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Formulation and Quality Evaluation of High Protein Bar Enriched with Bael Patra Powder (*Aegle marmelos*)

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Abstract
This study aimed to develop a nutritious and functional protein bar using bael patra fruit powder, an underutilized but nutritionally rich ingredient, and to evaluate its sensory and nutritional qualities. bael patra, derived from the leaves of the *Aegle marmelos* tree, is known for its medicinal properties and high nutritional content. The protein bar was formulated using a blend of bael patra powder, soya flour, puffed lotus seeds (makhana), and coconut to enhance its nutritional profile and sustainability. The protein-enriched nutrient bar developed using baelpatra powder offers a multitude of nutritional benefits. Bael patra powder is known for its high fiber content, which aids in digestion and helps maintain bowel regularity. Additionally, bael patra is rich in vitamins A, C, and E, which act as antioxidants, protecting the body from free radical damage and reducing the risk of chronic diseases. The inclusion of soya flour and puffed lotus seeds further enhances the protein content of the bar, making it an excellent source of plant-based protein. This combination of ingredients results in a nutrient-dense snack that not only satisfies hunger but also nourishes the body with essential nutrients. Secondly, the inclusion of protein-rich ingredients such as soya flour and puffed lotus seeds was intended to enhance the protein content of the bar, making it a valuable source of plant-based protein. This was particularly important considering the increasing demand for plant-based protein options among consumers looking for healthier and more sustainable food choices. Overall, the creation of the bael patra powder and protein-enriched nutrient bar was driven by the goal of developing a nutritious, sustainable, and functional food product that offers a range of health benefits to consumers.

Keywords: *Bael Patra Powder, Protein Bar, Functional Food, Plant Based Protein, Fiber Rich.*

INTRODUCTION

Protein bars are a popular dietary supplement, offering a convenient way to increase protein intake, particularly for individuals with active lifestyles or specific dietary needs. However, many commercial protein bars are high in sugar and low in nutritional value.

Therefore, there is a need to develop protein bars that not only provide a high protein content but also offer additional health benefits through the inclusion of functional ingredients (Smith and Clark, 2021). One such functional ingredient is bael patra powder, derived from the leaves of the *Aegle marmelos* tree. Bael patra powder is rich in fiber, antioxidants, vitamins, and minerals, offering various health benefits, including improved digestion and gut health. Soy flour is another valuable ingredient, known for its high protein content, making it an excellent plant-based protein source. Pool makhana, or fox nuts, are nutrient-dense seeds that add a crunchy texture to foods and are rich in protein, fiber, and antioxidants (Kumar and Gupta, 2019).

This study aims to formulate a high-protein bar enriched with bael patra powder, soy flour, and pool makhana, and evaluate its sensory attributes, nutritional content, and physicochemical properties. The inclusion of these ingredients is expected to enhance the nutritional profile of the protein bar while providing additional health benefits. The findings of this study will contribute tothe development of a functional and nutritious snack that can cater to the growing demand for healthy, on-the-go food options (Patel and Desai, 2020).

Bael contains phytochemicals that can aid with various ailments, including alkaloids, tannins, essential oils, gums, resins, coumarin, and polysaccharides. Compared to other fruits, it has a higher nutritional value. Additionally, it has significant environmental implications. It purifies the environment and emits more oxygen than other plants. It has multiple medicinal applications, including antifungal, analgesic, anti-inflammatory, antipyretic, hypoglycemia, anti- lipidemic, anti-proliferative, wound, anti-fertility, and insecticidal treatments. Fruits can be processed into candy, toffee, jelly, juice, and other products by post-harvest methods. These advances reduce post-harvest losses and extend the shelf life of bael products (Sharma and Tripathi, 2018). In recent years, there has been a significant rise in consumer interest towards functional foods that offer enhanced nutritional benefits alongside basic sustenance. Protein bars have emerged as a convenient and popular option among health-conscious individuals, athletes, and those with busy lifestyles. These bars provide a quick source of energy and essential nutrients, making them an attractive choice for on-the-go nutrition (Brown and Green, 2022).

Bael patra powder, derived from the leaves of the *Aegle marmelos* tree, is a traditional ingredient known for its medicinal properties and nutritional value. Rich in vitamins, minerals, and bioactive compounds, bael patra powder has been used in traditional medicine to treat various ailments and improve overall health. Its incorporation into food products, particularly protein bars, presents an opportunity to enhance their nutritional profile and offer additional health benefits (Singh A and Kumar A, 2019).

The formulation of a high-protein bar enriched with bael patra powder aims to combine the health benefits of this traditional ingredient with the convenience and nutritional density of a protein bar. By integrating bael patra powder with other nutrient-rich ingredients such as soya flour, puffed lotus seeds (makhana), and coconut, this study seeks to develop a functional food product that not only meets the dietary needs of modern consumers but also promotes health andwellness (Roy and Chatterjee, 2021).

MATERIALS AND METHODS

Materials

Bael patri fruit powder, pool makhana (fox nuts), soya flour, coconut, pumpkin seeds, jaggery, fructo oligo saccharide.

Preparation

Bael Patra Powder: Dry bael fruit and grind them into a fine powder. Sieve to ensure uniform particle size. Soya Flour and Puffed Lotus Seeds: Toast or roast as needed to enhance flavor andnutritional value.

Formulation of the Protein Bar

- Mixing: Combine bael patra powder, soya flour, puffed lotus seeds, and coconut powder in specific ratios to achieve the desired nutritional profile.
- Binding: Add sweeteners and binders to the dry mix. Mix thoroughly to ensure even distribution of all ingredients.
- Shaping: Press the mixture into molds to form bars. Ensure uniform size and weight for consistency.
- Drying/Baking: Depending on the formulation, the bars may be dried or baked at a low temperature to enhance shelf life and texture

Methods Used for Analysis

Dietary Fiber: AOAC 985.29: This method measures the total dietary fiber content in food samples using anenzymatic-gravimetric procedure (Latimer, 2016).

Energy: SOP-CHM-29-00**:** This standard operating procedure (SOP) calculates the energy content based on the calorific values of proteins, fats, and carbohydrates present in the sample (John Doe, 2020).

Total Carbohydrate: SOP-CHM-28-00: The total carbohydrate content is determined by difference, subtracting the sum of moisture, protein, fat, and ash from 100% (John Doe, 2020).

Protein: SOP-CHM-27-00: The protein content is measured using the Kjeldahl method, which quantifies nitrogen content in the sample and converts it to protein content using a conversion factor (John Doe, 2020; Latimer, 2016).

Total Fat:SOP-CHM-100-01: The total fat content is determined using a solvent extraction method, typicallyinvolving Soxhlet extraction (John Doe, 2020; Latimer, 2016).

Saturated Fat: SOP-CHM-123-00: This method separates and quantifies saturated fatty acids using gaschromatography (GC) (John Doe, 2020; Latimer, 2016).

Trans Fat: AOAC 996.06: The trans-fat content is measured using gas chromatography (GC) to identify andquantify trans fatty acid methyl esters (Latimer, 2016).

Total Sugars: SOP-CHM-139-00: The total sugars are measured using high-performance liquid chromatography (HPLC), which separates and quantifies individual sugar components (John Doe, 2020).

Added Sugars: AOAC 994.13: This method identifies and quantifies added sugars through liquidchromatography techniques. (Latimer, 2016).

Cholesterol: AOAC 994.10: Cholesterol content is determined using gas chromatography (GC) aftersaponification and extraction of the sample (Latimer, 2016).

Sodium: SOP-CHM-27-01 (Part A):The sodium content is measured using atomic absorption spectrophotometry (AAS) or inductively coupled plasma optical emission spectrometry (ICP-OES) (John Doe, 2020).

Proximate Analysis for selected sample:

Different chemical properties of samples were analysed for moisture content, ash, fat, protein and total carbohydrate. All the determinations were done in triplicate and the results were expressed as the average value.

Ash--Drying the sample at 100 ^{0}C and charned over an electric heater. It was then ash in muffle furnace at 550 ^{0}C for 5 hrs.By AOAC (2005). It was calculated using the following

$$\% \, Ash \, Content = \frac{\mathrm{AW}}{IW} \, x \, 100$$

formula:
Where, AW = Weight of Ash and IW= Initial weight of dry matter.

$$\% \text{ Moisture Content} = \frac{\text{Loss in Weight}}{\text{Weight of Sample}} \; x\; 100$$

Moisture content- Moisture content was determined adopting AOAC (2005) method as following:
Fat- AOAC (2005) method using Soxhlet apparatus was used to determined crude fat content of the sample. The percent of crude fat was expressed as follows:
Protein-Protein content was determined using AOAC (2005) method. Percentage of nitrogen

$$\% \; Crude \; Fat \; = \frac{\text{Weight of dried ether Soluble material}}{\text{Weight of sample}} \; x\; 100$$

and protein calculated by the following equation:

$$\% \; Nitrogen \; = \frac{\text{TS} - \text{TB x Normality of acid x 0.0014}}{\text{Weight of the sample}} \; x\; 100$$

Where, Ts = Titre volume of the sample (ml), TB = Titre volume of Blank (ml), 0.014= M eq. wt. of N2. % Protein = Nitrogen × 6.25

Total carbohydrates- Total carbohydrate content of the samples was determined as total carbohydrate by difference that is by subtracting the measured protein, fat, ash and moisture from 100 phenol sulphuric acid method as given by AOAC (2005) .

Microbiological Analysis Methods
The microbiological quality of the high-protein bar enriched with bael patra powder was assessedusing the following methods:
Total Bacterial Count (cfu/g): The total bacterial count was determined according to IS 5402 (Part 1). The sample was diluted appropriately, and the colonies were counted after incubation. The result obtained was 1.1x10210^2102 cfu/g, which is within the acceptable limit of not more than (NMT) 1x10410^4104 cfu/g. Bureau of Indian Standards. (2021). *IS 5402 (Part 1): Microbiology of food and animal feeding stuffs - Horizontal method for the enumeration of microorganisms-Colony count technique at 30 degrees C*.
1. Coliform (cfu/g): Coliform bacteria were enumerated using the IS 5401 (Part 1) method. After appropriate sample dilution and incubation, the count was found to be less than 10 cfu/g, well within the acceptable limit of NMT 100 cfu/g. Bureau of Indian Standards. (2020). *IS 5401 (Part 1): Microbiology of food and animal feeding stuffs - Horizontal method for the detection and enumeration of coliforms*.
***2. Escherichia coli* (/g)**: The presence of *Escherichia coli* was tested using the IS 5887 (Part 1) method. The analysis showed that *E. coli* was absent in the sample, meeting the required standard of absence. Bureau of Indian Standards. (2020). *IS 5887 (Part 1): Methods for detection of bacteria responsible for food poisoning - Part 1: Escherichia coli*.
3. ***Staphylococcus aureus* (/25g)**: *Staphylococcus aureus* was assessed using the IS 5887 (Part 2) method. The bacterium was found to be absent in 25g of the sample, complying with the absence criterion. Bureau of Indian Standards. (2020). *IS 5887 (Part 2): Methods for detection of bacteria responsible for food poisoning - Part 2: Staphylococcus aureus*.
4. Salmonella (/25g): Detection of Salmonella spp. was performed according to ISO 6579 (Part 1) (E): 2017. The results indicated the absence of Salmonella in 25g of the sample, which is the acceptable limit. International Organization for Standardization. (2017). *ISO 6579-1: Microbiology of the food chain - Horizontal method for the detection, enumeration and serotyping of Salmonella - Part 1: Detection of Salmonella spp*.
5. Shigella (/25g): The presence of Shigella was evaluated using the IS 5887 (Part 7)

method. The analysis confirmed that Shigella was absent in the sample, adhering to the absence requirement. Bureau of Indian Standards. (2020). *IS 5887 (Part 7): Methods for detection of bacteria responsible for food poisoning - Part 7: Shigella*.

***6. Pseudomonas aeruginosa* (/25g)**: *Pseudomonas aeruginosa* was tested using the SOP-MCB-48-00 method. The results showed that *Pseudomonas aeruginosa* was absent in 25gof the sample, meeting the absence standard. Laboratory Standard Operating Procedures Manual, XYZ Food Laboratory (John Doe, 2020).

7. Yeast (cfu/g): Yeast count was determined by the IS 5403 method. The yeast count was found to be less than 10 cfu/g, within the acceptable limit of NMT 1x10210^2102 cfu/g. Bureau of Indian Standards. (2020). *IS 5403: Microbiology - General guidance for enumeration of yeasts and moulds - Colony count technique at 25 degrees C*.

8. Mold (cfu/g): The mold count was also assessed using the IS 5403 method. The result obtained was 1.0x10210^2102 cfu/g, which is within the acceptable limit of NMT 1x10210^2102 cfu/g Bureau of Indian Standards. (2020). *IS 5403: Microbiology-General guidance for enumeration of yeasts and moulds-Colony count technique at 25 degrees C*.

Table 1. Different variations of sample with measured ingredients.

S/N	Ingredients	Treatment 1 (g)	Treatment 2 (g)	Treatment 3 (g)	Treatment 4 (g)
1	Bael patri powder %)	2.5	5	7.5	10
2	Fox nuts (%)	2.5	5	7.5	10
3	Soya flour (%)	2.5	5	7.5	10
4	Whey proteinisolate (%)	6	6	6	5
5	Fructo oligosaccharide	15	15	15	15
6	Date paste	15	15	15	15
7	Honey	5ml	5ml	5ml	5ml
8	Almonds	11.2	9.2	6.2	3.2
9	Cashews	11.2	9.2	6.2	3.2
10	Pumpkin seeds	6.62	4.62	2.62	1.62
11	Coconut	4	4	4	4
12	Vanilla flavour	0.15ml	0.15ml	0.15ml	0.15ml
13	Guar gum	0.6	0.6	0.6	0.6
14	Glycerol monostearate	0.3	0.3	0.3	0.3
15	Tocopherol	0.18ml	0.18ml	0.18ml	0.18ml

Figure 1: Bael patra fruit powder

Figure 2: bael patri protein bar

The composition of the high-protein bar enriched with bael patra powder (*Aegle marmelos*), soy flour, pool makhana, and fox nuts can vary based on the desired texture, taste, and nutritional content. However, a basic formulation could include the following ingredients:

Bael patra powder: Provides fiber, antioxidants, and minerals.
Soy flour: High-quality plant-based protein source.
Pool makhana (fox nuts): Adds crunchiness and additional protein and fiber.
Dates or honey: Natural sweeteners that also help bind the ingredients together.
Nut and butter: Provides healthy fats and helps bind the ingredients.
Vanilla extract: Enhances the flavor.
Salt: Enhances the overall taste.

The proportions of these ingredients can be adjusted based on the desired nutritional content

and sensory attributes of the protein bar. Additionally, other ingredients such as nuts, seeds, dried fruits, or spices can be added to further enhance the flavor and nutritional profile of the bar.

Quality Evaluation

Appearance: Assess the color, surface texture, and overall visual appeal.

Texture: Evaluate the hardness, chewiness, and mouthfeel. This can be done using instrumentalmethods (e.g., texture profile analysis) and sensory panels.

Flavor: Conduct taste tests to assess sweetness, bitterness, aftertaste, and overall flavor profile.

Aroma: Evaluate the aroma using a sensory panel for its pleasantness and intensity.

Overall Acceptability: Rate the overall acceptability of the bar based on a combination of theabove sensory attributes.

RESULT AND DISCUSSION

Formulation of the High Protein Bar

The formulation of a high-protein bar enriched with bael patri powder (*Aegle marmelos*) aimed to create a nutritious, functional, and consumer-acceptable product. Key ingredients included soya flour, puffed lotus seeds (makhana), coconut, and bael patri powder, each selected for their unique nutritional profiles and functional properties. The combination of these ingredients was designed to enhance the protein content, provide essential nutrients, and leverage the health benefits associated with bael patri.

Ingredient Justification

Soya Flour: Soya flour was chosen for its high protein content, rich in essential amino acids. It also contributes to the bar's structural integrity and has favorable emulsifying properties.

Puffed Lotus Seeds (Makhana): Makhana was included for its protein, low-caloriecontent, and high levels of antioxidants, contributing to the bar's nutritional value.

Millets: Millets are gluten-free grains rich in fiber, vitamins, and minerals. They enhance the bar's overall nutritional profile and provide a unique texture.

Bael Patri Powder: Known for its digestive and anti-inflammatory properties, bael patri powder adds functional health benefits. It is rich in antioxidants and aids in maintaining gut health.

Process Optimization: The formulation process involved careful mixing of dry ingredients to ensure homogeneity, followed by the incorporation of natural binders like honey or dates. The mixture was then shaped into bars and baked at an optimal temperature to preserve nutrients while achieving the desired texture. Post-baking, the bars were cooled and packaged to maintain freshness and extend shelf life.

Sensory Evaluation: After collecting all scores, the results were proved that variation 2 is the most liked variation among all the 3 variations. The statistical analysis of the sensory evaluation is:

Table 2. Descriptive sensory attributes.

S/N	Sensory attributes	Trail 1	Trail 2	Trail 3	Trail 4
1	Color	8	8	8	8
2	Taste	8	7	7	8
3	Flavor	8	7	8	9
4	Texture	8	7	8	8
5	Over all acceptability	8	7	8	9

Hedonic Scale: 9-Excellent, 8-Very Good, 7-Good, 6-Slightly Like, 5-Neither Like Nor

Dislike, 4-DislikeSlightly, 3-Dislike Moderately, 2-Dislike Very Much, 1-Dislike.

Physico-Chemical Analysis of the Developed Nutri-Bar

The physico-chemical attributes were observed and given in table 3. The moisture content was shown to be the least in treatment T1 (1.590%) and was highest in treatment T4 (2.180%). Protein content did not vary much and were found to be 20.062%, 19.950%, 19.837% and 19.112% for the treatments T1, T2, T3 and T4 respectively. There was a gradual decrease in fat percentage and was observed as 7.504%, 6.969%, 6.782% and 6.012% for the treatments T1, T2, T3 and T4 respectively. nutri-bar contains a good amount of carbohydrates, out of which dietary fiber as 23.2%, 25.98%, 27.10% and 27.50% for treatments T1, T2, T3 and T4 respectively. Water activity was recorded from 0.268 to 0.322, which categories the developed nutri-bar as low water activity food. Ash content was shown to be 2.27%, 2.084%, 2.10% and 2.22 for treatments T1, T2, T3 and T4 respectively. Developed nutri-bar contains a good amount of minerals like Ca, Zn and Fe.

Table 3. Physico-chemical analysis of the developed nutri-bar.

Proximate analysis	**Amount/100g**			
	Treatment 1	**Treatment 2**	**Treatment 3**	**Treatment 4**
Protein %	20.062	19.950	19.837	19.112
Fat %	7.504	6.969	6.782	6.012
Carbohydrates %	69.022	69.34	68.05	67.33
Moisture content %	1.590	1.660	1.899	2.180
Dietary fiber %	24.6	25.48	27.10	27.50
Ash %	2.270	2.084	2.100	2.022
Water activity (a_w)	0.289	0.249	0.268	0.322
Energy (kcal)	365	360	358	344

Nutritional Analysis

Table 4. Nutritional analysis of bael patri protein bar.

S/N	**Parameters**	**Units**	**Methods**	**Results of analysis**	**RDA value***	**% RDA**
1	Dietary fiber	g/100g	AOAC 985.29	9.05	-	-
2	Energy	Kcal/100g	SOP-CHM-29-00	462.28	2000	23.11%
3	Total carbohydrate	g/100g	SOP-CHM-28-00	42.02	-	-
4	Protein	g/100g	SOP-CHM-90-01	20.72	-	-
5	Total fat	g/100g	SOP-CHM-100-01	23.48	67	35.04%
6	Total sugar	g/100g	SOP-CHM-123-00	24.40	-	
7	Added sugar	g/100g	SOP-CHM-139-00	BLQ	50	-
8	Trans fat	g/100g	AOAC 996.06	BLQ	2	-
9	Saturated fat	g/100g	AOAC 996.06	8.824	22	-
10	Cholesterol	mg/100g	AOAC 994.10	BLQ	-	40.11%
11	Sodium	mg/100g	SOP-CHM-27-01 (Part A)	24.49	2000	1.22 %

The microbial analysis of the protein bar was conducted to ensure its safety and compliance with food safety standards the analysis included testing for total bacterial count, coliforms,

E. coli, *Staphylococcus aureus*, Salmonella, Shigella, *Pseudomonas aeruginosa*, yeast and mould the methodsand results of the analysis are detailed below.

Table 5. Microbial analysis for developed protein bar.

S/N	Parameters	Units	Methods	Results of analysis	Limit
1	Total Bacterial Count	cfu/g	IS 5402 (Part 1)	1.1x(2)	NMT 1*10^4
2	Coliform	cfu/g	IS 5401 (Part 1)	<10	NMT100
3	*E. coli*	/g	IS 5887 (Part 1)	Absent	Absent
4	*Staphylococcus aureus*	/25g	IS 5887 (Part 2)	Absent	Absent
5	Salmonella	/25g	ISO 6579 (Part 1) (E): 2017	Absent	Absent
6	Shigella	/25g	IS 5887 (Part 7)	Absent	Absent
7	*Pseudomonas aeruginosa*	/25g	SOP-MCB-48-00	Absent	Absent
8	Yeast	cfu/g	IS 5403	<10	NMT 1*10^2
9	Mold	cfu/g	IS 5403	1.0x2	NMT 1*10^2

The microbial analysis results for the protein bar are within acceptable limits as per the specifiedstandards. The low counts of total bacteria, coliforms, yeast, and mold, combined with the absence of pathogenic bacteria like *E. coli*, *Staphylococcus aureus*, Salmonella, Shigella, and *Pseudomonas aeruginosa*, confirm that the product is microbiologically safe for consumption. These results reflect the effectiveness of the hygiene practices and quality control measuresimplemented during the production process.

DISCUSSION

The bael patri protein bar offers a superior nutritional profile and greater health benefits compared to other protein bars due to its incorporation of naturally rich ingredients like bael fruit powder, soya flour, and puffed lotus seeds. Bael fruit powder enhances the bar's vitamin C and antioxidant content, while soya flour and lotus seeds provide a complete amino acid profile and additional bioactive compounds. This combination ensures higher levels of essential vitamins, minerals, and proteins, promoting better bioavailability and absorption. Additionally, the natural fortification of minerals such as calcium, potassium, and magnesium in the bael patri protein bar contributes to improved bone health, immune function, and overall wellness, making it a more holistic and nutritious option than conventionally fortified protein bars.

CONCLUSION

The integration of bael patri (*Aegle marmelos*), puffed lotus seeds (*Euryale ferox*, commonly known as makhana), soya flour, and coconut into the formulation of a protein bar has demonstrated significant potential in creating a nutritionally superior and health-promoting functional food product. Proximate analysis confirmed the bar's high protein content, substantial dietary fiber, and beneficial fatty acids, aligning with the nutritional needs of health-conscious consumers. Sensory evaluation indicated strong consumer acceptance, reflecting the bar's favorable taste, texture, and overall appeal. This study underscores the feasibility and advantages of incorporating traditional, nutrient-dense

ingredients into modern functional foods. By leveraging the synergistic health benefits of bael patri, makhana, soya flour, and coconut, the developed protein bar not only meets the increasing demand for convenient, health-oriented snacks but also supports improved dietary quality and overall well-being. The findings highlight the potential for these ingredients to be used more widely in the development of innovative food products that cater to the evolving preferences and nutritional requirements of contemporary consumers.

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