Annals of Agri-Bio Research **30** (1): 112–121, 2025

Impact Score: 0.4 (Scopus)

Development of Fibre and Protein-Rich Macaroni from *Phaseolus lunatus*, *Manihot esculenta*, and Greens of *Pisum sativum*: Selection of Best Samples by a Sensory Evaluation, MAHP, and TOPSIS Method

Luxita Sharma [1], Dhananjay Sharma [1]*, Deepika Pal [1], Kajal Dhama [1] and Akanksha Yadav [2]

[1] *Department of Dietetics and Applied Nutrition, Amity Medical School, Amity University Haryana, Gurgaon 122413, India*
[2] *Department of Nutrition & Dietetics, Faculty of Allied Health Sciences, SGT University, Gurugram 122505, India*
*(e-mail: medhananjaysharma@gmail.com)

(Received: 10 April 2025; Accepted: 30 May 2025)

ABSTRACT

Food products like macaroni are very trendy nowadays. Macaroni is a staple diet for Italian people. There are so many ways of making macaroni. It is normally prepared with wheat flour by adding water or eggs. After the revolution in the food industry, a variety of ingredients are now used to prepare various types of macaroni. The primary objective of this study is to investigate the incorporation of soybeans, lima beans, pea husk powder, and tapioca into macaroni production, with a focus on optimizing the nutritional content, sensory qualities, and sustainability aspects of the final product. By harnessing the individual strengths of these ingredients, this research aims to contribute to the development of healthier and more environmentally friendly macaroni alternatives. Four different samples of macaroni were made using a variation of lima seed flour, pea husk powder, tapioca, soybean flour, and wheat flour. Sample 'A' constitutes 20 g lima seed flour and 5 g pea husk powder, Sample 'B' constitutes 15 g lima seed flour and 10 g pea husk powder, Sample 'C' constitute10 g lima seed flour and 15 g pea husk powder, and Sample 'D' constitute 5 g lima seed flour and 20 g pea husk powder. The sensory result showed that Sample A (8.5 ± 1.0) with higher overall acceptability, followed by Sample B, C and D. The result of the MAHP of CI value (Consistency Index) was 0.008, and CR (Consistency Ratio) was 0.005. A CI of less than 0.1 is acceptable. Positive and Negative Ideal Situation of Sample A was found to be 0 and 0.58911, and the ranking by TOPSIS was found to be 1 for Sample A, indicating higher acceptability. The proximate analysis result showed that the newly developed macaroni contains a larger amount of fiber (10.23 g). The calorie content of newly developed macaroni is 380.67 Kcal, and it has a high protein content (22.82 g).

Key words: dietary fibre, *Phaseolus lunatus*, *Manihot esculenta*, *Pisum sativum*, sensory evaluation, MAHP, TOPSIS

INTRODUCTION

In a world where health consciousness and sustainability are gaining increasing prominence, the demand for nutritious and eco-friendly food options has grown exponentially (Ohlhorst et al., 2013; Sharma et al., 2024). Amidst this trend, macaroni, a beloved staple in many cultures, has undergone remarkable transformations to cater to diverse dietary preferences and nutritional requirements (Rozin et al., 2012). This work delves into the realm of healthy macaroni making by exploring the utilization of soybeans, lima beans, pea husk powder, and tapioca—an innovative combination that holds the potential to revolutionize the macaroni industry (Grundy et al., 2016).

Soybeans, known for their high protein content, offer an excellent opportunity to enhance the nutritional profile of macaroni (Garcia et al., 1997). With their potential to provide essential amino acids and their recognized health benefits, such as improving cardiovascular health (Mullins & Arjmandi, 2021) and reducing the risk of chronic diseases, soybeans present an exciting avenue for fortifying macaroni with vital nutrients (Hu et al., 2023). The consumption of soybeans has been correlated to various potential health benefits and in reduction of numerous chronic illnesses like cardiovascular disease, diabetes, immune disorders, certain types of cancer, and obesity (Dukariya et at., 2020; Messina, 2014; Ravishankar et al., 2016).

Lima beans, often overlooked, possess a remarkable array of health-promoting properties. Their rich dietary fibre content aids digestion, promotes satiety, and contributes to overall gut health. Additionally, lima beans are an abundant source of essential vitamins and minerals, including folate, potassium, and iron, all of which are crucial for maintaining optimal health and well-being (Adebo, 2023). Lima beans contain insoluble fiber, which improves stool bulk and prevents constipation. It has also been reported to promote cardiovascular health, control blood sugar levels due to its low glycemic index, manage blood glucose and reduce cholesterol, as it is rich in fibre. It contains the trace amounts of isoflavones (daidzein and genistein), which can assist in preventing breast and colon cancer (Adebo, J. A. (2023).

The incorporation of pea husk powder, a by-product of pea processing, introduces an additional layer of nutritional benefits. This powder not only enhances the fibre content of the macaroni but also provides valuable antioxidants that can potentially improve human health by combating oxidative stress and reducing inflammation. Moreover, the utilization of pea husk powder also aligns with the principles of sustainability by repurposing an otherwise underutilized waste product (Hanan et al., 2020; Ramirez et al., 2021). The pharmacological benefits offered by pea pods are antidiabetic, hepatoprotective, reno-protective, reproductive, antibacterial, and α-amylase inhibition activity (Nasir et al., 2024; Dahl et al., 2012).

Lastly, tapioca, derived from the cassava root, offers an intriguing gluten-free alternative to conventional wheat-based macaroni. Its unique properties provide an opportunity to address the needs of individuals with gluten intolerance or those seeking varied dietary options. Tapioca's gentle impact on the digestive system, coupled with its ability to contribute to the desired texture of macaroni, renders it a valuable ingredient in this research (Hsieh et al., 2019).

Throughout this study, a comprehensive exploration of these four key ingredients will be conducted, including their nutritional composition, functional properties, and sensory attributes. The research will involve experimental investigations, recipe development, and the evaluation of the resultant macaroni in terms of its nutritional quality, texture, flavour, and overall acceptability.

By shedding light on the potential of soybeans, lima beans, pea husk powder, and tapioca in healthy macaroni making, this study aims to contribute to the broader understanding of sustainable food production and innovative approaches to meeting the evolving needs of health-conscious consumers. Overall, this study aspires to provide valuable insights and practical recommendations for the macaroni industry, chefs, nutritionists, and consumers alike, encouraging a shift towards healthier and more sustainable food choices.

Food product like macaroni is very trendy now a days. Macaroni is a staple diet for Italian people. There are so many ways of making macaroni. It is normally prepared with wheat flour by adding water or eggs. But it can also be prepared by using rice flour, pulses, beans and many more ingredients (Sissons, 2022). After the revolution in food industry, a variety of ingredients are now used to prepare various types of macaroni. They are filled with lots of nutrients like fiber, iron, protein, etc. Raw macaroni can be baked or boiled for eating. Various vegetables can be added according to the taste. Macaroni mainly available in two forms fresh and dried macaroni. Dried macaroni is prepared by extrusion process and is mainly for commercial purposes. It is packed and sold on a large scale. It can be available in different shapes and sizes (Poutanen et al., 2022). The study phases have been illustrated in Figure 1 of the methodology section.

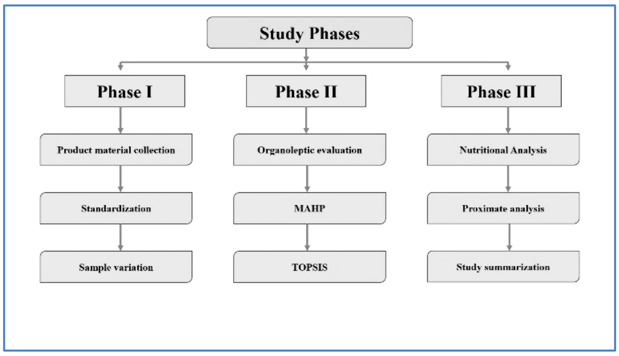


Fig. 1. Study phases.

OBJECTIVES OF THIS STUDY

1. To develop high dietary fiber and high protein macaroni from peapods, lima beans, and tapioca.
2. To assess the organoleptic evaluation of the developed product.
3. To conduct the MAHP and TOPSIS methods to statistically select the best samples from the variation of the samples.
4. To analyze the proximation value of developed macaroni.

MATERIALS AND METHODOLOGY

Raw Materials Collection and Preparation

All the preparation was done in the nutrition Lab of the Department of Dietetics and Applied Nutrition, Amity University Haryana, Gurugram.

Ingredients

Purchased: Dried seeds of soya beans, and lima beans were brought from the local shop from the nearest market (Panchgaon, Manesar, Gurugram, Haryana). Then these seeds are cleaned of any pebbles and other unwanted things. They were washed properly in running water and then fried in the sun. After drying the seeds were powdered into fine ones. Then, the flour was sieved through a 120 US mesh.
Drying of pea pod: Pea pods were brought from the market, sun-dried for 3 consecutive days, and then ground into a fine powder, after the powder was sieved through 120 US mesh.

Development of Product

For the development of the product which is macaroni, three main ingredients were used namely

- Soya bean flour
- Lima bean flour
- Pea husk powder

Also, tapioca flour is added in a small amount just for its binding properties. Four varieties were developed by choosing various proportions of the ingredients to see the acceptability of the prepared samples.

Sample Variation

Four different samples of macaroni were made using a variation of lima seed flour, pea husk powder, tapioca, soybean flour, and wheat flour. Sample 'A' constitutes 20 g lima seed flour and 5 g pea husk powder, Sample 'B' constitutes 15 g lima seed flour and 10 g pea husk powder, Sample 'C' constitute10 g lima seed flour and 15 g pea husk powder, and Sample 'D' constitute 5 g lima seed flour and 20 g pea husk powder. The Sample variations for the preparation of Macaroni are described in Table 1.

Table 1. Sample variations for the preparation of Macaroni.

Varieties	Soya bean flour (g)	Lima seed flour (g)	Pea husk powder	Tapioca	Wheat flour
A	30 g	20 g	5 g	5 g	40 g
B	30 g	15 g	10 g	5 g	40 g
C	30 g	10 g	15 g	5 g	40 g
D	30 g	5 g	20 g	5 g	40 g

Methods of Preparation Procedure

- ➢ Take a bowl and mix all the flour in it in the given ratio.
- ➢ Flours should be sieved properly to remove big particles and only fine flour should be used to avoid breakage of macaroni pieces.
- ➢ Add all the flour to a mixer and prepare the dough by adding water slowly and gradually.
- ➢ Using a mixer is prescribed to prepare a good-quality dough.
- ➢ Now prepare macaroni from the dough by using a hand macaroni maker.
- ➢ Carefully place all the pieces of macaroni on a plate.
- ➢ Let it sun dry for one day by covering it with a cotton cloth to avoid any dust particles.
- ➢ Now boil the dried macaroni in a pan for 20 min by adding water and a little salt to taste.
- ➢ Strain macaroni and remove excess water.
- ➢ Serve them with macaroni sauce or homemade tomato sauce.
- ➢ This can be prepared using Vegetables like the classic macaroni recipe.
- ➢ The same method can be used to prepare other samples.

The Figure 2 illustrates the flow chart of the Methods of preparation and procedure of macaroni.

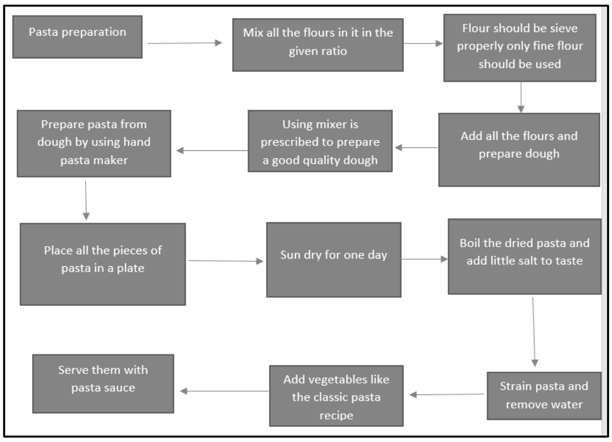


Fig. 2. The flow chart of the Methods of preparation and Procedure of macaroni.

Assessment of Acceptability

The technique of sensory evaluation or sensory assessment is a very basic and important step in the product development process (Mihafu et al., 2020). In this particular research sensory assessment is done by 9 point hedonic testing scale and using the parameters such as, Color, Texture, Appearance, Taste, Flavor, Chewiness, Consistency, and Overall acceptability.

Using a 9-Point Hedonic Testing Scale for the Sensory Study of This Research

It is one of the most popular scales used in various food industries to evaluate the attributes of their food products before launching them into the market. The scaling is done given as below in Table 2.

Table 2. 9-point hedonic testing scale.

Scaling	Keys
9	Like extremely
8	Like very much
7	Like moderately
6	Like slightly
5	Neither like or dislike
4	Dislike slightly
3	Dislike moderately
2	Dislike very much
1	Dislike extremely

Out of various samples with different compositions of ingredients panel members give marking according to their like and dislike of the particular sample under various attributes related to a particular product. The picture of various samples (A, B, C, and D) of macaroni is depicted in Figure 3, and the sensory result bar graph depicted in Figure 4 of various attributes such Color, Texture, Appearance, Taste, Flavor, Chewiness, Consistency, and Overall acceptability.

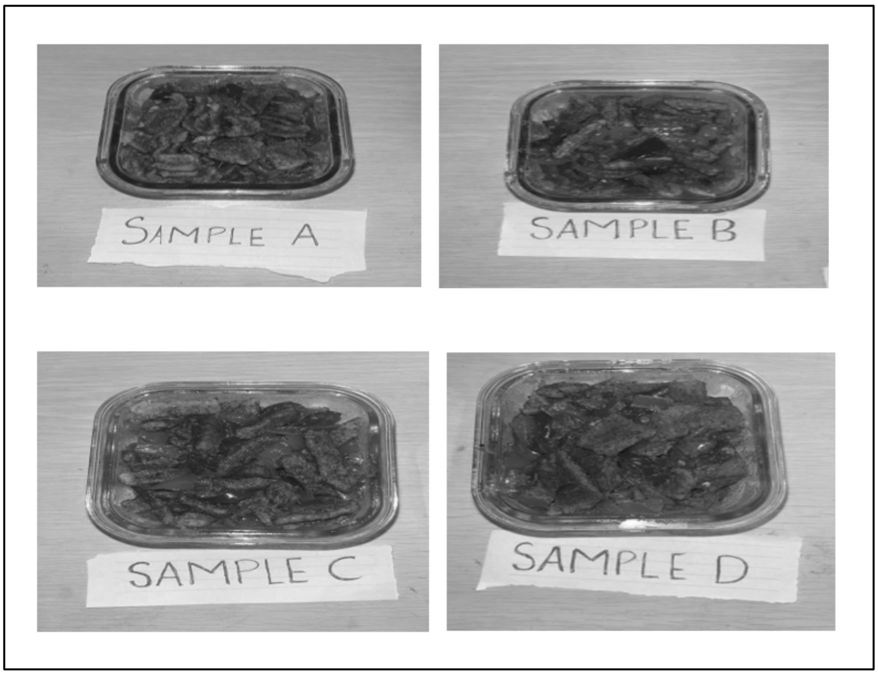
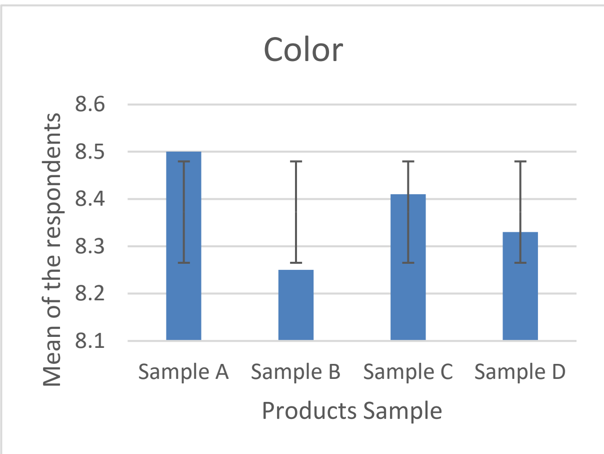
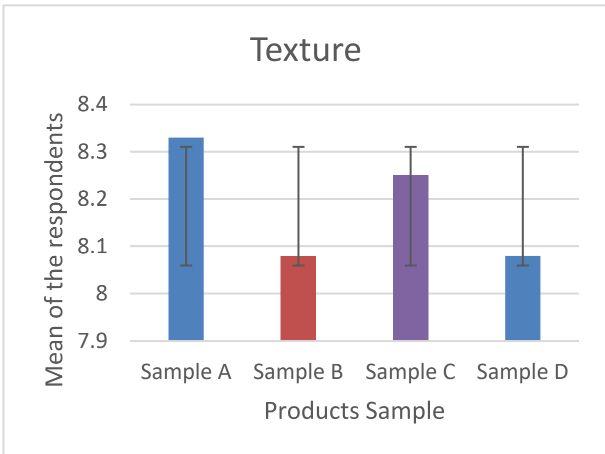


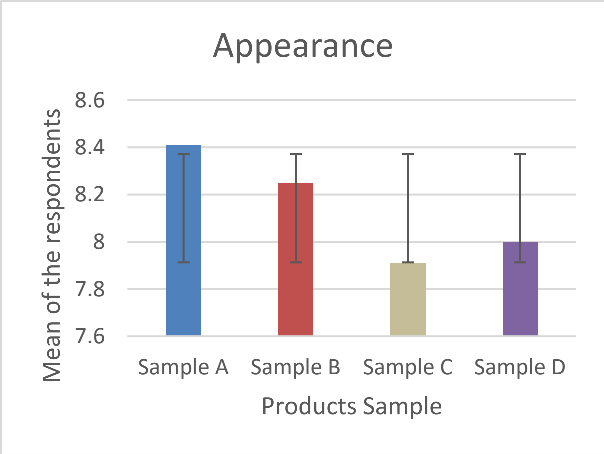
Fig. 3. Pictures of Samples (A, B, C, and D).



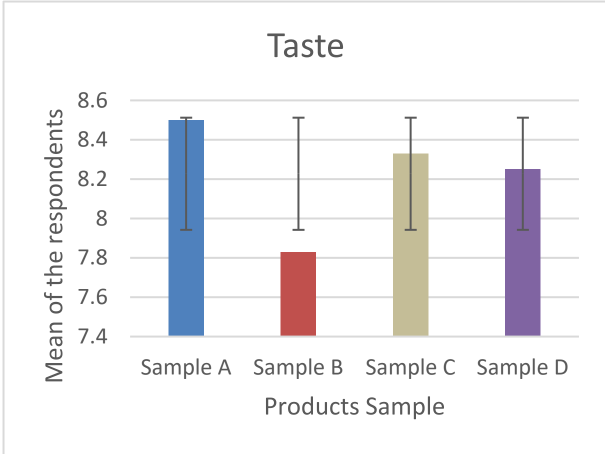
4.1 Graphical representation of colour



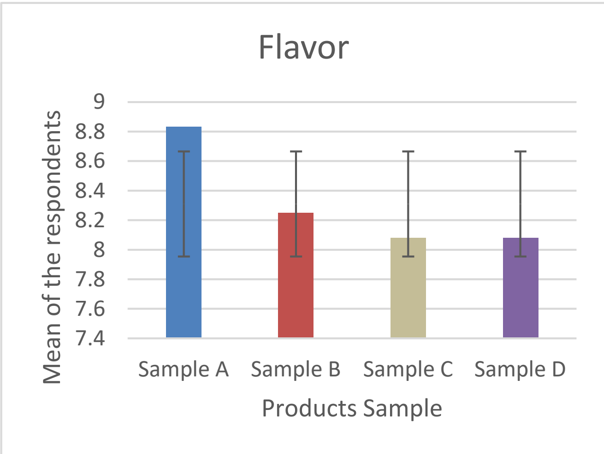
4.2 Graphical representation of texture



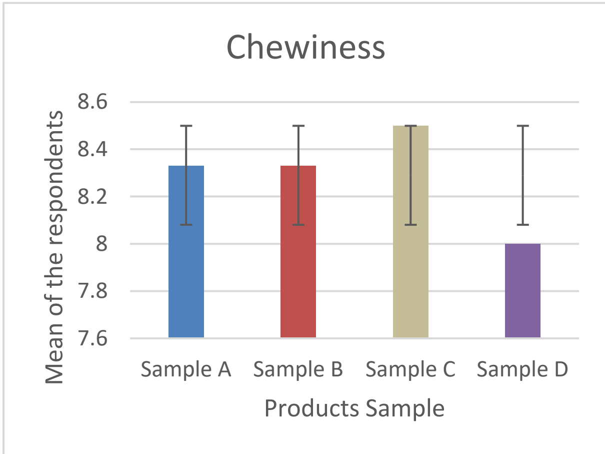
4.3 Graphical representation of appearance



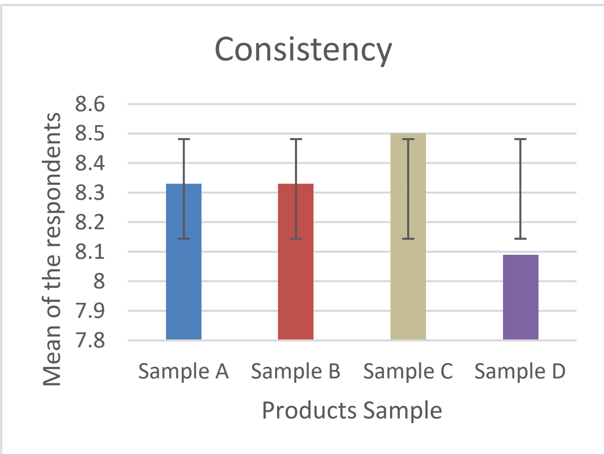
4.4 Graphical representation of taste



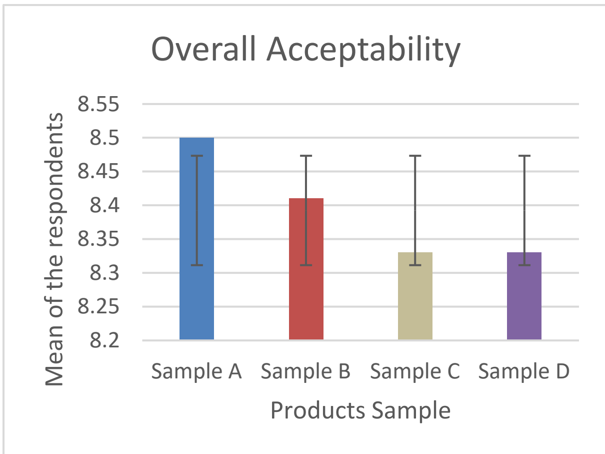
4.5 Graphical representation of flavour



4.6 Graphical representation of chewiness



4.7 Graphical representation of consistency



4.8 Graphical representation of overall acceptability

Fig. 4. Bar graphs representing the sensory assessment results for various attributes of Macaroni.

Results of Assessment for Sensory Attributes

Total Scores for Acceptability of the product "Macaroni" after addition of various ratio of ingredients and developing four samples in terms of colour, shape, texture, taste, mouth feel, after taste, and overall acceptability is described in Table 3.

Table 3. Sensory evaluation result.

	Color	Texture	Appearance	Taste	Flavor	Chewiness	Consistency	Stickiness	Overall acceptability
Sample A	8.5 ± 1.16	8.33 ± 0.98	8.41 ± 0.99	8.5 ± 1.31	8.83 ± 1.11	8.33 ± 1.15	8.33 ± 0.57	8.6 ± 1.12	8.5 ± 1.0
Sample B	8.25 ± 0.96	8.08 ± 1.24	8.25 ± 1.05	7.83 ± 1.33	8.25 ± 0.96	8.33 ± 1.30	8.33 ± 1.30	8 ± 1.68	8.41 ± 1.16
Sample C	8.41 ± 0.99	8.25 ± 0.75	7.91 ± 0.99	8.33 ± 0.88	8.08 ± 0.99	8.5 ± 0.98	8.5 ± 1.11	8.16 ± 0.98	8.33 ± 0.77
Sample D	8.33 ± 0.77	8.08 ± 0.79	8 ± 0.95	8.25 ± 0.96	8.08 ± 1.24	8 ± 1.13	8.09 ± 0.79	8 ± 1.65	8.33 ± 0.98

TOPSIS for Marconi

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), came into existence in the 1980s as a multi-criteria-based decision-making method. In the context of food products, AHP (Analytic Hierarchy Process) and TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) are valuable tools for multi-criteria decision making. AHP and TOPSIS are helpful in decision-making by providing structured frameworks for evaluating alternatives based on multiple criteria. AHP helps organize criteria and determine their relative importance, while TOPSIS ranks alternatives based on their closeness to an ideal solution. This statistical method is generally used to choose the alternative of the shortest Euclidean distance from the ideal solution and the greatest distance from the negative ideal solution. After the organoleptic analysis of the product, if the panelist was slightly confused about which one would be the best one, then we would go with TOPSIS, which would rank based on the weightage and the impact of the food factors. Now let's understand the weightage, weightage defines the mean of how much a given factor should be taken into consideration (default weight a = 1 for all factors). This method is widely used in the area such as purchase decisions and outsource provider selection (Kahraman et al., 2009; Shyur & Shih 2006), manufacturing decision-making (Agrawal et al., 1991), service quality assessment (Mukherjee & Nath, 2005), educational selection application (Nanayakkara et al., 2020) an many more.

Calculation of Weights by MAHP (Means of Analytical Hierarchy Process)

The MAHP is based on the principle of the selecting of the best products from the various options. The ranking is generally done for the pair-wise comparison (Forman et al., 2001; Sharma et al., 2024).

Analytical Hierarchy Process technique

Let set the criteria be A = (Aj), where j implies 1, 2, 3, 4, 5…n.
The pair-wise comparison done for the Z matrix of "n" number of criteria and it can be (n*n) matrix. Each n*n matrix is "ij", where ij is 1, 2, 3, 4, …n. The Pair-wise comparison matrix for n number of criteria is described in Table 4.

Table 4. Pair-wise comparison matrix for n number of criteria.

K	A_1	A_2	…	A_n
A1	1	a_{12}	a_{13}…	a_{1n}
A2	a_{21}	1	a_{23}…	a_{2n}
A3	a_{31}	a_{32}	1…	a_{3n}
.	.	.	…	.
An	a_{n1}	a_{n2}	a_{n3}…	1

AHP Calculation

Step 1: First draw 4 × 4 matrix because we have used four variation of the sample and let the calculation done. The '4 × 4' matrix for four different samples calculation described in Table 5.

Table 5. 4 × 4′ matrix for four different samples.

	Sample A	Sample B	Sample C	Sample D	4th. Root	PV (Priority Vectors) weights
Sample A	1	2	3	6	2.4494897	0.497351695
Sample B	0.50	1.00	1.00	3.00	1.1066819	0.224703994
Sample C	0.33	1.00	1.00	3.00	1	0.203042979
Sample D	0.17	0.33	0.33	1.00	0.368894	0.074901331
Sum	2.00	4.33	5.33	13.00	4.93	
SUMPV	0.99	0.97	1.08	0.97	4.03	
CI	0.008345					
CR	0.005755					

Step 2: After matrix calculation, the 4th root calculation needs to done for $A = (1*2*3*6)^{1/4} = 2.45$; will do the same for all four variables.

Step 3: Next will do the sum of 4th root, which was obtained 4.93.

Step 4: Then the priority vector was calculated for each group. To find the PV value, the 4th root of each sample is divided by the sum of the 4th root i.e., 2.45/4.93 = 0.49 will do for the all variables.

Step 5: Ather calculating the PV value, then need to calculate the sum of PV value for each variable, i.e., the Sum PV for A = 0.49*2.0 = 0.99; will do for the other four variables.

Step 6: Then, the Total of Sum PV λ(max) {Lambda-max} was calculated. λ(max) = ∑(PV (A, B, C, D) = 4.03

Step 7: Then calculated CI value (Consistency Index). It has been calculated by the given formula:

CI= (λ(max) − n)/(n − 1), where n = number of systems/variables being compared CI (Consistency Index) = 4.03 − 4/3 = 0.008

Step 8: At last, the CR (Consistency Ratio) value was calculated by dividing CI (Consistency Index) by the Random Index value. Values of RI are given in Table 6 below.

Table 6. Random Consistency Index.

Random Index (RI)										
N	1	2	3	4	5	6	7	8	9	10
RANDOM INDEX (RI)	0.000	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

In our study, total of 6 criteria were compared, so, n = 6. RI for 6 is used to calculate the CR value. CR = 0.008/1.45 = 0.005

- The CR is the indicator of the consistency among the various samples. A consistency ratio of less than 0.1 is only acceptable.
- The calculated CR of the study was found to be 0.005, which was less than 0.1, so our pair-wise comparison test was found to be consistent.

The average value of all the 9 attributes of the sample variable was used to interpret the TOPSIS, and the weightage of each sample was calculated using the AHP method. The nine attributes used in the study were colour, texture, appearance, taste, flavor, chewiness, consistency, stickiness, and overall acceptability. The nine different attributes of sensory evaluation and calculated weights from the AHP technique have been depicted in Table 7.

TOPSIS for Ranking the Samples

Table 7. Nine different attributes of sensory evaluation and calculated weights from the AHP technique.

Mean scores obtained from sensory evaluation and calculated weights from the AHP technique									
	Color	Texture	Appearance	Taste	Flavor	Chewiness	Consistency	Stickiness	Overall acceptability
Sample A	8.5	8.33	8.41	8.5	8.83	8.33	8.33	8.6	8.5
Sample B	8.25	8.08	8.25	7.83	8.25	8.33	8.33	8	8.41
Sample C	8.41	8.25	7.91	8.33	8.08	8.5	8.5	8.16	8.33
Sample D	8.33	8.08	8	8.25	8.08	8	8.09	8	8.33

Test results of 9-scale Hedonic rating were then analysed, mean and standard deviation was calculated. All the four samples were ranked using TOPSIS.

m = varieties of sample = 4; n = number of attributes = 9

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

The Calculation of $(\Sigma x^2{}_{ij})^{1/2}$ for each row has been described in Table 8.

Table 8. Calculation of $(\Sigma x^2{}_{ij})^{1/2}$ for each row.

Calculation of (Σx2 ij)1/2 for each column and divide each column by (Σx2 ij)1/2 to Get rij										
	Color	Texture	Appearance	Taste	Flavor	Chewiness	Consistency	Stickiness	Overall acceptability	Weightage
Sample A	0.50758301	0.5088128	0.5162729	0.51632842	0.53092273	0.502292512	0.500975354	0.524794688	0.506386846	0.45
Sample B	0.4926541	0.4935423	0.5064508	0.47562959	0.496048983	0.502292512	0.500975354	0.488181105	0.501025103	0.22
Sample C	0.5022086	0.5039262	0.4855789	0.50600185	0.485827367	0.51254338	0.511199341	0.497944728	0.49625911	0.2
Sample D	0.49743135	0.4935423	0.4911038	0.50114229	0.485827367	0.482393769	0.486541491	0.488181105	0.49625911	0.07

Step 2: Calculation of r_{ij}

To calculate r_{ij} for each attribute, divide the mean score for every attribute by (Σx2 ij) 1/2 for every sample, which has been calculated in Table 9, and the Positive and Negative Ideal Situation calculation described in Table 10.

Table 9. r_{ij} Values.

	r_{ij} for each attribute								
	Color	Texture	Appearance	Taste	Flavor	Chewiness	Consistency	Stickiness	Overall acceptability
Sample A	0.22841235	0.2289657	0.2323228	0.23234779	0.238915228	0.22603163	0.225438909	0.23615761	0.227874081
Sample B	0.1083839	0.1085793	0.1114192	0.10463851	0.109130776	0.110504353	0.110214578	0.107399843	0.110225523
Sample C	0.10044172	0.1007852	0.0971158	0.10120037	0.097165473	0.102508676	0.102239868	0.099588946	0.099251822
Sample D	0.03482019	0.034548	0.0343773	0.03507996	0.034007916	0.033767564	0.034057904	0.034172677	0.034738138

Table 10. Positive and Negative Ideal Situation.

Calculate ideal best and worst									
positive (v+) and negative (v−) ideal situation									
V+	0.22841235	0.2289657	0.2323228	0.23234779	0.238915228	0.22603163	0.225438909	0.23615761	0.227874081
V−	0.03482019	0.034548	0.0343773	0.03507996	0.034007916	0.033767564	0.034057904	0.034172677	0.034738138

Where,
"V+" = Positive Ideal Solution
"V−" = Negative Ideal Solution
Step 3: V+ and V− were determined.
"V+" indicates the highest value for each attribute, while the lowest value for each attribute indicated by "V−".
Step 4: Then the separation from "V+" as well as "V−" was determined-
Si = [S(vj* − vij*)2] 1/2 Si+ and Si− negative values were calculated for all the samples.
"Si+" = Separation from Positive Ideal Solution,
"Si−" = Separation from the Negative Ideal Solution.
Step5: Then the relative closeness to the ideal solution was calculated using the formula-

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

Si values and Ci values for each sample. Ranks of different samples have been calculated and described in the Table 11.

Table 11. Si values and Ci values for each sample. Ranks of different samples.

Si+	Si−	Pi	Rank
0	0.58911	1	1
0.365669276	0.22374	0.3796	2
0.392442239	0.19699	0.33421	3
0.589111028	0	0	4

Ranking

As per the result obtained from AHP and TOPSIS, it has been found that Sample is ranked first, followed by Sample B, Sample C, and Sample D was ranked last. This indicates that Sample A was the most accepted variation among the samples based on all nine sensory attributes.

Hierarchical Structure

The hierarchical structure for the ranking evaluates the macaroni samples systematically based on the various sensory qualities. The ranking system split it based on the nine parameters such as colour, texture, appearance, taste, flavor, chewiness, consistency, stickiness, and overall acceptability (Figure 5). The parameter assessment is related to the macaroni samples of A, B, C, and D, and was analysed in many dimensions. The interwoven lines frame the comparison assessment process, highlighting the mechanism for selecting the best option.

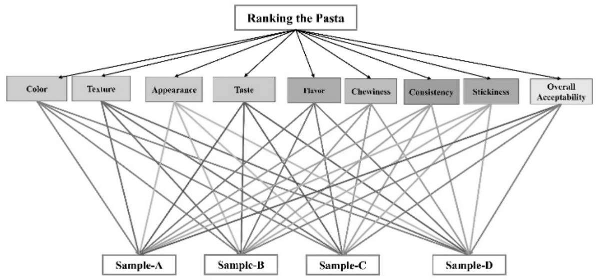


Fig. 5. Hierarchical Structure of various sample of macaroni.

Nutritive Composition & Values of Newly Developed Product Fiber-Rich Macaroni

The analysis of 100 g samples included carbohydrates, dietary fibre, proteins, lipids, and energy. Fats were quantified using the Soxhlet device, whereas carbohydrates were assessed using the Antrone technique. Protein content was estimated using the Kjeldahl technique, which provides a consistent estimate of total nitrogen and protein content. After multiplying protein and carbohydrate by four and fat by nine, energy was calculated by adding the amounts.
The results of the nutritive value of newly developed macaroni were described in Table 12.

Table 12. Nutritional contents of developed macaroni.

Parameter	Nutritional value (100 g)
Energy (Kcal)	380.67
Protein (g)	23.82
Carbohydrate (g)	56.97
Dietary Fiber (g)	10.23
Fat (g)	6.39
Ash (g)	2.54
Moisture (%)	5.14

The Nutritional Value of Newly Developed Macaroni

We found that the newly developed macaroni of sample A contains a significant amount of fiber (10.23 g). The calorie content of newly developed macaroni (380.67 Kcal) is high, and it has a high protein content (22.82 g). The nutritive value is described in Table 12. Thuy et al. (2023) developed macaroni products from chickpea and green banana flours by partial substitution of wheat flour in the ratio of 16%, 14%, and 70%, shows that the developed macaroni containing 4.97 g protein, 29.37 g carbohydrates, 1.35 g fats, 1.21 g fiber and 0.50 g ash content. So, it indicated that our developed macaroni from peapod and lima bean showed better proximate analysis results.

CONCLUSIONS

The study concluded that Sample A, which consisted of 20 g lima seed flour and 5 g pea husk powder, was rated best among all four samples in terms of taste, color, texture, firmness, stickiness, and overall acceptability. In view of the findings obtained by the current research, it could be concluded that macaroni containing a significant amount of dietary fiber and protein is good and effective for obese as well as diabetic patients.

AUTHORS CONTRIBUTIONS

Study concept and design (L.S., D.S. and D.P.), Statistical Analysis (D.S., D.P. and K.D.), manuscript drafting (L.S., K.D. and A.Y.), critical revision of the manuscript (D.S. and A.Y.), and supervision (L.S.). All authors have read and agreed to the published version of the manuscript.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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