Research Proposal

Valorization of Underutilized Oilseed Cakes as Sustainable Sources of Functional Plant Proteins and Bioactive Ingredients and it's Food Applications

1. Background and Rationale

Oilseed cakes, the residual by-products obtained following mechanical or solvent-based oil extraction, are typically relegated to animal feed or discarded as waste. These materials, however, are rich in proteins, dietary fiber, minerals, and bioactive compounds, presenting a significant opportunity for nutritional and functional enhancement in human food systems.

The increasing global demand for affordable, plant-based protein sources—driven by protein deficiency and the rising cost of animal-derived proteins—has intensified interest in alternative ingredients. In India, oilseed crops such as sesame, mustard, flaxseed, and watermelon seed are widely cultivated, yet their cakes remain underutilized for human consumption. Existing literature predominantly focuses on conventional oilseed cakes (e.g., soybean, groundnut, sunflower), leaving a substantial gap in the exploration of lesser-known varieties.

Moreover, these underutilized cakes contain polyphenols, flavonoids, and antioxidants, which may confer health-promoting properties when incorporated into food products. Their valorization aligns with circular economy principles and sustainable food system goals, offering a dual benefit of waste reduction and nutritional enhancement.

This research proposes to investigate 2–3 underutilized oilseed cakes as potential sources of functional proteins and bioactive compounds, with the objective of developing novel food applications that contribute to sustainable nutrition.

2. Research Objectives

1. To collect and prepare 2–3 underutilized oilseed cakes for study (e.g., sesame, mustard, flaxseed, or watermelon seed cakes).
2. To extract and characterize protein isolates from the selected cakes.
3. To analyze bioactive components (total phenolics, flavonoids, antioxidants) in both raw cakes and their protein isolates.

4. To evaluate the functional properties of protein isolates: solubility, water/oil absorption, foaming, and emulsifying capacities.
5. To develop functional food prototypes (e.g., protein bars, powders, or beverages) using the most promising protein isolates.
6. To assess nutritional composition, bioactive retention, and sensory acceptability of the developed products.
7. To compare and identify the best-performing oilseed cake(s) for potential functional food or nutraceutical applications.

3. Novelty and Research Gap

- **Novel Raw Materials:** Focus on lesser-studied oilseed cakes such as mustard, flaxseed, sesame, or watermelon, which have received minimal attention for human food applications.
- **Integrated Approach:** Combines protein extraction, functional property assessment, and bioactive profiling within a single framework.
- **Comparative Evaluation:** A cross-analysis of 2–3 different cakes will identify the best candidates for sustainable protein recovery.
- **Sustainability Angle:** Promotes circular economy principles by valorizing agro-industrial by-products.
- **Industry Linkage:** The study will provide a foundation for developing novel, affordable, plant-based functional ingredients for the food and nutraceutical sectors.

4. Methodology

Raw Material Collection and Preparation

- Source 2–3 underutilized oilseed cakes from local mills.
- Dry, grind, and sieve (<250 μm); store in airtight containers at low temperature.

Proximate and Physico-Chemical Analysis

- Analyze moisture, protein, fat, ash, fiber, and carbohydrates (AOAC methods).

- Measure pH, color (Hunter Lab), water/oil holding capacities, swelling index, and bulk density.

Protein Extraction and Characterization

- Use alkaline solubilization and isoelectric precipitation.
- Determine yield, recovery, proximate composition, SDS-PAGE profile, and amino acid composition.

Bioactive Component Analysis

- Total phenolics (Folin–Ciocalteu), flavonoids ($AlCl_3$ method), antioxidant activity (DPPH, ABTS, FRAP).
- α-amylase and α-glucosidase inhibition assays for anti-diabetic potential.

Functional Property Evaluation

- Assess solubility, water/oil absorption, emulsifying activity/stability, foaming capacity/stability.
- Correlate with protein content and structure.

Product Development and Evaluation

- Develop food prototypes (bars, powders, beverages) using promising isolates.
- Conduct sensory evaluation (9-point hedonic scale).
- Analyze nutritional composition, bioactive retention, and shelf-life under ambient/refrigerated conditions.

Data Analysis

- Use ANOVA and post hoc tests ($p < 0.05$).
- Apply correlation and PCA to interpret functional, nutritional, and bioactive relationships.

5. Expected Outcomes

Through this study, I expect to identify underutilized, bioactive-rich sources that could serve as valuable functional ingredients for food applications.
The outcomes may include:

- Characterization of nutritional and functional properties of novel plant-based materials.
- Development of functional or value-added food prototypes with good sensory acceptance.
- Publication of the findings in peer-reviewed journals related to food science and nutrition.
- Contribution to sustainable utilization of agricultural by-products and reduction of food waste.
- Scope for future collaborations or technology transfer with the functional food or nutraceutical sector.

6. Significance of the Study

This work directly supports the need for affordable, plant-based functional ingredients and addresses both protein deficiency and sustainable food production. It promotes the use of agro-industrial residues or by-products for human nutrition, aligning with the UN Sustainable Development Goals (SDGs).

7. Work Plan and Timeline:

Phase	**Duration**	**Major Activities**
Phase I	Months 1–6 (Year 1)	Literature review, selection of oilseed cakes, procurement, protocol standardization
Phase II	Months 7–12 (Year 1)	Raw material preparation, proximate and functional analysis
Phase III	Months 1–6 (Year 2)	Protein extraction, yield analysis, amino acid profiling
Phase IV	Months 7–12 (Year 2)	Bioactive and functional property evaluation
Phase V	Months 1–8 (Year 3)	Product development, nutritional and sensory evaluation
Phase VI	Months 9–12 (Year 3)	Data analysis, interpretation, publication, thesis writing

8. References:

1. Dayal, D., & Khanna, K. (2023). *Oilseed meals: A sustainable resource for food and feed industries.* **Journal of Cleaner Production, 420**, 138611.
2. Sagar, N. A., Pareek, S., Sharma, S., Yahia, E. M., & Lobo, M. G. (2022). *Oilseed by-products as sources of functional ingredients: A review.* **Food Reviews International, 38(5)**, 1–27.
3. Kumar, V., et al. (2020). *Oilseed cakes as emerging sources of plant proteins and bioactives: Composition, extraction, and applications.* **Food Hydrocolloids, 109**, 106120.
4. Ramachandraiah, K., & Chin, K. B. (2021). *Valorization of oilseed residues for protein recovery and functional food applications.* **Food Bioscience, 44**, 101394.
5. Kaur, M., Singh, N., & Sandhu, K. S. (2020). *Functional and structural properties of plant protein isolates: A review.* **Food Hydrocolloids, 98**, 105293.
6. Thakur, N., et al. (2023). *Comparative study on extraction methods for plant protein isolates from oilseed meals.* **LWT – Food Science and Technology, 187**, 115984.
7. Soria-Hernández, C. G., et al. (2021). *Structure–function relationships of plant proteins used in food systems.* **Food Chemistry, 360**, 129965.
8. Nwachukwu, I. D., & Aluko, R. E. (2019). *Plant protein isolate production and functional characterization: Challenges and opportunities.* **Food Research International, 123**, 631–648.
9. Fasolin, L. H., et al. (2022). *Functional protein ingredients from oilseed meals for plant-based foods.* **Trends in Food Science & Technology, 121**, 130–144.
10. Rahman, M. M., et al. (2021). *Underutilized oilseeds as sustainable sources of phenolics and antioxidants.* **Food Chemistry, 345**, 128789.
11. Zhu, Y., et al. (2023). *Phenolic and antioxidant potential of defatted oilseed meals and their applications in functional foods.* **Journal of Functional Foods, 104**, 105562.
12. Chakraborty, S., et al. (2020). *Bioactive peptides from plant proteins: A sustainable approach for nutraceutical development.* **Food Reviews International, 36(8)**, 789–820.

13. Singh, S., & Bajaj, R. (2022). *Nutraceutical potential of oilseed cakes: A review of bioactive peptides and antioxidants.* **Critical Reviews in Food Science and Nutrition, 62(18)**, 5013–5031.

14. Manzoor, M., et al. (2017). *Physicochemical, functional and bioactive properties of protein isolates from melon and mustard oilseed cakes.* **Journal of Food Science and Technology, 54(13)**, 4375–4386.

15. Niero, M., & Kalbar, P. P. (2020). *Sustainability assessment of food production systems based on circular economy principles.* **Resources, Conservation & Recycling, 159**, 104818.

16. Pratap-Singh, A., et al. (2023). *Advances in circular utilization of plant-based agro-industrial residues for functional ingredient production.* **Innovative Food Science & Emerging Technologies, 86**, 103464.

17. Joshi, A., et al. (2022). *Valorization of oilseed meals for functional and nutraceutical food formulations.* **Journal of Food Science and Technology, 59(1)**, 10–23.

18. Silva, A. R. A., et al. (2023). *Protein-enriched snack bars from plant-based residues: A sustainable approach.* **Food Research International, 170**, 112978.

19. Tan, M., & Miao, S. (2022). *Plant protein-based formulations for functional foods: Opportunities and challenges.* **Comprehensive Reviews in Food Science and Food Safety, 21(2)**, 1300–1325.

20. AOAC (2019). *Official Methods of Analysis of AOAC International.* 21st Edition.