**Academic Year 2025-26**

09

Group No:

*Mini Project Synopsis on*

**AI- POWERED PRECISION NUTRITION**

*Submitted by*

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**AI – Powered Precision Nutrition**

# 1. Introduction - The Multi-Objective Challenge of Modern Meal Planning

The global landscape is facing a significant rise in chronic diseases, such as obesity and type 2 diabetes, which are often linked to dietary habits. Traditional dietary guidance, which typically follows a "one-size-fits-all" approach, has proven limited in its ability to effectively address these complex health challenges. These generalized recommendations often fail to account for the unique physiological differences, personal preferences, and lifestyle variations of individuals, leading to poor dietary adherence and suboptimal health outcomes.

Beyond the individual, the process of meal planning itself is a complex, multi-faceted challenge. For a single person or household, planning meals involves a constant negotiation of often conflicting priorities. A meal that is highly nutritious and aligned with health goals may be too expensive or require ingredients that are not readily available. Similarly, recipes that are affordable may not be environmentally sustainable or may contribute to food waste if they require a large number of ingredients that aren't fully utilized. This balancing act creates a significant cognitive load, which can be a major barrier to consistent healthy eating.

Current solutions, including many existing recipe applications, typically solve for only a single objective, such as cost-minimization or calorie-counting. This narrow focus fails to capture the intricate trade-offs of real-world decision-making. The problem is not simply finding a healthy recipe, but finding one that is simultaneously healthy, affordable, sustainable, and respectful of a user's existing pantry to prevent waste. This challenge requires a new approach—one that can model and navigate these competing objectives to provide a range of truly holistic and personalized solutions.

# 2. Objective

The primary objective of this project is to develop a hybrid AI system for meal planning that transcends conventional single-objective solutions.

Specifically, the system aims to:

* **Generate nutritionally-optimized recipes** that align with a user’s specific health goals and dietary requirements.
* **Balance conflicting priorities** by simultaneously optimizing for four key objectives:
  + **Nutritional Adequacy:** Maximize the health score of recipes by meeting macro and micronutrient targets.
  + **Cost-Effectiveness:** Minimize the total ingredient cost of a meal plan.
  + **Environmental Sustainability:** Reduce the carbon footprint of meals by prioritizing the use of seasonal and locally sourced ingredients.
  + **Food Waste Reduction:** Maximize the utilization of ingredients from a user's existing pantry, particularly those nearing their expiration date.

# 3. Proposed Methodology

This project will employ a hybrid, multi-model AI architecture to address the complex, multi-objective meal planning challenge. By combining the strengths of different AI paradigms, the system will be able to balance creativity with safety, accuracy, and real-world practicality.

1. **Hybrid AI Architecture:** The system will be built with a layered architecture that integrates three core components to ensure a safe, reliable, and user-centric experience:
   * **Generative AI Core:** A generative model will be used to create a diverse set of initial recipe candidates from user inputs, providing the creative foundation for the system.
   * **Optimization Engine:** A multi-objective optimization (MOO) algorithm, such as a Genetic Algorithm (GA), will refine these candidates. This engine will balance the four key objectives of the project-nutritional value, cost-effectiveness, environmental sustainability, and food waste reduction-to identify a set of optimal trade-offs. Python libraries like pymoo or DEAP are well-suited for this task.
   * **Rule-Based Safety Layer:** A separate, deterministic, and auditable rule-based system will act as a fail-safe. This layer will enforce critical, non-negotiable constraints, such as filtering out a user's specific allergens, to ensure that no unsafe recommendations are ever made.
2. **Robust Data Pipeline:** A comprehensive data pipeline will transform raw data into a structured format for the AI models. This will include:
   * **Data Ingestion:** The system will ingest data from multiple sources, including a recipe corpus, nutritional databases like the USDA FoodData Central, real-time grocery pricing APIs, and a sustainability database.
   * **Natural Language Processing (NLP):** NLP techniques will be used to parse unstructured ingredient text from recipes into a standardized format (e.g., quantity, unit, food item). This is crucial for accurate mapping to nutritional and cost data.
3. **Explainability and Transparency:** To build user trust and promote health literacy, the system will not be a "black box". It will integrate

**Explainable AI (XAI)** techniques, such as SHAP and LIME, to provide transparent explanations for its recommendations. This will allow users to understand

*why* a particular recipe was recommended, showing how it meets their health goals while balancing other factors like cost or environmental impact.

# 4. Conclusion

This project presents a novel, hybrid AI framework that addresses the complex challenge of modern meal planning by moving beyond single-objective solutions. The system's core innovation lies in its ability to simultaneously optimize for multiple, often conflicting, objectives, such as nutritional value, cost-effectiveness, environmental sustainability, and food waste reduction, thereby generating a set of truly holistic and personalized recommendations. This approach is made possible by a robust architecture that combines the creative power of generative AI for recipe ideation with a multi-objective optimization engine for balancing competing goals. A critical, rule-based safety layer acts as a non-negotiable filter to prevent unsafe recommendations, particularly for food allergies. By leveraging these methodologies, the system offers a practical and transparent solution that empowers individuals to make informed decisions that align with their health, economic, and ethical priorities.

# 5. References

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[2] M. Chen, "Research on Multi-Objective Optimization Algorithm Based on Children's Diet Optimization," 2024 3rd International Conference on Artificial Intelligence and Autonomous Robot Systems (AIARS), Bristol, United Kingdom, 2024, pp. 252-257, doi: 10.1109/AIARS63200.2024.00052.

[3] X. Zhu, "Research and Implementation of Multi-Objective Optimization Algorithm in Dietary Collocation," 2024 IEEE 2nd International Conference on Image Processing and Computer Applications (ICIPCA), Shenyang, China, 2024, pp. 121-125, doi: 10.1109/ICIPCA61593.2024.10709157.