Groups		61.667	116	0.532		
Total		75.867	119			

Table 03: ANOVA table

Moisture content (8.39±0.19%): Moisture content indicates the water present in the sample. At 8.39%, the moisture content is relatively low and is typical for dried or processed food products. This low moisture level contributes to a better shelf life and stability of the product by reducing the potential for microbial growth.
Ash content (2.66±0.28%): Ash content indicates the mineral content of the sample. 2.66% suggests a moderate mineral concentration, which is essential for the nutritional value of the product. Minerals such as calcium, potassium and magnesium contribute to this ash content, which is responsible for maintaining physical activity.
Crude protein (20.66±0.57%): A protein content of 20.66% indicates a significant source of protein. This is a significant amount of protein, making the sample suitable for vegetarians or for inclusion in diets that require a high amount of protein, such as sports nutrition.
Crude Fiber (12.96±0.25%): The fiber content of 12.96% suggests that the sample contributes to better digestive health. The high fiber content contributes to regular bowel movements, lowers cholesterol levels, and manages blood sugar levels.Crude Fat (12.66±0.57%): At 12.66%, the fat content is moderate, indicating that the sample can be a good source of energy while providing essential fatty acids. However, this fat content should be balanced with the overall nutrient profile of the product to avoid excessive calorie intake.
Crude Carbohydrates (42.64±0.67%): Carbohydrates are the largest part of the composition, comprising 42.64%. This carbohydrate can be a combination of sugar and starch, which provides energy to the body. Depending on the type of carbohydrate, the product can serve as a quick source of energy.
In addition to the approximate composition, the total soluble solids (TSS) content of the sample is 4.06±0.15%, which indicates the concentration of dissolved solids such as sugars, acids, and minerals in the product. This indicates that the sample is quite concentrated, but may not be too sweet or acidic. It is beneficial to the body because it is not sweet. Since no sugar is added, it can be added as much as needed.
Finally, the antioxidant activity (44±0.05%) highlights the ability of the sample to neutralize free radicals that are harmful to the body. This has a very good antioxidant activity. The antioxidant percentage suggests that the sample may provide health benefits related to reducing oxidative stress and inflammation.

9. Sensory Analysis.

The one-way ANOVA findings show that the three formulations differed significantly ($p < 0.05$) in terms of color, aroma, taste, mouthfeel, and overall acceptability, indicating that the formulation changes significantly affected all sensory attributes. Contrary to the previous interpretation, color also showed a statistically significant difference ($p = 0.000$, $F = 14.012$), suggesting that the appearance of the bread was influenced by the varying amounts of avocado seed powder used. The significant difference in aroma ($p = 0.000$, $F = 12.395$) indicates that the scent profile of the bread was affected, likely due to the natural aromatic compounds in the avocado seed powder, which became more prominent as the
concentration increased. Similarly, taste ($p = 0.000$, $F = 12.075$) showed a highly significant difference, suggesting that the formulation played a crucial role in flavor perception, possibly due to the distinct bitter or nutty notes of the avocado seed

powder.

Mouthfeel also exhibited a significant difference ($p = 0.000$, $F = 7.175$), indicating that the avocado seed powder altered the bread's texture, potentially affecting its softness, density, or crumb structure. Changes in fiber content and moisture retention may have contributed to these variations. Furthermore, overall acceptability showed a notable difference ($p = 0.000$, $F = 8.904$), signifying that the panelists had clear preferences among the formulations. The significant differences across all sensory attributes suggest that modifications in formulation, particularly the amount of avocado seed powder, influenced the bread's overall sensory quality. These findings highlight the necessity of careful formulation optimization to balance sensory appeal and consumer acceptance.

5.1 Proximate Analysis

Proximate analysis results of the selected breakfast cereal (B) are given in Table 4.

Constituent	Results (%)
Moisture	8.39±0.19
Ash	2.66±0.28
Crude Protein	20.66 ±0.57
Crude Fiber	12.96±0.25
Crude Fat	12.66±0.57
Crude Carbohydrate	42.64±0.67
TSS	4.06 ±0.15
Antioxidant	44±0.05

Table 04:Proximate Analysis

Moisture content (8.39±0.19%): Moisture content indicates the water present in the sample. At 8.39%, the moisture content is relatively low and is typical for dried or processed food products. This low moisture level contributes to a better shelf life and stability of the product by reducing the potential for microbial growth.

Ash content (2.66±0.28%): Ash content indicates the mineral content of the sample. 2.66% suggests a moderate mineral concentration, which is essential for the nutritional value of the product. Minerals such as calcium, potassium and magnesium contribute to this ash content, which is responsible for maintaining physical activity. Crude protein (20.66±0.57%): A protein content of 20.66% indicates a significant source of protein. This is a significant amount of protein, making the sample suitable for vegetarians or for inclusion in diets that require a high amount of protein, such as sports nutrition. Crude Fiber (12.96±0.25%): The fiber content of 12.96% suggests that the sample contributes to better digestive health. The high fiber content contributes to regular bowel movements, lowers cholesterol levels, and manages blood sugar levels.Crude Fat (12.66±0.57%): At 12.66%, the fat content is moderate, indicating that the sample can be a good source of energy while providing essential fatty acids. However, this fat content should be balanced with the overall nutrient profile of the product to avoid excessive calorie intake. Crude Carbohydrates (42.64±0.67%): Carbohydrates are the largest part of the composition, comprising 42.64%. This carbohydrate can be a combination of sugar and starch, which provides energy to the body. Depending on the type of carbohydrate, the product can serve as a quick source of energy.

In addition to the approximate composition, the total soluble solids (TSS) content of the sample is 4.06±0.15%, which indicates the concentration of dissolved solids such as sugars, acids, and minerals in the product. This indicates that the sample is quite concentrated, but may not be too sweet or acidic. It is beneficial to the body because it is not sweet. Since no sugar is added, it can be added as much as needed. Finally, the antioxidant activity (44±0.05%) highlights the ability of the sample to neutralize free radicals that are harmful to the body. This has a very good antioxidant activity. The antioxidant percentage suggests that the sample may provide health benefits related to reducing oxidative stress and inflammation

6.1 Shelf-life analysis

Microbial analysis of the selected snack bar was carried out over 3-week period, and the results are presented in Table 6.

Test	Prepared day	Week 01	Week 02
Yeast and mold (CFU/g)	N/A	N/A	N/A
Total plate count	N/A	0.4 x 10^2	0.78 x 10^2

Table 5: Shelf-life analysis of Cereal breakfast B

The observed counts were acceptatble and is in line with the Micorbial limits for dried and instant processed cereal products requiring re-constitution; Aerobic plate count per gram: $5x10^4$; Yeast and mold counts per gram: $1x10^2$ as per Food act No. 26 of 1980 [6].

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9.CONCLUSIONS

This study successfully demonstrates an innovative approach to developing a nutritious and functional breakfast cereal that aligns with the growing consumer preference for healthy and minimally processed food options. By incorporating sprouted green beans, roasted flaxseeds and dried dates, the optimized formulation ensures improved nutritional value, improved sensory characteristics and overall consumer acceptance. It is also unique in that it allows for the inclusion of dates in the diet only for those who are willing to eat them.

Among the tested formulations, Treatment 3 (T3) emerged as the most optimal choice, excelling in sensory properties, protein content, microbial stability and long shelf life. The balance of macronutrients, along with the presence of bioactive compounds from flaxseed and natural sugars from dried dates, make this formulation a promising candidate for commercialization in the functional food sector.

The optimized breakfast cereal formulation offers multiple health benefits, including improved protein bioavailability, omega-3 fatty acids, dietary fiber, and reduced reliance on refined sugars. Furthermore, the study highlights the potential of food innovations based on natural ingredients in meeting the evolving dietary preferences of health-conscious consumers.

Overall, this research lays a solid foundation for future product development and commercialization in the functional food industry, reinforcing the importance of nutrient- rich breakfast options that balance both health and convenience .

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