FORMULATION AND EVALUATION OF PHYSICO CHEMICAL, TEXTURAL, NUTRITIONAL AND SENSORY PROPERTIES OF PROTEIN ENRICHED CHEESE ANALOGUE FROM PLANT SOURCES

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Keywords:

Plant-based cheese, Dairy-free alternative, Lactose free, Sustainable product development, Sensory evaluation.

Introduction:

1. The growing shift toward plant-based diets, driven by health, environmental, and ethical concerns, has increased the demand for dairy alternatives. Among these, cheese analogues have gained significant attention. However, developing a product that mimics the texture, flavor, and nutritional quality of traditional cheese remains a major challenge. One of the key limitations of many plant-based cheese alternatives is their low protein content compared to dairy cheese.
2. Protein plays a crucial role not only in nutrition but also in determining the functional properties of cheese, such as texture and structure. Therefore, there is a need to develop cheese analogues that are both nutritionally enriched and sensorially acceptable.
3. In this context, the present project focuses on the development of a protein-enriched cheese analogue using plant-based ingredients. The aim is to enhance the nutritional profile while maintaining desirable sensory and textural characteristics. This study contributes to the advancement of sustainable food alternatives and addresses the increasing consumer demand for healthy, high-protein, dairy-free products.

Objectives:

1. To formulate a standard protein enriched cheese analogue.
2. To determine proximate composition (moisture, protein, fat, ash, carbohydrate and energy value) of the protein enriched cheese analogue.
3. To characterise physico chemical, textural, nutritional properties via instrumental analysis.
4. To conduct sensory evaluation to asses appearance, aroma, flavour, texture and overall acceptability of the protein enriched cheese analogue.

Methodology:

1. **Raw Materials:**

Food-grade raw materials used for the preparation of plant-based cheese analogues (PBCA) included cashew nuts, almond milk, soy milk, tofu, moong dal (whole and flour), oat milk, tapioca starch, corn starch, agar agar, κ-carrageenan, coconut oil, coconut cream, rice bran oil, nutritional yeast, lemon juice, salt, water, probiotic capsules, and cheese flavouring agents. All ingredients were procured from local commercial sources.

2. **Equipment Used:**

The equipment used for product development included a digital weighing balance, blender, thick-bottomed pan, spatulas, cheese moulds, and a refrigerator.

3. **Development of PBCA:**

Preliminary trials were conducted using different base ingredients categorized as nut-based (cashew, almond), pulse/legume-based (moong dal, soy, tofu), and cereal-based (oats).

4. **Incorporation of Protein Isolates and Sensory Evaluation:**

Three protein isolates mainly yeast protein, soy protein, and pea protein were incorporated into the standardized formulation at levels of 8%, 10%, and 12% (w/w). All samples were subjected to sensory evaluation using a semi-trained panel assessing appearance, flavour, texture, mouthfeel, aroma, and overall acceptability. The most acceptable concentration for each protein was selected, followed by comparative evaluation to determine the most suitable protein source. The best-performing formulation was chosen for further analysis.

5. **Nutritional Analysis:**

The selected cheese analogue was analyzed for proximate composition, including moisture, ash, protein, fat, carbohydrate, and energy content, using standard methods prescribed by AOAC.

6. **Texture Analysis:**

Texture Profile Analysis (TPA) was performed using a Stable Micro Systems TA.HD Plus Texture Analyzer. A 5 mm cylindrical probe with a 50 kg load cell was used, and samples were subjected to a double compression test at a speed of 5 mm/s with 75% strain and a 5-second interval between cycles. Textural parameters such as hardness, cohesiveness, springiness, and chewiness were calculated from the force–time curves.

7. **Final Sensory Evaluation:**

A final sensory evaluation was conducted for the selected protein-enriched cheese analogue to confirm its overall acceptability.

Result and Conclusion:

Development of base formulation

A total of thirteen preliminary trials were conducted. Based on evaluation of texture, structural integrity, and overall acceptability, cashew-based formulation was selected as the standardized base.

Figure 1: Developed cashew based PCA

Sensory Evaluation of Protein-Enriched Samples

Protein enrichment (8%, 10%, 12%) using yeast, soy, and pea proteins was evaluated by ranking tests. The 12% yeast protein sample was most preferred, indicating good acceptability at higher levels. Soy protein showed highest preference at 8%, while pea protein was most acceptable at 10%. Overall, yeast protein showed superior sensory performance with better flavour, texture, mouthfeel, and aroma due to its umami properties.

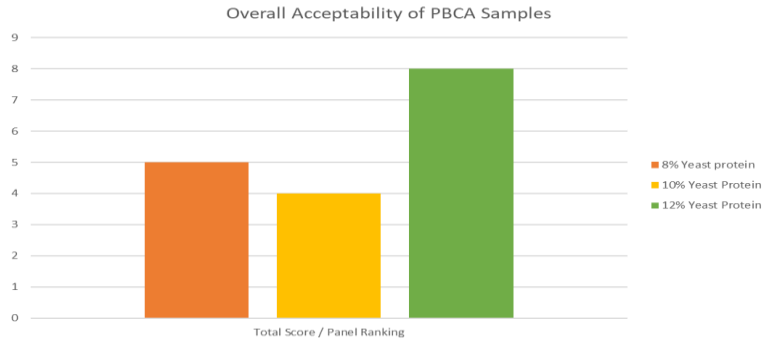

Figure 2: Multiple ranking test of 8%, 10% & 12% Yeast protein enriched PBCAs

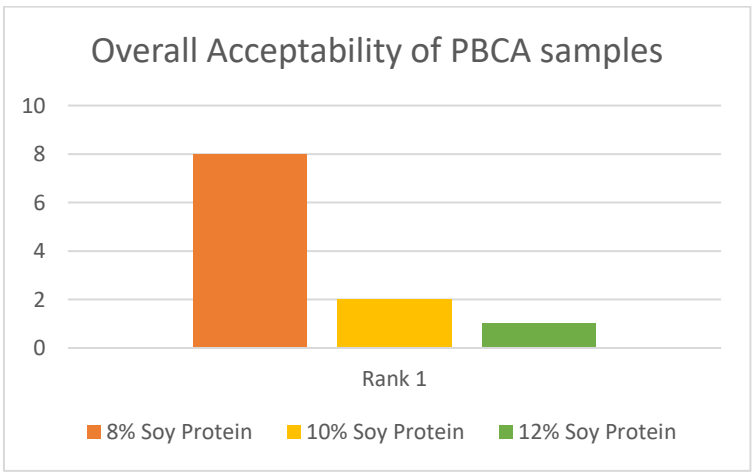

Figure 3: Multiple ranking test of 8%, 10% & 12% Soy protein enriched PBCAs

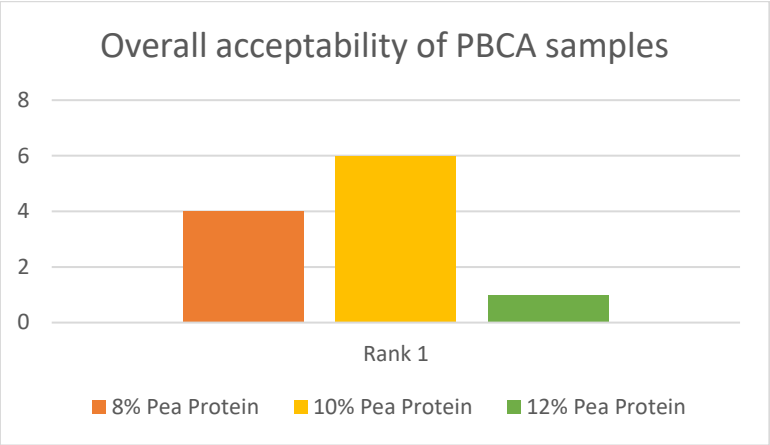

Figure 4: Multiple ranking test of 8%, 10% & 12% Pea protein enriched PBCAs

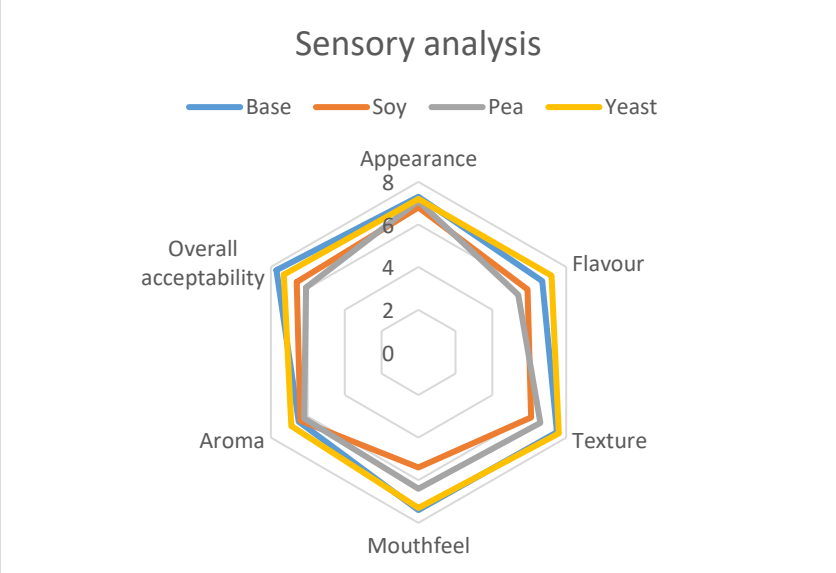

Figure 5: 9-point hedonic scale of Base Formulation, 12% Yeast protein enriched PBCA, 10% Soy protein enriched PBCA, 8% Pea protein enriched PBCA

Nutritional Analysis

Protein enrichment was highly successful, with protein content increasing from 4.75 to 12.29 g/100 g. This confirms effective enhancement of nutritional quality. Energy value increased from 143.59 to 180.86 kcal/100 g due to higher protein and fat. Fat content slightly increased (10.86 g/100 g), improving mouthfeel. Moisture decreased (66.22 g/100 g) and carbohydrate reduced (8.49 g/100 g), while ash content remained stable.

Table 1: Nutritional analysis of base formulation and protein enriched formulation

	Ash (g/100g)	Moisture (g/100g)	Fat (g/100g)	Protein (g/100g)	Carbohydrate (g/100g)	Energy (Kcal/100g)
Base	2.24	72.95	8.87	4.75	11.19	143.59
Protein enriched	2.14	66.22	10.86	12.29	8.49	180.86

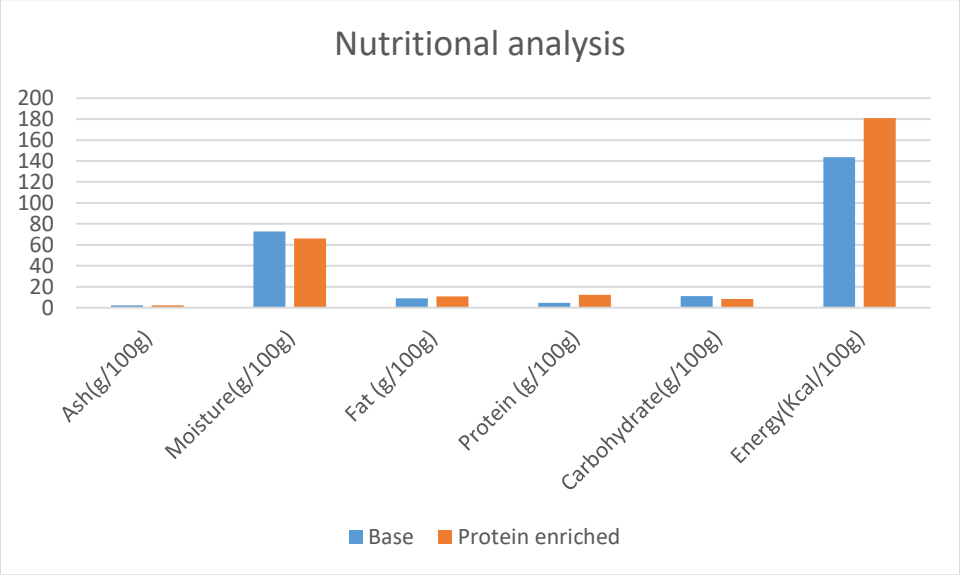

Figure 6: Comparison of nutritional analysis between base formulation and protein enriched formulation

Texture Profile Analysis

The yeast protein-enriched sample showed moderate hardness (4.99 N), indicating a soft but stable structure. Cohesiveness was low (0.111), suggesting weaker internal bonding. Springiness remained constant (1.00), indicating good elasticity. Gumminess and chewiness were low (0.55), reflecting a soft texture. Adhesiveness was also low (0.252 N·s), indicating minimal stickiness.

Table 2: TPA of developed cheese analogues

Batch	Hardness (N)	Cohesiveness	Springiness	Gumminess	Chewiness	Adhesiveness (N·s)
Base	7.61 ± 0.12	0.139 ± 0.061	1.00 ± 0.00	1.06 ± 0.44	1.06 ± 0.44	0.219 ± 0.050
Yeast	4.99 ± 0.24	0.111 ± 0.027	1.00 ± 0.00	0.55 ± 0.15	0.55 ± 0.15	0.252 ± 0.057

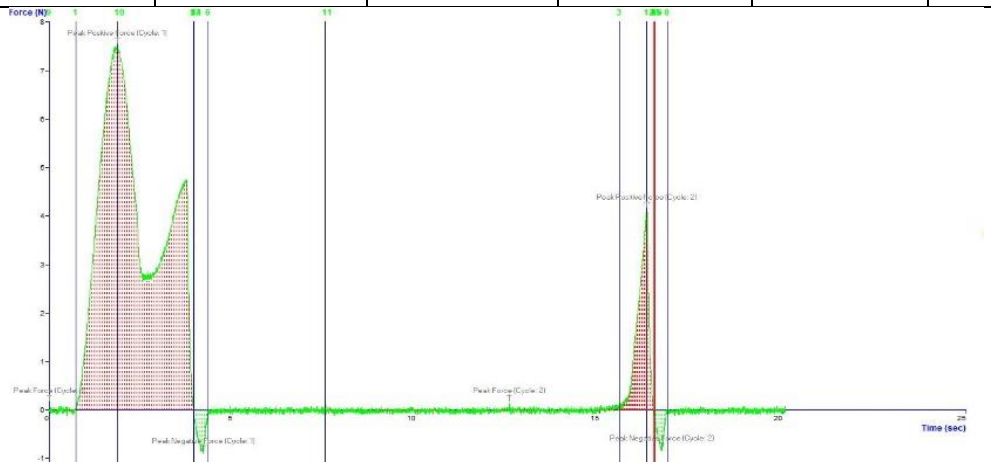

Figure 7: Force-time curve of base formulation

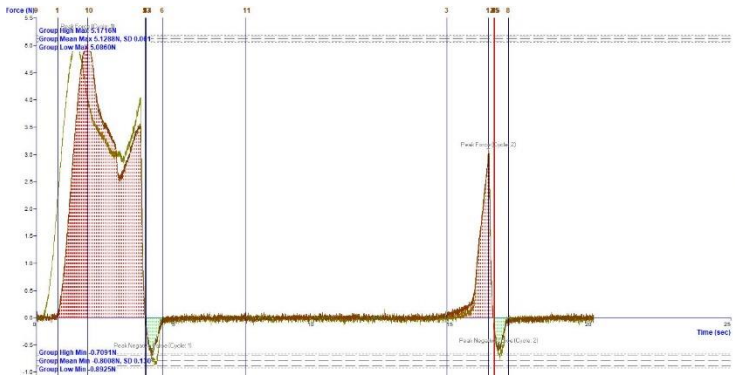

Figure 8: Force-time curve of protein enriched formulation formulation

JAR Analysis

Most attributes of the developed protein enriched cheese analogue were rated “Just About Right.” Flavour, saltiness, and oiliness were well-balanced, indicating good acceptability.

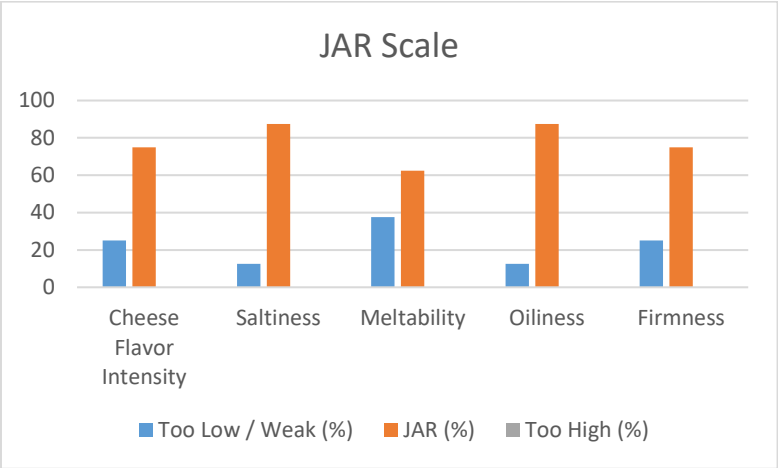

Figure 9: JAR Scale Sensory Analysis of Developed Protein-Enriched Cheese Analogue

Project Outcome & Industry Relevance

1. The developed protein-enriched plant-based cheese analogue demonstrates significant potential as a nutritious and sustainable alternative to conventional dairy cheese. The successful incorporation of protein isolates, particularly yeast protein, resulted in improved protein content without compromising sensory acceptability. This addresses a major limitation of existing plant-based cheeses, which are often low in protein. The product also showed desirable texture, flavour, and overall acceptability, making it suitable for consumer use.
2. From an industrial perspective, this formulation can be applied in the growing plant-based food sector, especially for vegan and lactose-intolerant populations. The use of readily available plant-based ingredients and simple processing techniques enhances its feasibility for large-scale production. Additionally, the incorporation of functional ingredients such as yeast protein adds value by improving both nutrition and flavour. Thus, the project contributes to the development of high-protein, dairy-free alternatives with improved market potential.

Working Model

This project involved the development of a physical working model. A plant-based cheese analogue was formulated, standardized, and evaluated through experimental trials. The study included practical preparation, sensory evaluation, nutritional analysis, and texture profile analysis, rather than being a theoretical or simulation-based study.

Project Outcomes and Learnings

The key outcome of the project was the successful development of a protein-enriched cheese analogue with improved nutritional and sensory properties. The study confirmed that protein enrichment, especially using yeast protein, significantly increased protein content while maintaining acceptability. It also demonstrated the impact of different protein sources on texture, flavour, and overall quality.

Through this project, important learnings were gained in formulation development, ingredient functionality, and the role of hydrocolloids and proteins in texture formation. Practical experience was obtained in conducting sensory analysis, nutritional evaluation, and texture profile analysis. The project also enhanced understanding of challenges involved in developing plant-based alternatives and the importance of balancing nutrition with sensory quality.

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Future Scope:

The future scope of this project includes:

1. **Flavour Development and Product Variants:**
   Future work can focus on incorporating different flavours such as herbs, spices, garlic, and smoked variants to improve consumer appeal and create a wider range of cheese analogue products.
2. **Improvement of Texture and Spreadability:**
   Optimization of formulation using different hydrocolloids, fat sources, or processing conditions can be carried out to improve spreadability, creaminess, and overall mouthfeel.
3. **Scale-Up and Commercial Production:**
   The process can be scaled up for industrial production, with further studies on packaging, shelf life, and storage stability to enhance market potential.