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EatWise: AI-Based Food Expiry, Usage & Nutrition Optimizer

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Abstract: Food waste remains one of the most pressing global sustainability challenges, significantly contributing to environmental degradation, economic loss, and food insecurity. A major cause of household and small-scale commercial food waste is inefficient inventory management and the absence of intelligent tracking systems capable of monitoring freshness, expiry timelines, and nutritional relevance. To address these challenges, this paper presents EatWise, an AI-driven smart food management application designed to minimize food waste while simultaneously promoting healthier eating habits.

EatWise integrates barcode scanning technology, manual food logging, machine learning–based expiry prediction models, and personalized nutritional guidance into a unified platform. The system prioritizes food consumption based on predicted expiry urgency and provides tailored dietary recommendations aligned with user-defined health objectives such as weight loss, weight gain, or balanced nutrition. By combining real-time alerts with sustainable food utilization strategies.

Keywords: *Food Waste Reduction; Artificial Intelligence (AI); Expiry Prediction; Smart Inventory Management; Nutrition Optimization; Barcode Scanning; Machine Learning; Sustainable Consumption.*

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I. INTRODUCTION

Food waste has emerged as one of the most pressing global challenges of the 21st century, affecting environmental sustainability, economic stability, and social equity. According to global estimates, nearly one-third of all food produced for human consumption is lost or wasted at various stages of the supply chain. While significant attention is often placed on industrial and supply-chain inefficiencies, household-level food waste represents a substantial and preventable portion of this problem. In many homes, food items are discarded not because they are spoiled, but because they are forgotten, improperly stored, or misjudged based on unclear expiration labeling. Poor household inventory management, lack of systematic tracking, and limited awareness of expiry timelines contribute directly to unnecessary disposal of edible food. The environmental consequences of food waste are severe. Wasted food translates into wasted water, energy, labor, and agricultural resources. Additionally, decomposing food in landfills generates greenhouse gases such as methane, further accelerating climate change. From an economic perspective, households incur repeated financial losses by purchasing items that are ultimately thrown away. Socially, food waste presents a stark contrast to ongoing food insecurity challenges faced by millions worldwide. These issues directly conflict with the objectives of Responsible Consumption and Production, which emphasizes efficient resource utilization and reduction of food loss at both production and consumer levels.

Simultaneously, the rapid growth of digital health and nutrition applications has transformed the way individuals monitor their diets. Popular platforms focus on calorie counting, macronutrient breakdown, and fitness tracking, helping users align food intake with health goals such as weight management or muscle gain. However, these applications largely overlook the sustainability dimension of food consumption. They do not provide integrated mechanisms for tracking household food inventory, monitoring expiry dates, prioritizing soon-to-expire items, or minimizing waste.

Advancements in Artificial Intelligence (AI), particularly in machine learning, predictive analytics, and computer vision, offer powerful tools to address this challenge. Machine learning models can analyze consumption patterns and predict expiry urgency based on product type, storage conditions, and historical usage behavior. Computer vision and barcode scanning

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technologies enable automatic food identification and seamless logging, reducing manual effort and increasing accuracy. Predictive analytics can generate smart reminders and prioritize items nearing expiration, while recommendation systems can suggest recipes tailored to both nutritional requirements and available inventory.

By combining these technologies, passive food tracking can evolve into an intelligent food management ecosystem. Instead of merely recording consumption data, AI-driven systems can actively guide users toward optimal decisions—suggesting what to eat next based on freshness, health objectives, and sustainability impact. Such integration promotes behavioral change, encouraging responsible consumption habits while improving overall dietary quality.

EatWise is the proposed AI-based food monitoring application developed in this study. It not only minimizes household food waste but also enhances nutritional awareness and financial efficiency. By aligning food consumption decisions with both freshness indicators and personalized health metrics, the platform bridges the gap between sustainability and wellness. Ultimately, EatWise aims to foster responsible consumption behavior, support Sustainable Development Goal 12, and promote healthier, smarter, and more sustainable lifestyle choices through the intelligent application of AI technologies.

II. RELATED WORK

Several research efforts and commercial applications have explored food management and nutrition optimization. However, most existing systems focus on isolated aspects rather than providing an integrated solution.

Intelligent Inventory Tracking: Sneha Chauhan et al. (2025) developed a web-based platform that uses artificial intelligence for predicting expiry dates and suggesting recipes. The system was built using React.js and Python and emphasized automated food usage recommendations. However, it lacked personalized health-based dietary optimization and mobile integration for daily usage [1].

Spoilage Prediction Using Machine Learning: Helen Onyeaka et al. (2025) reviewed predictive analytics approaches for early spoilage detection. Their study highlighted the application of machine learning in food supply chains and referenced industry implementations such as Shelf Engine and IKEA's food waste management initiatives. While effective at the industrial level, these systems are not directly accessible for individual household users [2].

Environmental Data Integration: Khuram Shehzad (2025) explored predictive shelf-life estimation models incorporating environmental variables such as temperature and humidity. Although these models improved prediction accuracy, they required advanced sensor infrastructure, increasing implementation costs and limiting household applicability [3].

Limitations of Popular Consumer Applications MyFitnessPal (by MyFitnessPal, Inc.) focuses primarily on calorie and macronutrient tracking but lacks expiry monitoring and waste-reduction functionality. Yuka (by Yuka SAS) provides health impact scores through barcode scanning but does not track pantry inventory or personalize recommendations based on health objectives. Out of Milk (by InMarket Media LLC) efficiently manages shopping lists and pantry items but does not incorporate nutrition analytics or AI-driven expiry prioritization. These gaps demonstrate the need for a unified system that integrates inventory tracking, spoilage prediction, and personalized nutrition optimization — a gap EatWise aims to fill [4].

AI-Based Food Monitoring System**:** Recent studies on AI-based food monitoring systems highlight that most existing solutions primarily focus on prediction models rather than user-level personalization. These systems often lack real-world deployment and fail to address individual user needs in managing food efficiently. To overcome these limitations, the proposed approach integrates AI-based prediction with user-centric food management features, enabling personalized recommendations, improved usability, and practical implementation in everyday household environments [5].

K. Lee, H. Park, and J. Kim (2024) proposed *NutrifyAI*, a deep learning-based food recognition system that identifies food items from images using CNN-based techniques. The study focused on improving accuracy in food classification and enabling nutrition estimation from recognized meals. However, it mainly emphasized recognition performance and did not include real-time expiry tracking, barcode scanning, or personalized diet planning features for users [6].

H. Wang, Y. Zhang, and L. Chen (2016) developed *Yum-me*, a personalized nutrient-based meal recommender system that suggests meals according to user nutrient requirements and preferences. The model aimed to support healthier eating by recommending balanced food options based on nutritional data. However, it lacked modern AI features such as image-based food recognition, real-time tracking, and integration with smart inventory systems for food waste reduction [7].

P. Singh and V. Patel (2022) designed a smart food waste management system using artificial intelligence to monitor food consumption patterns and reduce wastage through predictive analysis. The system aimed to provide recommendations for efficient food usage and waste control in households. However, it did not include advanced features such as personalized nutrition analysis, barcode scanning, or automated expiry reminders integrated into a mDobile application for daily user convenience [8].

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III. PROPOSED SYSTEM ARCHITECTURE

The architecture of EatWise is designed as a modular AI-driven pipeline that transforms raw food inventory inputs into intelligent expiry alerts and personalized nutrition recommendations. The system integrates barcode scanning, machine learning models, and recommendation algorithms to promote sustainable consumption and healthier dietary decisions.

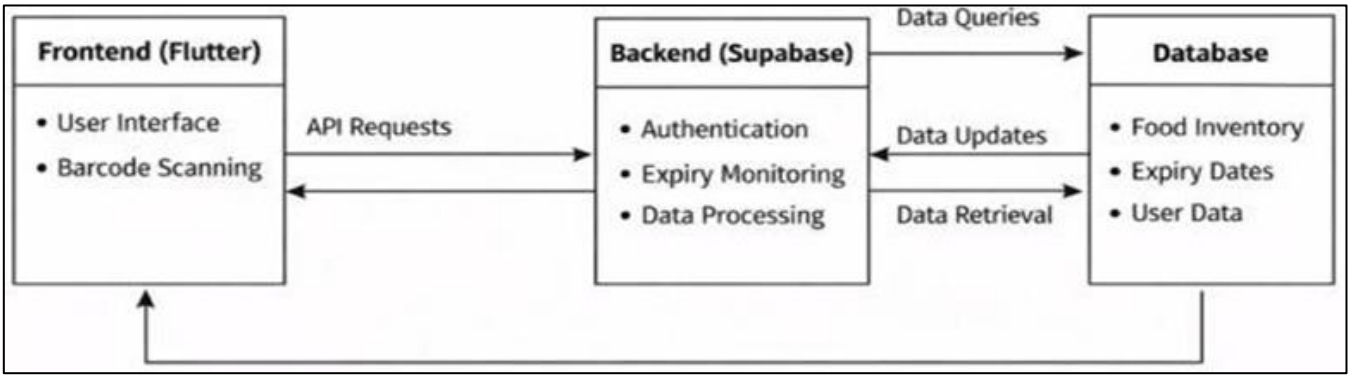

Fig 1 System Architecture

➢ *System Modules*

The workflow of EatWise is divided into the following functional modules:

- *User Profile Module:*

Manages user registration and collects essential details such as age, dietary preferences, allergies, and health goals. This information is used for personalization.

- *Food Data Acquisition Module:*

Allows users to add food items through barcode scanning or manual entry. Product details such as name, category, and expiry date are stored in the system database.

- *Inventory Management Module:*

Maintains a real-time digital inventory by tracking purchase date, expiry date, and consumption status. Items are categorized as Fresh, Near Expiry, or Expired.

- *Expiry Prediction Module (AI Engine):*

Uses machine learning techniques to calculate an Expiry Urgency Score based on food type, storage duration, and usage patterns. This helps prioritize items that should be consumed first.

- *Nutrition Recommendation Module:*

Analyzes stored items and user health goals to suggest suitable recipes and meal plans. It ensures alignment between food freshness and nutritional requirements.

- *Alert & Reporting Module:*

Generates real-time notifications for near-expiry items and provides waste reduction insights and sustainability reports.

➢ *Erasure Selection Logic*

The system applies a weighted logic to ensure balanced decision-making:

- Expiry Urgency – 50% Importance
- Nutritional Alignment – 30% Importance
- Consumption Behavior – 20% Importance

This structured approach enables EatWise to reduce food waste while supporting personalized health management in an efficient and sustainable manner.

IV. EXPERIMENTAL SETUP

The implementation of EatWise is divided into distinct Frontend and Backend setups, ensuring modular development and efficient system integration.

➢ *Backend Setup*

The backend handles core logic, inventory management, AI-based expiry prediction, nutrition analysis, and recommendation generation. It is implemented using:

- API Framework: FastAPI (for developing RESTful APIs)
- Language: Python 3.10+
- Database: MongoDB / Firebase (for storing user profiles and inventory data)
- Barcode Processing: OpenCV / Pyzbar (for barcode detection and decoding)
- Machine Learning: Scikit-learn (for expiry prediction models)
- Nutritional Analysis: Pandas & integrated nutrition datasets
- Recommendation Engine: Content-based filtering using Python
- Notification Services: Firebase Cloud Messaging (for real-time alerts)

The backend performs three primary analyses:

✓ Expiry Urgency Prediction
✓ Consumption Pattern Analysis
✓ Nutritional Relevance Evaluation

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These outputs are combined using a weighted prioritization logic to generate intelligent recommendations.

➢ *Frontend Setup*

The frontend provides a user-friendly interface for managing food inventory and viewing recommendations. It is developed using:

- Framework: Flutter (for cross-platform mobile application development) *(Alternatively: React.js for web-based implementation)*
- Networking: HTTP / Axios (for API communication with backend)
- UI Components: Material Design framework
- Barcode Scanner Integration: Mobile camera plugin The frontend allows users to:
- Register and manage profiles
- Scan or manually add food items
- View categorized inventory (Fresh / Near Expiry / Expired)
- Receive real-time alerts
- Access recipe suggestions and nutrition insights The interface is designed to be simple, interactive, and optimized for daily household use.

V. RESULTS & DISCUSSION

Preliminary implementation results indicate that EatWise effectively improves user awareness of food expiry timelines and inventory status. The barcode recognition module demonstrates high identification accuracy for packaged food products, enabling quick and reliable product detection. The prioritization engine successfully generates actionable alerts, encouraging users to consume items before spoilage and thereby reducing food waste.

The integration of nutritional guidance further enhances user engagement by linking food usage with personal health objectives such as weight management and dietary preferences. Instead of merely notifying users about expiry dates, EatWise provides meaningful suggestions such as suitable recipes, consumption order, and diet-based recommendations.

The results demonstrate that combining smart inventory management with personalized health insights creates stronger behavioral incentives for responsible consumption and supports the goals of sustainable food management.

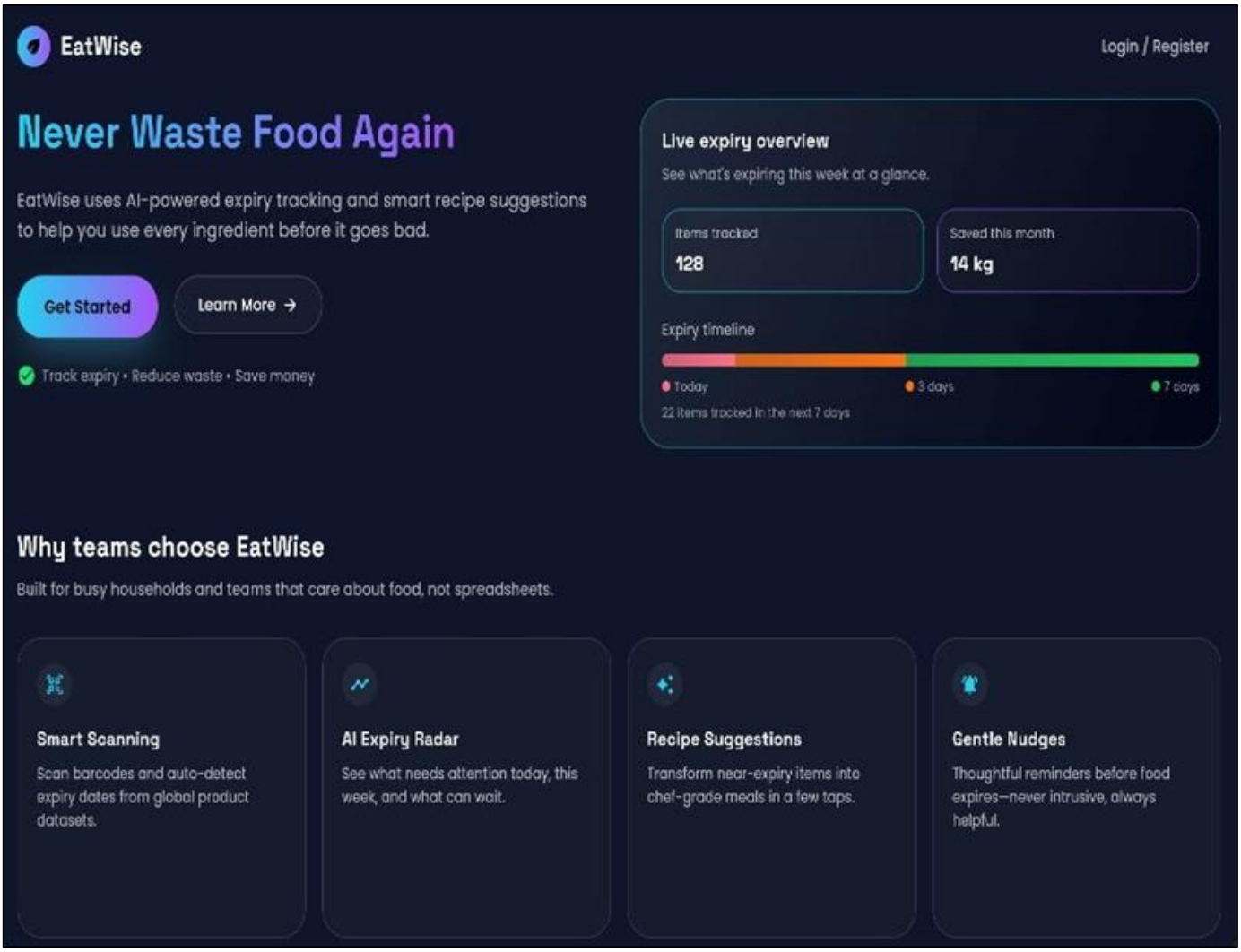

Fig 2 Home Page

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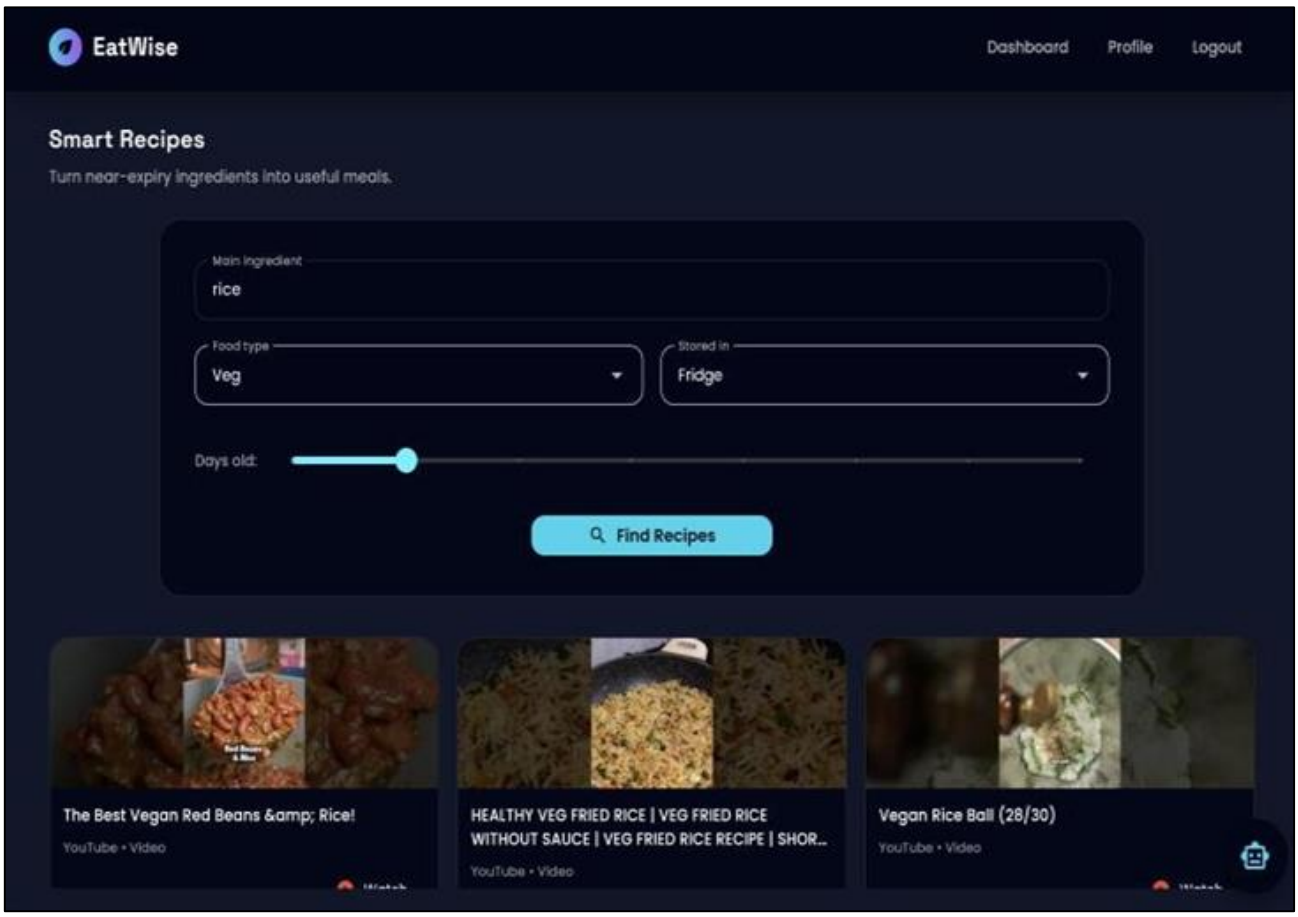

Fig 3 Dashboard Page

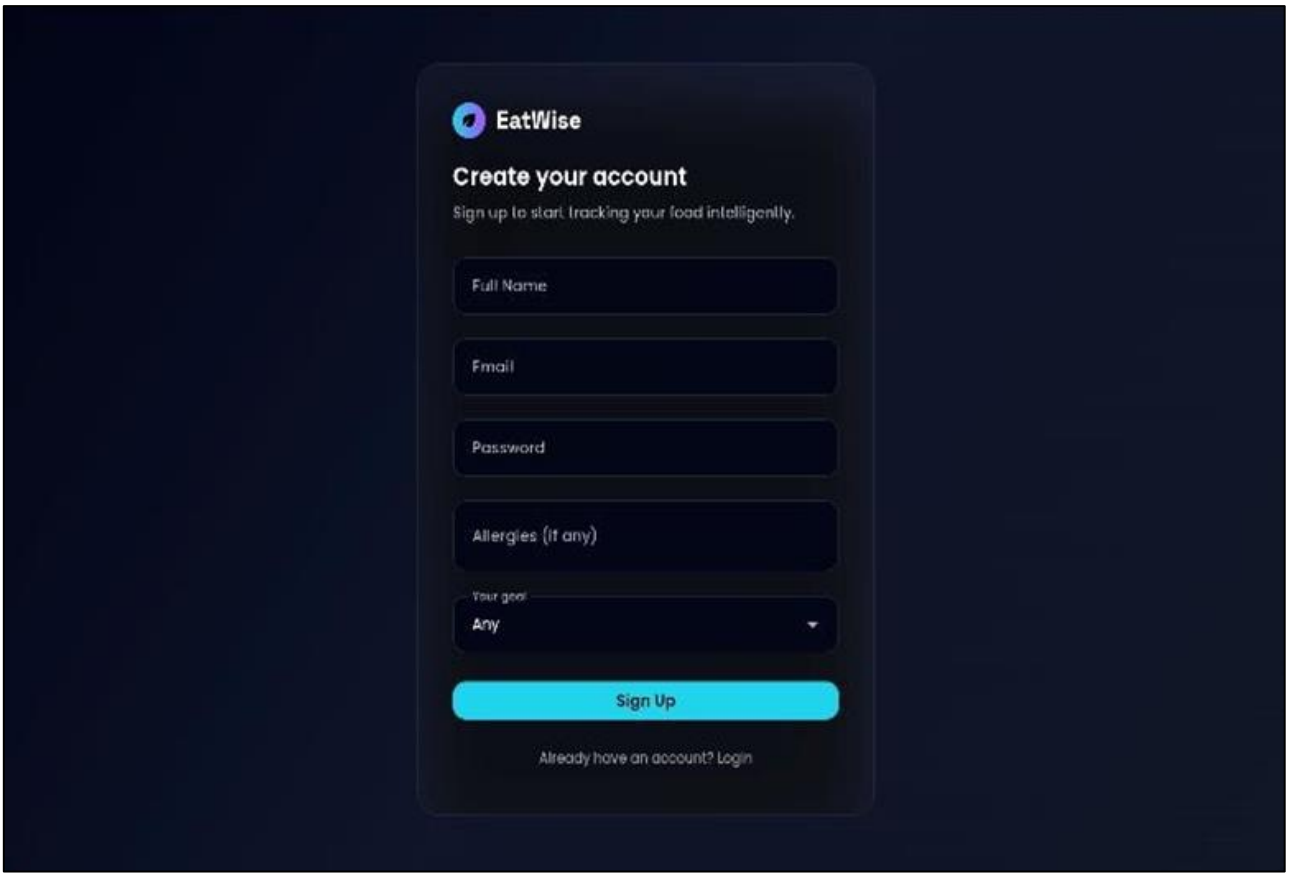

Fig 4 Login / Register Page

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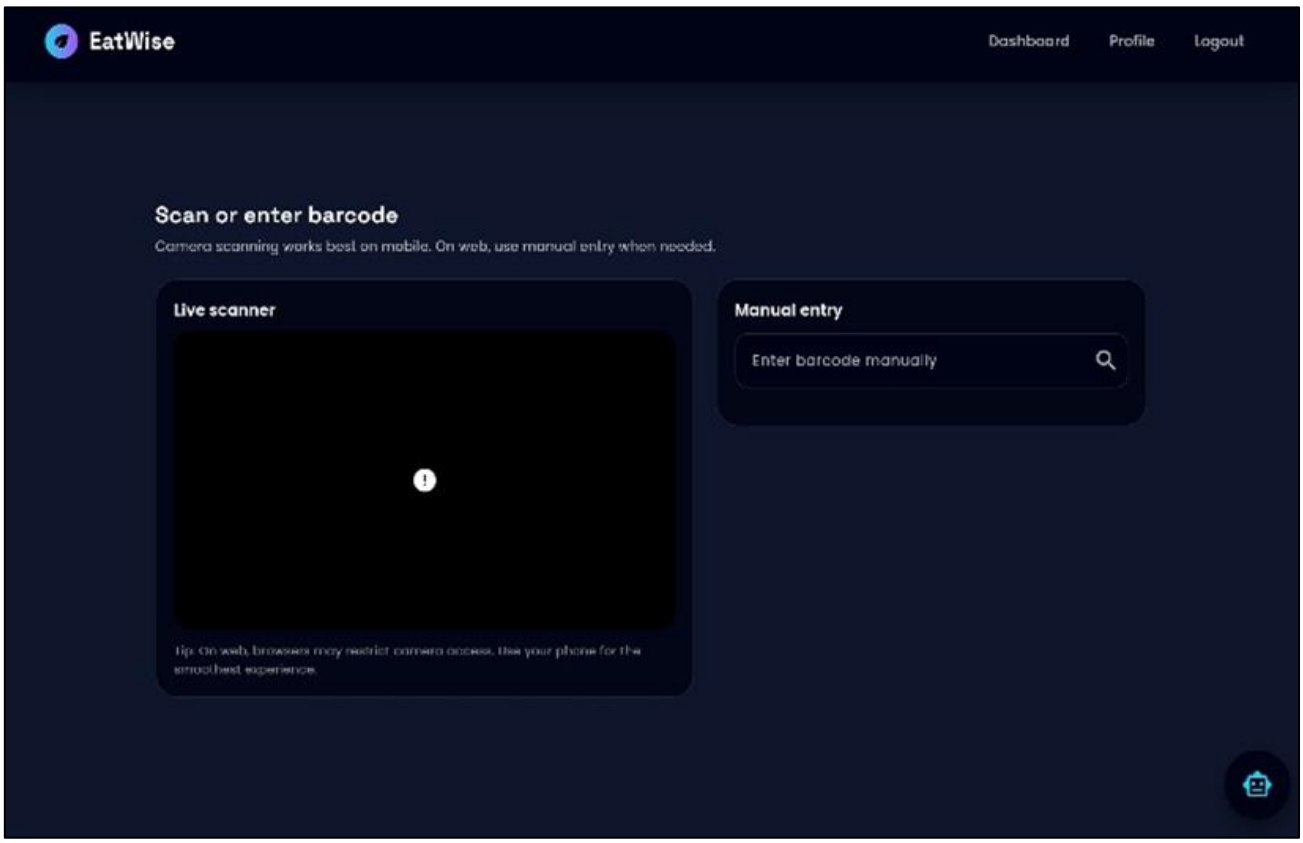

Fig 5 Bardcode Scanning Page

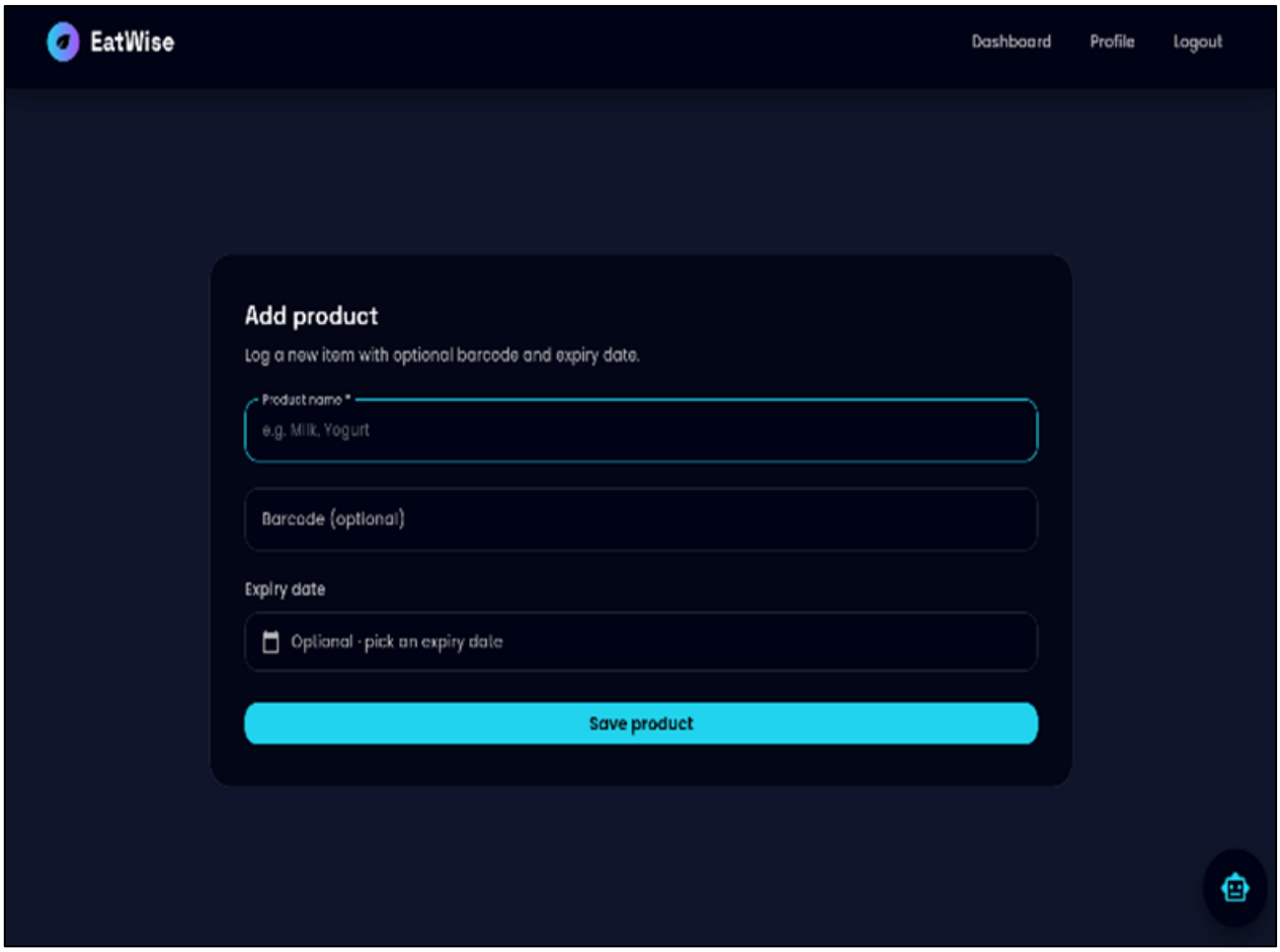

Fig 6 Recipe Recommendation

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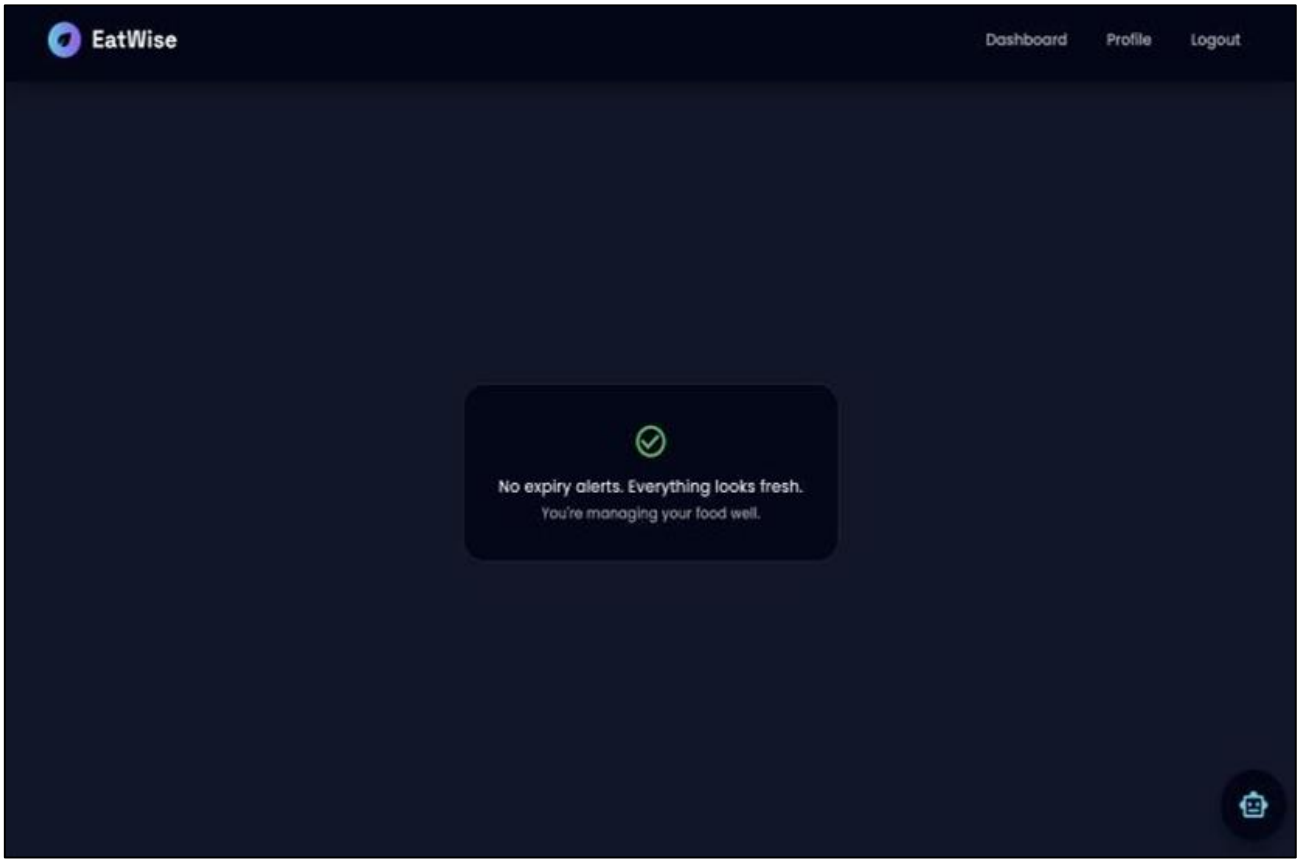

Fig 7 Expiry Alert Page

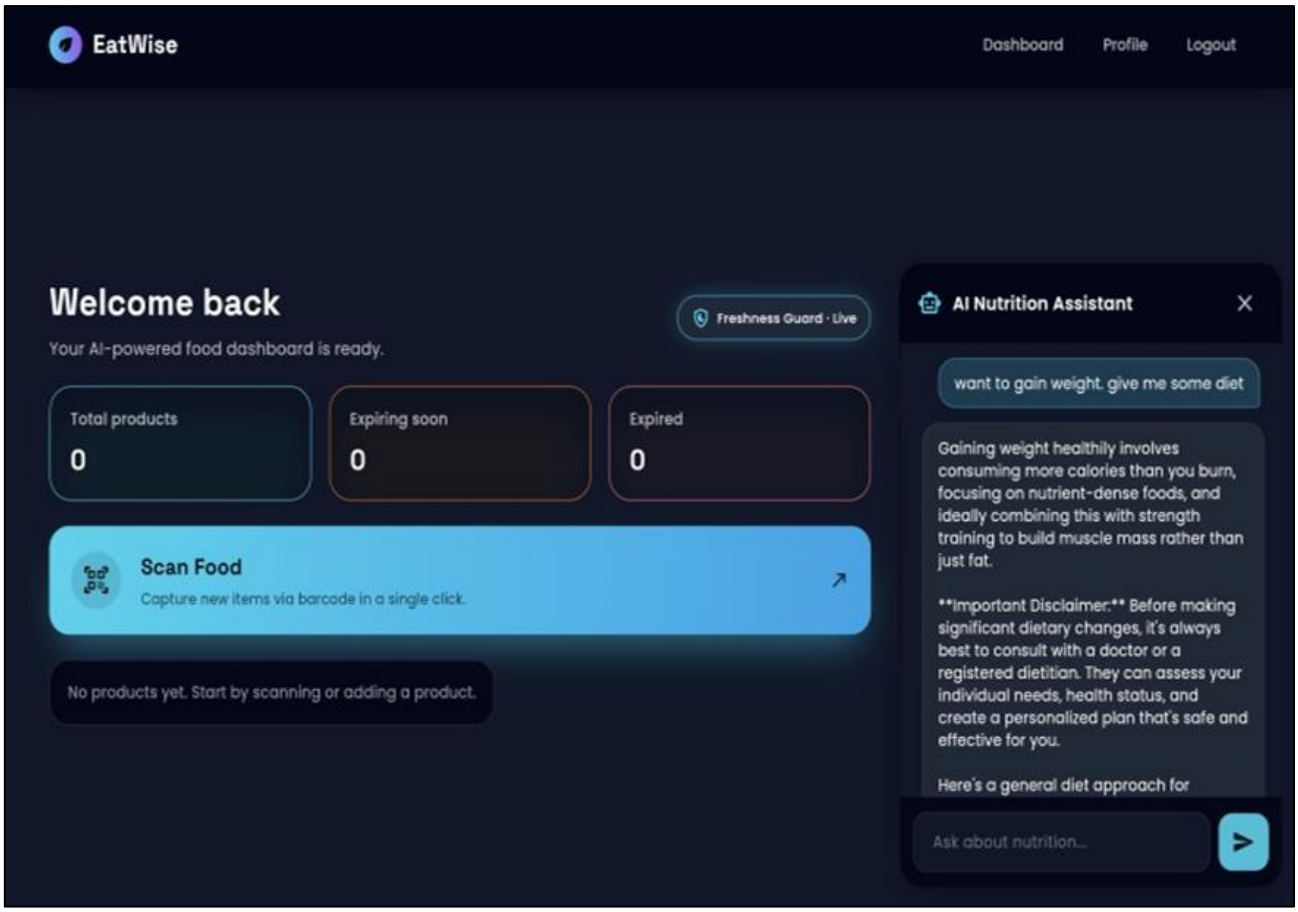

Fig 8 AI Nutritionist Chatbot

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VI. CONCLUSION & FUTURE WORK

EatWise is a smart food management system that helps users reduce food waste and eat healthier. It combines features like barcode scanning, expiry date tracking, nutrition checking, and personalized recommendations in one platform. The project supports sustainable living by reminding users to use food before it expires and guiding them to make better food choices.

In the future, EatWise can be improved by launching it fully on mobile apps, adding smarter notifications, using better AI models for spoilage prediction, and even introducing a food-sharing feature. With these upgrades, EatWise can become a helpful daily assistant for healthy and waste-free living.

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