

A SMART MEAL RECOMMENDATION SYSTEM

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Authors

Abstract

The growing rate of noncommunicable diseases, including premature heart diseases, diabetes, and cancer is caused by unhealthy diets which is seen as a key contributor. In response, personalized nutrition holds a significant sector, aiming to provide customized dietary recommendations based on individual physiological data. Several types of research paper have already proposed computational models for personalized meal recommendation based on individual data and nutritional entities. This report introduces a framework for creating daily meal plans based on nutrition-focused information. The framework features a filtered daily meal plan using a multi-criteria decision tree, to exclude unsuitable foods based on the user's proper nutritional need. It also provides grocery suggestions, which tell users what kinds of foods they should have and shouldn't, as well as reminders about the food items that are running low. The benefit of this recommender system is that users may find their daily meal plans by altering the quantity of macronutrients they need each day. The recommendation algorithm looks over all of the meal plans, determines which is ideal based on the users' calorie intake, modifies the meal plans appropriately, and suggests groceries to fit the suggested meal plans.

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1 Introduction

1.1 Background

Effective meal management is crucial in today's world, where lifestyle-related diseases such as heart disease, diabetes, and eating disorders are prevalent. The widespread availability of junk food fuels these diseases, making it harder to maintain a healthy lifestyle. Our app offers a personalized meal planning system to help regulate vital dietary components like calories, sugar, and unhealthy fats. Our system uses the Dietary Reference Intake (DRI) tool, which factors in individual parameters such as age, height, weight, and desired intake of kilocalories, carbohydrates, proteins, and fats. By focusing on these critical aspects, our app provides a comprehensive solution for managing diet and health, helping users make informed choices for a healthier lifestyle. With a customized meal plan that meets each user's unique needs and is nutritionally balanced, our app makes it easier to achieve a healthy lifestyle.

Our app is designed to help users make healthy meal choices that are tailored to their nutritional requirements and taste preferences. It uses a decision tree algorithm, which is a kind of technology that helps suggest daily meal options. The algorithm can adapt to different goals, like losing weight, maintaining weight, or gaining weight, and it offers a variety of meal choices every day. The app also has a Body Mass Index (BMI) tool that helps users assess their health and set achievable goals. It's easy to use and can support health management in many ways. Another useful feature of the app is its grocery management tool. It helps users keep track of what they have in their pantry and sends notifications when items are running low. This makes grocery shopping easier and ensures that users always have the ingredients they need to make healthy meals. Overall, our app is a comprehensive tool for maintaining a balanced diet and promoting good health. It's designed for people who are health-conscious and want to make healthy choices.

Our app provides a complete approach to meal planning and grocery management by integrating various helpful features. Users can make informed decisions about their health and diet with ease. This initiative is not just a technological advancement; it's a step towards a healthier, well-informed, and responsible society.

1.2 Objectives

In the case of an unhealthy and unplanned daily meal, we have depicted how to:

- i) Promote healthier eating habits by encouraging healthier eating patterns through structured meal plans.
- ii) Get personalized nutritional guidance based on individual nutritional needs and preferences, facilitating a balanced diet for users.
- iii) Ensure integrated grocery management that align with the planned meals, streamlining the process of meal preparation and shopping.

These objectives are in charge of steering the entire process of completing the project, as well as achieving the desired results and establishing the project's starting points.

1.3 Scope

The incorporation of age range and gender-specific meal suggestions in this meal recommendation app introduces a level of personalization that sets it apart from generic nutrition apps. By acknowledging the nuanced dietary needs that differ with one's age and gender, the app delivers a bespoke nutritional experience that is rare in the digital landscape. This approach not only aligns with individual health goals but also resonates with the users on a personal level, ensuring that each meal plan is not only nutritionally adequate but also culturally and personally relevant. It's a leap towards intuitive eating, where the app understands and adapts to the user's life stage and gender, enhancing their meal planning and eating habits in a way that general dietary guidelines cannot. This distinctive feature augments the app's appeal, positioning it as an innovative tool for comprehensive nutritional guidance.

1.4 Unfamiliarity of the problem

When it comes to this project, the unfamiliarity problem is rooted in the conspicuous lack of customized nutritional recommendations on online platforms, especially with regard to Bangladeshi food, which is a relatively unexplored yet essential subset of culinary diversity. This project sets itself apart by curating meal suggestions that resonate with the local palate, integrating cultural specificity with nutritional considerations. By doing so, it addresses a

distinct void in the digital culinary space, offering a service that personalizes eating habits according to regional tastes and dietary requirements.

The concept incorporates a proactive grocery management system, which goes beyond the typical meal planning apps. It streamlines the process of buying items by updating and recommending grocery lists in real-time. This feature ensures that the necessary supplies are available for preparing the suggested meals in addition to making the user's shopping experience easier. Consequently, it makes the shift from planning to preparation easier and guarantees that meal plans are followed.

1.5 Project planning

The Gantt chart presented here the timeline and progress of various tasks involved in this meal recommendation app project. Each task is represented by a horizontal bar, the length of which indicates the duration of the task, spanning across a 13-week period.

Here's a detailed breakdown of the tasks shown in the Gantt chart [Figure No 1.5.1]:

1. **Project Idea:** This is the inception phase where the project concept is formulated. It appears to be a one-week task where the foundational ideas for the project are laid out.
2. **Learning Flutter:** A multi-week phase dedicated to acquiring knowledge and skills in the Flutter framework, which is essential for building the app.
3. **Login Signup Authentication:** Development of user authentication systems, including login and sign-up features, indicating a multi-week duration for completion.
4. **Home Page UI and Profile Data Fetch:** Designing the user interface for the home page and integrating the functionality to retrieve user profile data from the database.
5. **DRI Tool, BMI Calculator and Data Set Create:** Implementing tools for dietary reference intake (DRI) calculations and body mass index (BMI) alongside the creation of necessary datasets.
6. **Personalized Data Settings:** Developing features that allow users to customize data settings according to their personal preferences and health goals.
7. **Meal Plans Upload and fetch using Database:** Establishing the backend functionality to upload meal plans to and fetch them from a database.

- 8. Meal Plan Suggestion:** Creating the algorithm or system that will suggest meal plans to users, which could include a variety of options based on their dietary needs.
- 9. Grocery List Update:** Implementing features to maintain and update a grocery list that corresponds with the suggested meal plans.
- 10. Local and Push Notification:** Setting up both local and push notifications to remind users of their meal plans, grocery lists, and other related actions.
- 11. Grocery Suggestion:** Developing a system that suggests groceries based on the user's meal plans and dietary requirements.
- 12. Documentation:** A period dedicated to documenting the project, which includes writing code comments, user manuals and other necessary documentation.
- 13. Final Report Submission:** Finalizing and submitting the project report, which is likely a summary of the project, its findings, and outcomes.
- 14. Final Project Showcasing:** The last phase where the completed project is presented or showcased, which is in the form of a presentation.

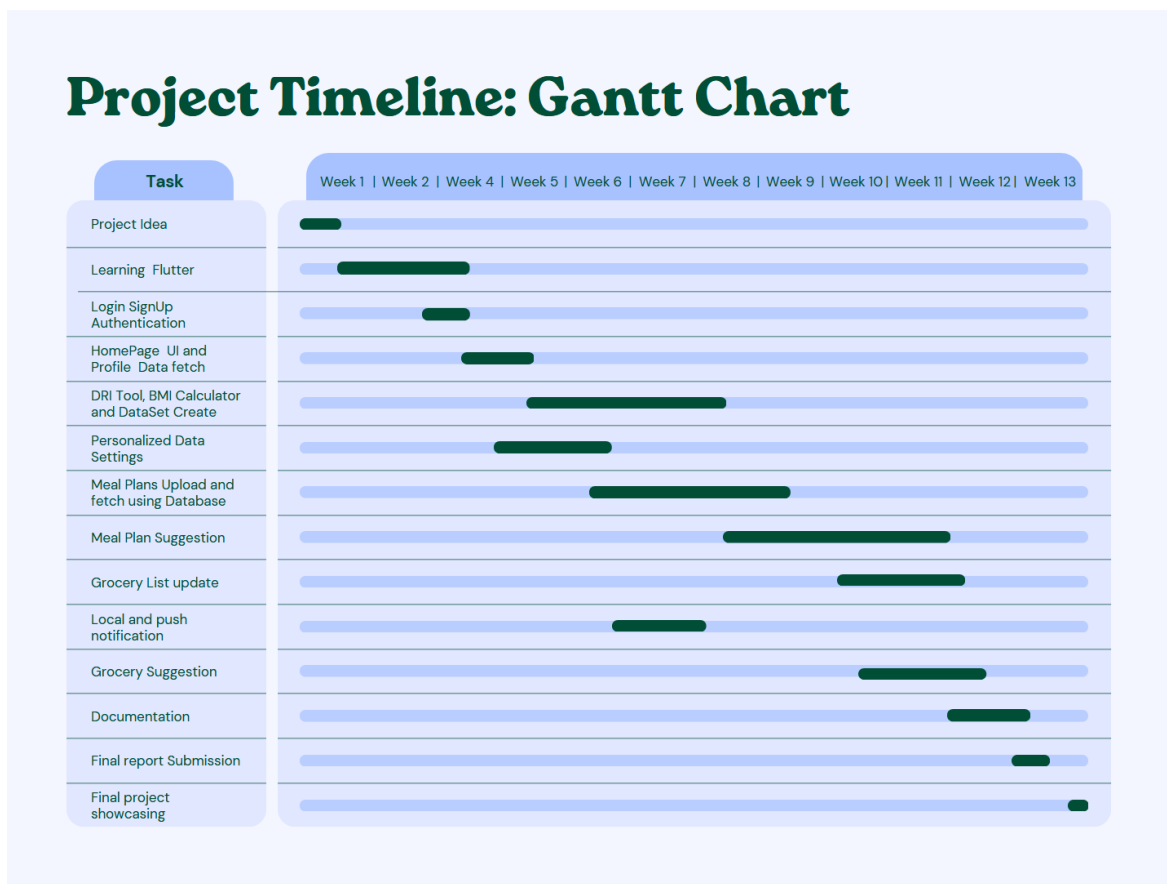


Figure 1.5.1: Gantt chart

2 System Design

In this section, we have shown how this recommendation system works, how users can use this app to get their perfect meal plan, how our app modules work and their detailed information.

2.1 Analysis of the system

Our meal recommendation system was analyzed through a multi-faceted approach. The Data Flow Diagram (DFD) [Figure no 2.2.1] was constructed to ensure clear visibility of data processing, from user input to meal suggestions. om

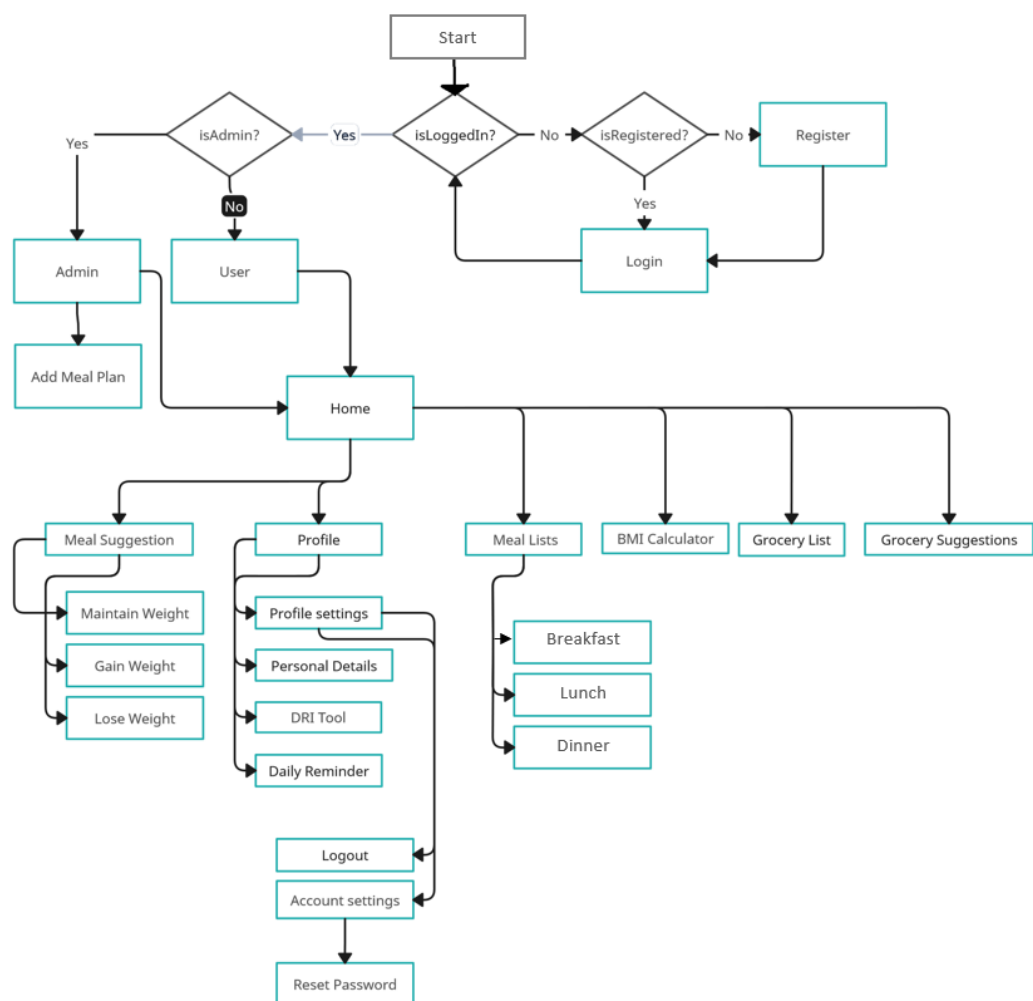


Figure 2.1.1: Data Flow Diagram

The flowchart outlines the logic of a meal recommendation app starting from user authentication, leading to a bifurcation where administrators can add meal plans, while users navigate from the home screen to various functionalities. The app provides various tools such as DRI tool for adjusting daily macronutrients, BMI tool for checking health condition.

2.1.1 DRI Tool

Calorie Needs: Basal Energy Expenditure (BEE), also known as Basal Metabolic Rate (BMR), is the amount of energy expressed in calories that a person needs to keep the body functioning at rest. BEE varies based on several factors, including age, sex, weight, and height. The Harris-Benedict Equation is commonly used to figure energy requirements based on sex, height, weight and age. Here's how DRI tool works[2]:

W = weight in kilograms, H = height in centimeters, A = age in years

Men: $BEE = 66.5 + 13.8(W) + 5.0(H) - 6.8(A)$

Women: $BEE = 655.1 + 9.6(W) + 1.9(H) - 4.7(A)$

Protein Needs: The American Dietetic Association (ADA) recommends daily protein intake for healthy adults as .8-1.0 g of protein/kg body weight.

Fat Needs: Fat intake should equal 30% of your total day's calories.

Carbohydrate Needs: The USDA recommends that 45 to 65 percent of your total daily calories come from carbohydrates.

2.1.2 BMI Tool

The BMI is calculated by dividing an adult's weight in kilograms by their height in metres squared. The BMI result will be displayed for adults as a number with one of these weight categories[1]:

- underweight (<18.5)
- a healthy weight (≥ 18.5 & ≤ 24.9)
- overweight (≥ 25 & ≤ 29.9)
- obese (>30)

2.1.3 Weight goal

If your maintenance caloric intake is 2,000 kcal/day:

Maintaining Weight: Continue consuming approximately 2,000 kcal/day.

Losing Weight: Reduce intake by 20%, which would be consuming about 1,500 to 1,700 kcal/day (500 to 300 kcal less than maintenance).

Gaining Weight: Increase intake by 15%, which would be consuming about 2,100 to 2,300 kcal/day (100 to 300 kcal more than maintenance)

2.1.4 Data Set Generation

Since admin can only upload meal plans which include kilocalorie value, carb, fat, protein, meal plan title, image, ingredients, recipe description and meal type, can be seen under admin User Id. Here is an example using JSON parsing[Figure 2.1.4.1]:

```
"-Nj0tnJjWta0JM7j2onI": {
  "carbs": "26",
  "fat": "7.1",
  "image": "https://firebasestorage.googleapis.com/v0/b/mealbuddy-e829c.appspot.com/o/recipes%2Fimages%20(24).jpg?alt=media&token=2c103bb7-5f7f-43c1-a13a-5781eb8737f6",
  "ingredients": [
    {
      "amount": "100",
      "name": "Chicken"
    },
    {
      "amount": "30",
      "name": "Mayonnaise "
    },
    {
      "amount": "30",
      "name": "Cheese"
    },
    {
      "amount": "150",
      "name": "Bread"
    }
  ],
  "kcal": 247.9,
  "mealType": "breakfast",
  "protein": "20",
  "recipe": "Prepare Chicken: Use pre-cooked chicken breast. If it's not seasoned, you can season it with salt, pepper, and any other desired spices. If you prefer toasted bread, lightly butter each slice and toast them in a pan or toaster until golden brown. Spread mayonnaise (and mustard, if using) on one side of each bread slice. Place lettuce leaves on one slice, followed by tomato slices, and seasoned chicken. Add a slice of cheese if you like. Sprinkle a little salt and pepper over the filling for added flavor.Close the Sandwich: Place the other slice of bread on top, mayonnaise-side down. Cut the sandwich in half, if desired, and serve immediately.",
  "title": "Chicken Sandwich "
},
```

Figure 2.1.4.1: JSON Parsing Data

2.1.5 Notification Reminder

Since users have to adjust their daily meal plan, they have to use DRI tool. Also, to check health condition daily/weekly/on time, we have introduced local notification and push notification system. Users can easily set the reminder with personalized text and preferred time to get notified.

2.1.6 Meal Suggestion Algorithm

This tool employs mathematical equations to determine an individual's daily nutritional requirements, including calories, proteins, fats, and carbohydrates. These needs vary according to age, gender, height, and weight. With these personalized nutritional profiles in hand, the algorithm sifts through a vast array of recipes, matching each person's unique dietary needs to the nutritional content of these meals. The process involves comparing the nutrient values of each recipe against the individual's requirements. The algorithm then calculates the difference, or 'deviation', for each nutrient. It prioritizes these deviations based on what the individual needs most - for example, more protein or fewer carbs. Recipes are then ranked from the most to the least suitable, allowing users to easily choose meals that best fit their dietary goals. This user-friendly approach simplifies the task of finding healthy, balanced meals tailored to one's specific nutritional needs. Here is an example to recommend breakfast items for maintaining weight at 155 kcal:

- Start with five items, each with specific kcal values: A (137 kcal), B (124 kcal), C (190 kcal), D (230 kcal), E (160 kcal).
- Calculate the absolute difference in kcal values between each item and the target of 155 kcal.
- Compile the differences into a list: A (18), B (31), C (35), D (75), E (5).
- Sort the list in ascending order based on the kcal differences.
- The sorted list, E (5), A (18), B (31), C (35), D (75), gives us the recommended order, with the item closest to the target kcal at the top.¹

Then repeat this process for protein, fat, and carbohydrates to determine the final recommendation.

2.1.7 Grocery Suggestion

The grocery suggestion feature of the app is designed to streamline the meal preparation process by ensuring all necessary ingredients are on hand. When a user selects a meal plan that contains ingredients not currently listed in their grocery inventory, the app will highlight the meal in red as an indication. To proceed with adding this meal to their plan, the user will be prompted to first add the missing ingredients to their grocery list, ensuring they have all the components required for the meal. Moreover, the app intelligently monitors the stock levels of ingredients and notifies users when supplies dip below a predefined threshold. This proactive notification system is pivotal in maintaining a well-stocked pantry, preventing any disruptions in the user's meal planning due to unavailable ingredients. It helps users to maintain a continuous flow in their meal preparation routine, avoiding last-minute grocery runs or meal plan alterations.

2.2 System architecture

The system architecture of our meal recommendation app is designed to provide a comprehensive and personalized user experience, with features related to individual dietary and health goals. At its core, the system is segmented into user and admin functionalities, each with its own set of features and permissions.

The UML diagram [Figure No 2.2.1] associated with the system architecture visually represents the classes and interactions within our app. Each class corresponds to a specific feature or functionality, detailing methods and attributes that define the logic and storage of user information, meal plans, reminders, and grocery suggestions.



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For users, the system architecture supports a secure login and sign-up process to authenticate and safeguard their profiles. Once logged in, users can access the Daily Recommended Intake (DRI) tool, which calculates the required daily kilocalories based on personal health data. The architecture further allows users to monitor their consumption of macronutrients, manage their water intake, and keep track of their health using the Body Mass Index (BMI) tool.

The Meal Plans module lies at the heart of the architecture, where users can browse through various meal options, including breakfast, lunch, and dinner. Each meal plan comes with detailed nutritional information and recipes. Users can add these meal plans to their dietary needs with the help of the Meal Suggestion feature.

A crucial aspect of the architecture is the grocery tracking system. This feature enables users to maintain a list of grocery items, monitor their quantities, and receive suggestions when stocks are low. To ensure users stay on track with their health goals, the system incorporates a reminder feature, which can be set for specific times or on a daily/weekly basis.

Admin Aspect: For admins, the architecture provides a separate login gateway, ensuring an administrative layer of control. Admins have the ability to add new meal plans, which are then made available to the users. They can also view and manage all meal plans, ensuring the content stays fresh and relevant.

2.3 Tools used

In our project (Meal Recommendation App), we have used flutter framework, dart language and android studio platform:

2.3.1 Flutter

Flutter's robust framework leverages Dart's capabilities to build natively compiled applications for mobile, web, and desktop from a single codebase. This ensures that this meal recommendation app delivers a smooth and consistent user experience across all platforms, with dynamic features like meal planning, DRI tracking, and grocery suggestions that enhance user engagement and provide personalized dietary guidance.

2.3.2 Dart

Dart, the programming language powering this Flutter app, enables the creation of a highly responsive and performant meal recommendation application. Its rich standard library and asynchronous features facilitate seamless data processing and UI rendering, crucial for the real-time customization of meal plans and nutritional tracking in this project.

2.3.3 Android Studio

Android Studio provided a development environment for this meal recommendation app project, offering powerful tools such as an intuitive UI builder and an integrated testing suite. This facilitated the efficient crafting of an interactive user interface and the seamless integration of backend services, ensuring a reliable and user-friendly application tailored to assist users with their dietary management.

2.3.4 Firebase Database

Firebase, a Google-provided cloud-based platform, is integrated in our project for secure login, registration, and storage of meal plans, personal details and grocery information, ensuring efficient management and retrieval of vital data. We have integrated firebase realtime database, storage, firebase authentication in this app.

2.3.5 GitHub

GitHub serves as a pivotal platform for collaborative software development, where branching is a core feature that facilitates teamwork. In essence, branches allow multiple team members to work on different features or sections of a project simultaneously without affecting the main codebase. Each branch is a copy of the main branch, also known as the 'master' or 'main', and developers can make changes independently. Once a feature or fix in a branch is complete and tested, it's merged back into the main branch, often after a review process. As it depends on team work, we used GitHub and worked on our branches and then merged our work.

3 Project Implementation

In this section, we have shown our time to time project implementation schedule and user guide to show how our recommendation system works and how to surf through our app efficiently to get the best beneficiary outcome.

Also, we have shown moral and ethical implications, socio economic impact and sustainability and financial budgets:

3.1 System implementation

3.1.1 User Manual:

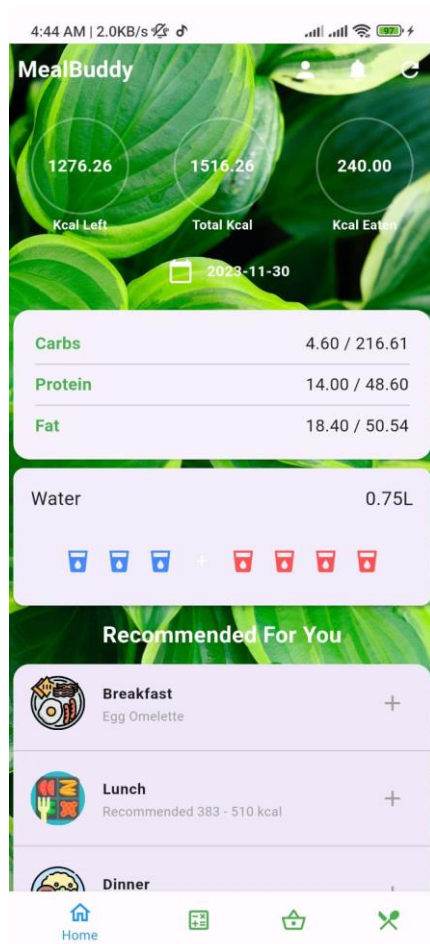


Figure 3.1.1.1: Home Page

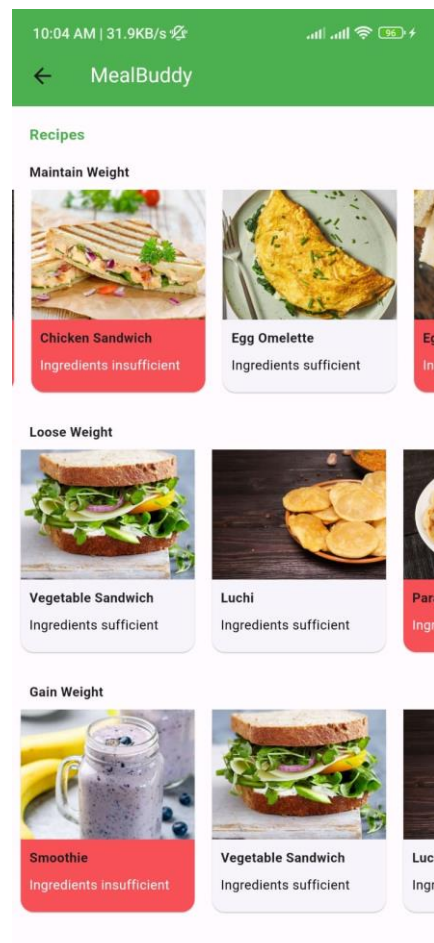


Figure 3.1.1.2: Meal Suggestion Page

Home Page: (As shown in Figure 3.1.1.1) Displays a user's daily caloric and nutrient intake, including calories consumed and remaining, and tracks the consumption of carbs, protein, and fats against daily targets. It also logs water intake and suggests meals for breakfast,

lunch and dinner, all to help manage diet and nutrition goals efficiently. This page also helps one to navigate to all the other pages of this app.

Meal Suggestion Page: (As shown in Figure 3.1.1.2) Organizes a list of recipes for breakfast, lunch, and dinner, ranking them from the best to least suitable options based on the user's dietary goals (maintaining weight, losing weight, or gaining weight). Additionally, it notifies the user whether they have all the necessary ingredients to prepare a selected recipe.

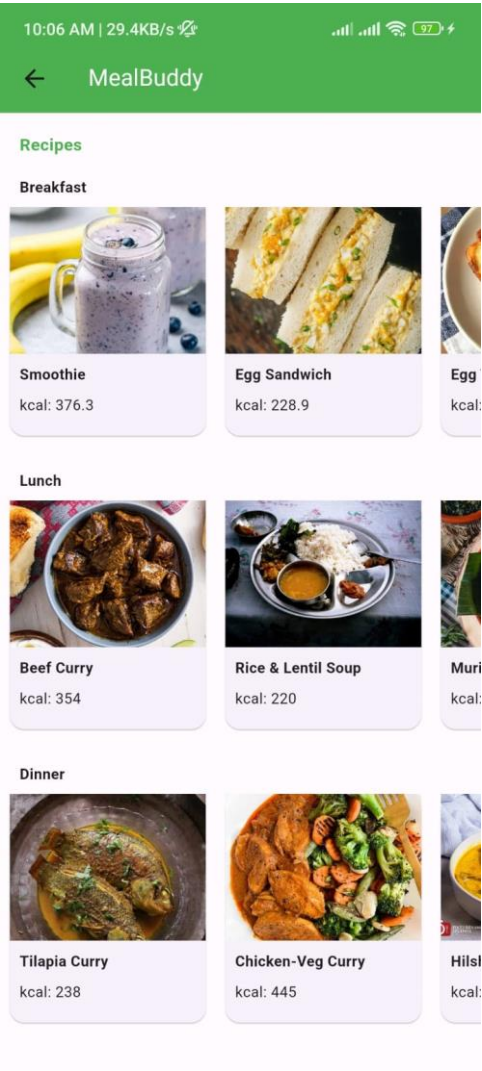


Figure 3.1.1.3: Recipe List Page

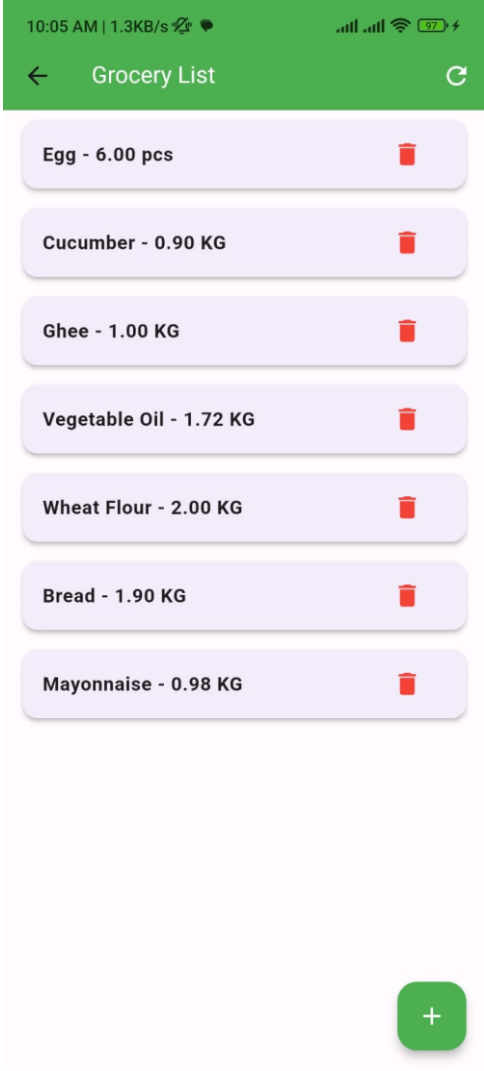


Figure 3.1.1.4: Grocery List Page

Recipe List Page: (As shown in Figure 3.1.1.3) Explore a comprehensive collection of recipes, complete with detailed descriptions for breakfast, lunch, and dinner, allowing you to effortlessly discover and plan your meals.

Grocery List Page: (As shown in Figure 3.1.1.4) View your complete list of grocery items, with the added convenience of seamlessly adding more products to ensure you're always stocked up on what you need.

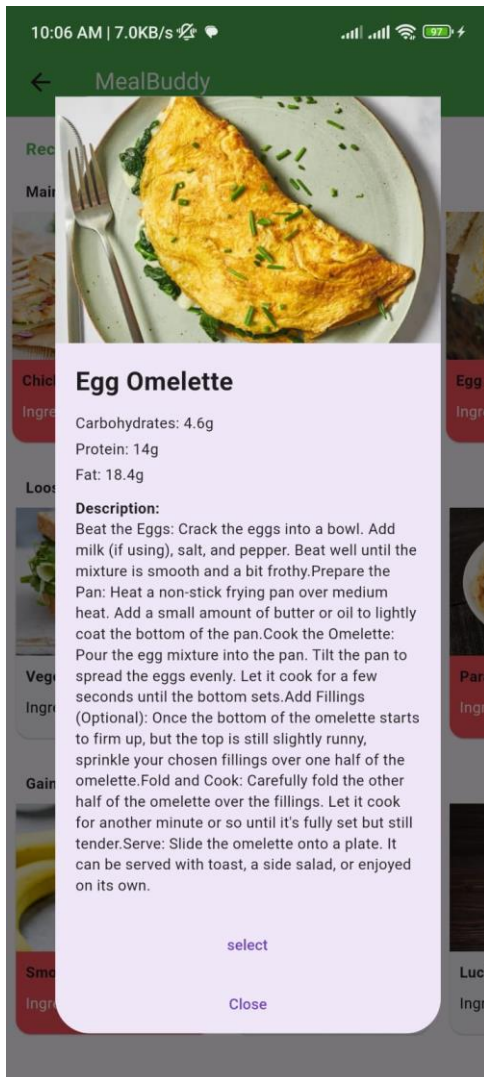


Figure 3.1.1.5: Recipe Card

Recipe Card: (As shown in Figure 3.1.1.5) This view card displays a recipe for an selected item, providing nutritional information such as carbohydrates, protein, and fat content. It includes a step-by-step cooking description. Users can select this recipe or close the card to return to the previous page.

3.2 Morality or ethical issues

The development of our meal recommendation app was guided by strict ethical principles, particularly in handling user data and respecting intellectual property. We prioritized user

privacy by encrypting personal health information and ensuring transparency in data usage. The app's design facilitates user consent and autonomy, upholding the trust placed in us by our users. We meticulously adhered to proper citations and acknowledgments for all third-party resources, avoiding plagiarism and honoring the work of other creators. Our commitment to these ethical practices demonstrates our dedication to maintaining high standards of integrity and respect within the technological and health promotion fields.

3.3 Socio-economic impact and sustainability

Our Food Recommender System, designed to focus on nutritional information, has significant positive effects on society and the economy, and it supports sustainable living:

1. **Better Public Health:** The app helps people eat healthier, which can reduce common diseases like heart disease and diabetes. This means healthier people and potentially lower healthcare costs.
2. **Saving Money:** By promoting cooking at home and reducing food waste, the app can help users save money. It also guides efficient grocery shopping which adds to these savings.
3. **Learning About Nutrition:** Users learn about healthy eating through the app, which can lead to better diet choices in the long term. This knowledge is beneficial for the whole community.
4. **Helping the Environment:** The app suggests eating local and seasonal foods, which is good for the environment. This supports local farmers and reduces the carbon footprint from transporting food.
5. **Inclusive for Everyone:** With its design, the app is useful for many different people, regardless of their dietary needs. This makes the app a tool for social inclusion and community health.

In summary, our app not only helps individuals with their health and finances but also educates them, supports the environment, and includes everyone.

3.4 Financial Analyses and budget

In the development of our meal recommendation, we adopted a cost-effective approach by leveraging existing tools and platforms that allowed us to bring our project to fruition

without incurring financial expenses. The financial budget for this project was minimal as the tools utilized were open-source or offered free tiers that were sufficient for our development needs such as Android Studio, Dart, and the Flutter framework. We capitalized on Firebase's free tier for backend services, demonstrating that sophisticated app development can be cost-effective and accessible, even on a tight budget.

4 Conclusion

4.1 Conclusion and challenges faced

Our Food Recommender System is a major step forward in using technology to customize nutrition and manage health. Our app offers personalized meal suggestions and grocery management tools and caters to specific dietary needs. It simplifies meal planning and provides users with knowledge and resources to make healthier food choices. As we continue to improve the app, it will be an invaluable tool in achieving better health, sustainable eating habits, and improved lifestyle choices. Throughout the development of our app, we encountered and overcame many challenges. One of the primary hurdles was the incorporation of a comprehensive database of Bangladeshi foods, which required research and nutritional analysis to ensure accuracy and relevance. Throughout the development of our app, we encountered and overcame many challenges. One of the primary hurdles was the incorporation of a comprehensive database of Bangladeshi foods, which required research and nutritional analysis to ensure accuracy and relevance.

4.2 Future Study

Our goal is to make our meal management app even better by focusing on several key improvements:

1. **Better Meal Suggestions:** We're working on a smarter algorithm that will learn what users like to eat and suggest meals that match their tastes and nutritional needs.
2. **Easy Grocery Management with Photos:** Users will be able to update their grocery list by taking pictures of their groceries. The app will recognize these items and add them to the inventory automatically.

- 3. Learning User Preferences Over Time:** Our app will get better at understanding users' changing tastes and dietary needs, adjusting meal and grocery suggestions as it learns more.
- 4. Working with Nutrition Experts:** We'll collaborate with dietitians and nutritionists to make sure our meal plans are healthy and up-to-date with the latest dietary advice.
- 5. Custom Recipe Creation:** Users will have the ability to add their own customized recipes into the app. This feature allows users to input their unique recipes, complete with ingredients, preparation methods, and nutritional information.

These updates are all about making our app more helpful and enjoyable for users who want to eat healthily and manage their meals more effectively.

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