Chapter 4

4 Development of the Nutrition-Based Recommendation System (NBRS) Model

4.1 Introduction

The development of the Nutrition-Based Recommendation System (NBRS) was a strategic and systematic process aimed at creating a personalized dietary recommendation tool for cardiac patients. This model combines the power of machine learning techniques with a user-friendly web interface to deliver tailored dietary suggestions. The NBRS system integrates various algorithms to analyze patient data and provide accurate food recommendations based on their Basal Metabolic Rate (BMR), activity levels, and food preferences.

The development process was divided into two key components: the front-end, which was built using the Django framework, and the back-end, where machine learning models were implemented using Python and essential libraries like Scikit-learn, NumPy, Pandas, and Surprise. By leveraging Django's form-handling features, a user-friendly interface was created for easy data input by patients, making the interaction seamless and efficient. The back-end was structured to process the input data, run machine learning algorithms, and generate the best dietary options, ensuring the system's predictions were personalized and precise.

The machine learning models employed in NBRS were chosen for their ability to handle complex user data, including factors such as age, gender, weight, height, and activity levels, to predict dietary needs. A hybrid approach was adopted, integrating algorithms like Baseline, KNN variations, Co-Clustering, SlopeOne, and SVD, each contributing to the accuracy of the recommendations. The system, through this multifaceted development process, aims to improve cardiac patients' dietary habits by offering a robust, scalable, and effective solution for nutrition management.

4.2 Data Collection

Data collection is a crucial step in our research process, as it involves gathering the necessary information to analyze and draw meaningful conclusions. This step is essential for ensuring

that our study is grounded in accurate and comprehensive data, which is particularly important when investigating the dietary habits and nutritional needs of cardiac patients. Our data collection strategy is meticulously planned and executed to ensure we capture all relevant information. It is divided into two main categories: primary data collection and secondary data collection, each serving a distinct purpose and complementing each other to provide a holistic view of the research subject.

Primary data collection involves gathering new, firsthand information directly from the sources. This method allows us to obtain specific, current, and contextually relevant data that directly pertains to our study. By engaging directly with cardiac patients through various methods such as interviews, surveys, and questionnaires, both online and in-person, we can gather detailed insights into their daily lives, dietary habits, and health conditions. This direct engagement not only helps in collecting precise data but also builds a deeper understanding of the patients' perspectives, challenges, and preferences, which are critical for tailoring effective dietary recommendations.

On the other hand, secondary data collection involves the compilation and analysis of existing information from reliable sources. This includes data from scientific research, nutritional databases, and dietary guidelines. Secondary data provides a broader context for our study, allowing us to compare and contrast our primary data with established norms and findings in the field of nutrition and cardiac health. By integrating secondary data, we can validate our primary findings, identify trends, and ensure that our recommendations are based on a robust and comprehensive dataset.

Together, these data collection methods provide valuable insights for our study. Primary data offers a snapshot of the current state of dietary habits among cardiac patients, while secondary data enriches this understanding with historical trends and established nutritional facts. This dual approach ensures that our research is not only grounded in real-world evidence but also aligned with broader scientific knowledge. Consequently, our findings will be well-rounded, reliable, and applicable in practical settings, ultimately contributing to better dietary strategies and improved health outcomes for cardiac patients.

4.2.1 Primary Data Collection

Primary data collection is a fundamental aspect of our research, involving the direct acquisition of information from cardiac patients to ensure the relevance and accuracy of our study. In this process, we engage directly with patients through various methods such as

interviews, surveys, and questionnaires. This hands-on approach allows us to gather detailed insights into their dietary habits, nutritional needs, and overall health conditions. To ensure the ethical integrity of our research, we obtain informed consent from all participating patients, explaining the purpose of our study and how their data will be used. Additionally, we have secured a permission letter from the Primary Health Center (PHC) in the Subhash Nagar area of Porbandar district. This authorization enables us to access and collect data from cardiac patients receiving care at this center. By working closely with the PHC and adhering to ethical guidelines, we aim to gather comprehensive and accurate data that will contribute significantly to our understanding of the dietary needs and health challenges faced by cardiac patients. This primary data is invaluable, providing a current and contextually relevant foundation for our research and ensuring that our findings are directly applicable to improving patient care and dietary recommendations.

4.2.1.1 Online & Physical Collection of Cardiac Patients Data

In this research, data collection from cardiac patients was conducted using both online and physical methods to ensure comprehensive and representative data. Online data collection involved the use of Google Forms, where patients were asked to fill out a detailed questionnaire. This form included questions about their dietary habits, food preferences, and health status. The convenience and accessibility of Google Forms allowed a larger number of patients to participate, particularly those who might find it difficult to attend physical data collection sessions due to mobility or health issues. Additionally, it ensured that data could be collected efficiently and securely, with immediate digital storage and easy access for analysis.

Physical data collection was conducted at the Primary Health Center (PHC) in the Subhash Nagar area of Porbandar district. Here, researchers engaged directly with patients to gather detailed dietary and health information. This approach allowed for a more personalized data collection process, where researchers could assist patients in understanding and accurately completing the questionnaire. Both online and physical methods included a rating system for food items, where patients rated their preferences on a scale from 1 to 10. This dual approach not only enriched the dataset with diverse entries but also ensured the inclusion of patients with varying levels of digital literacy. The data, including patient details and food item ratings, are presented in the figures below, illustrating their dietary preferences and selections.

In our data collection process for cardiac patients, we included comprehensive demographic and lifestyle information to provide a thorough understanding of each participant's profile. Specifically, we gathered details on their gender, age, height, and weight, which are essential for assessing their overall health status and nutritional needs. Additionally, we inquired about their daily activity levels, categorizing these into five distinct groups: sedentary, light, active, highly active, and extremely active. This categorization allowed us to evaluate the varying levels of physical exertion among patients, which is critical for tailoring dietary recommendations. By integrating these demographic and activity level data, we aimed to create a holistic view of each patient's lifestyle, enabling more precise and personalized nutritional guidance. The collected data, illustrated in the subsequent figures, highlight the diverse activity levels and demographic characteristics of the cardiac patients in our study.

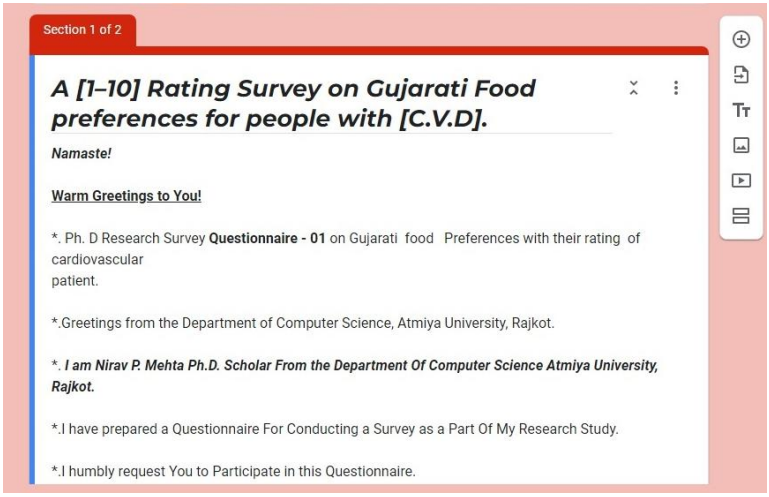

Figure 15 Online & Physical Collection of Cardiac Patients Data

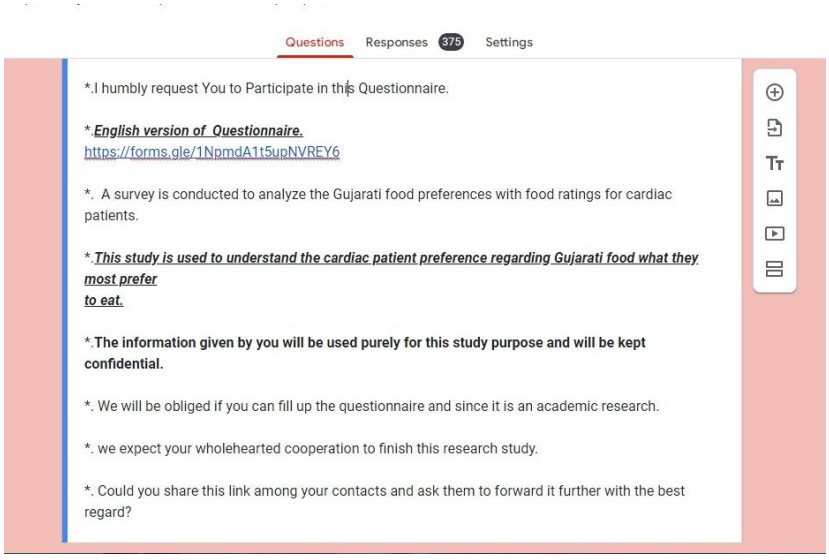

Figure 16 Online & Physical Collection of Cardiac Patients Data

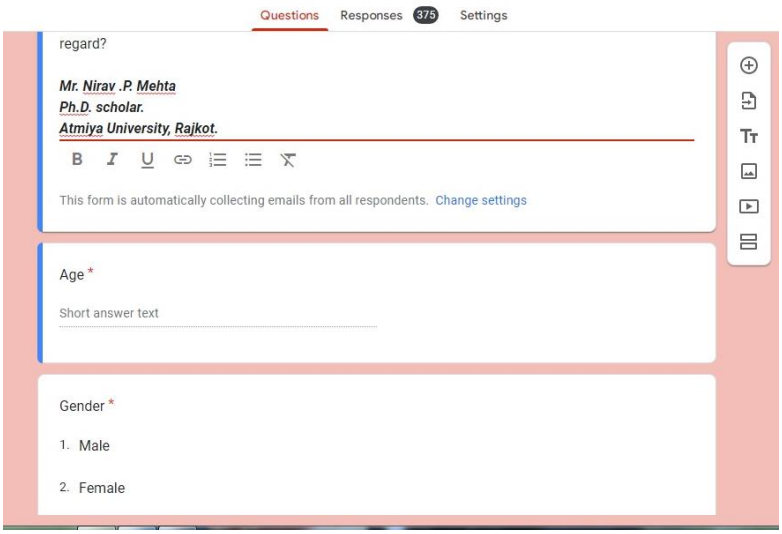

Figure 17 Online & Physical Collection of Cardiac Patients Data

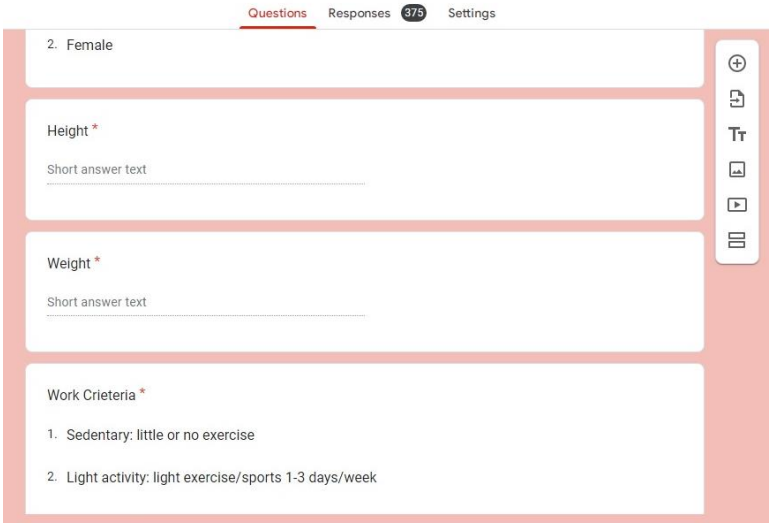

Figure 18 Online & Physical Collection of Cardiac Patients Data

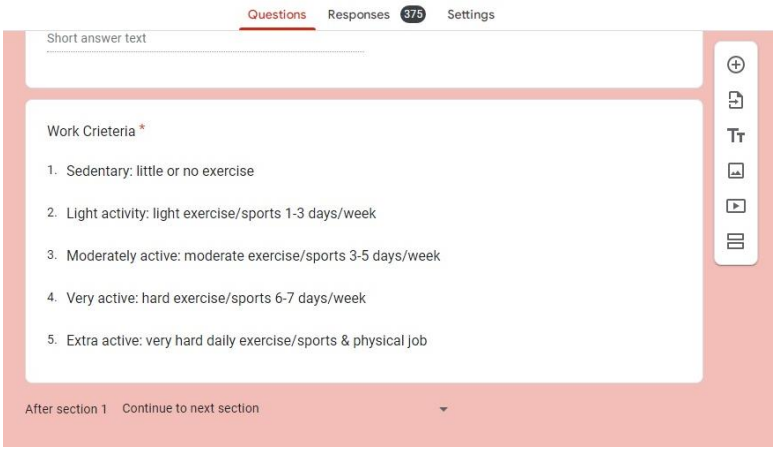

Figure 19 Online & Physical Collection of Cardiac Patients Data

4.2.1.2 Online Collection of Food Preference of Cardiac Patients

To gain a comprehensive understanding of the food preferences of cardiac patients, we implemented an online data collection strategy. Using a customized Google Forms survey, we gathered detailed information on the dietary choices and preferences of cardiac patients. This method allowed participants to rate various food items on a scale from 1 to 10, reflecting their personal preferences and the frequency with which they consume these items. The survey included a wide range of foods commonly found in Gujarati cuisine, ensuring that the data collected was relevant to our study's focus. The online format made it accessible for a broad audience, enabling us to collect a large dataset efficiently.

The convenience of online data collection meant that participants could complete the survey at their own pace and in their own time, which likely increased the accuracy and honesty of their responses. This approach also facilitated immediate data entry and storage, reducing the risk of data loss or error. The collected data was then analysed to identify trends and patterns in food preferences among cardiac patients. The graphical representation of this data is shown in the following figures, providing a clear and visual understanding of the food preferences of our study participants. These graphs illustrate the distribution of ratings for each food item, highlighting which foods are most and least favoured by cardiac patients.

To understand the food preferences of cardiac patients, the researcher developed a set of 15 questions covering about 90 different food items. Each question asked patients to rate these food items on a scale from 1 to 10, reflecting their preferences. Additionally, each question included nutritional values for the food items, providing patients with important information to make informed choices. This comprehensive approach not only helped in capturing the patients' preferences but also educated them about the nutritional content of their diet. The

data collected from these questions, shown in the following images, offers valuable insights into the dietary habits and preferences of cardiac patients, which can be used to tailor nutritional recommendations and interventions more effectively.

The Google Form questions for food preferences are designed to capture detailed ratings from cardiac patients for various food items. Each question includes a rating scale from 1 to 10 and provides nutritional values for the food items. The images of these questions are shown as follows:

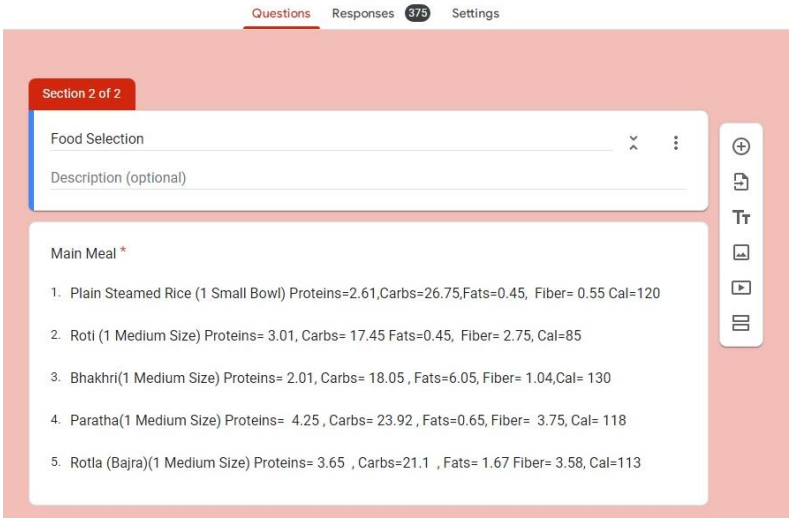

Figure 20 Online Collection of Food Preference of Cardiac Patients

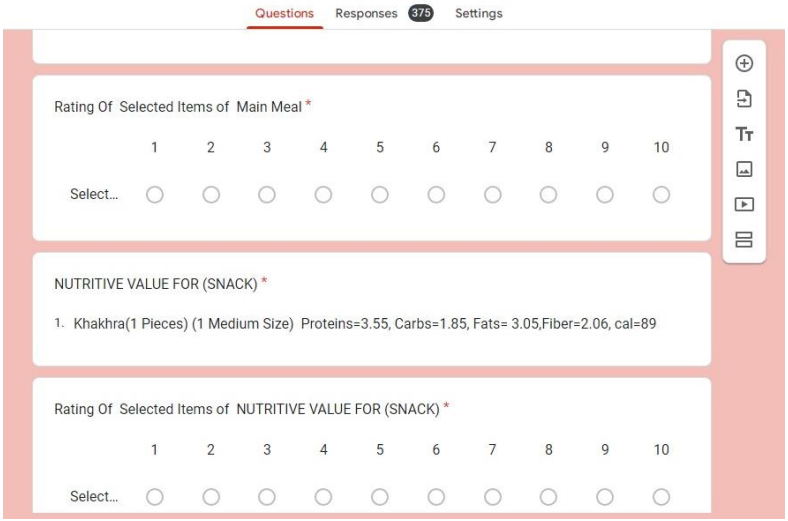

Figure 21 Online Collection of Food Preference of Cardiac Patients

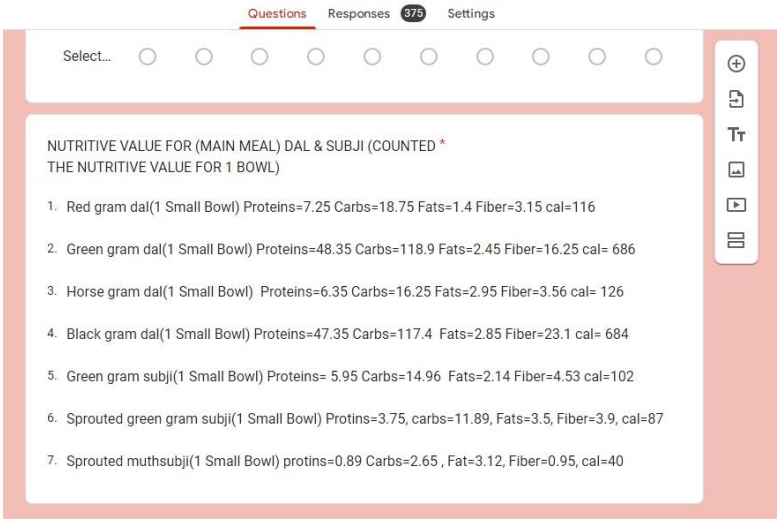

Figure 22 Online Collection of Food Preference of Cardiac Patients

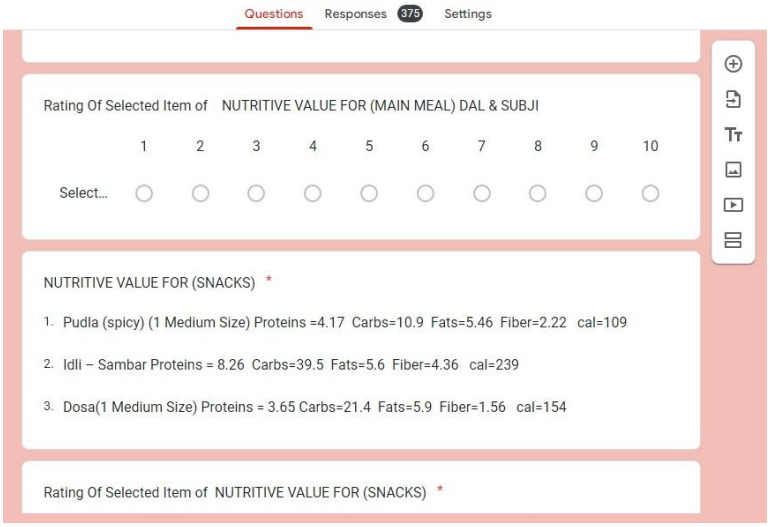

Figure 23 Online Collection of Food Preference of Cardiac Patients

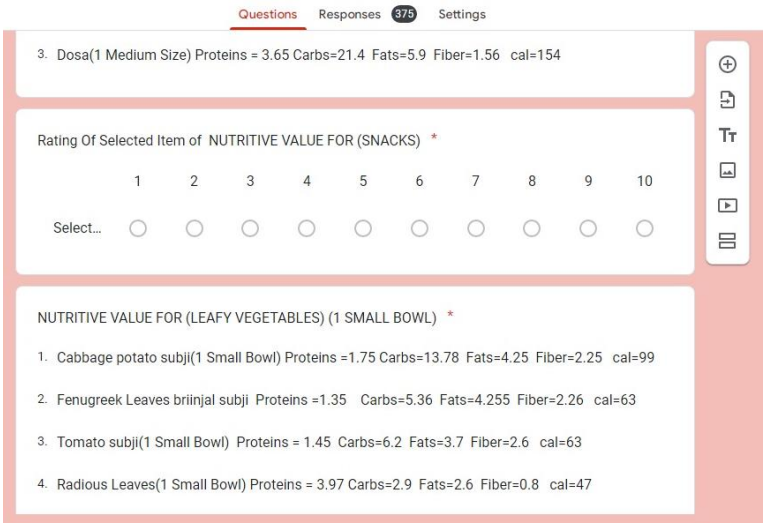

Figure 24 Online Collection of Food Preference of Cardiac Patients

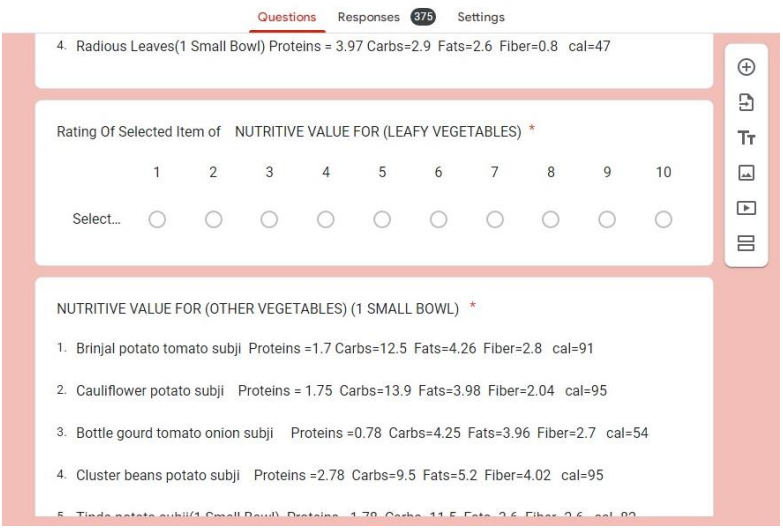

Figure 25 Online Collection of Food Preference of Cardiac Patients

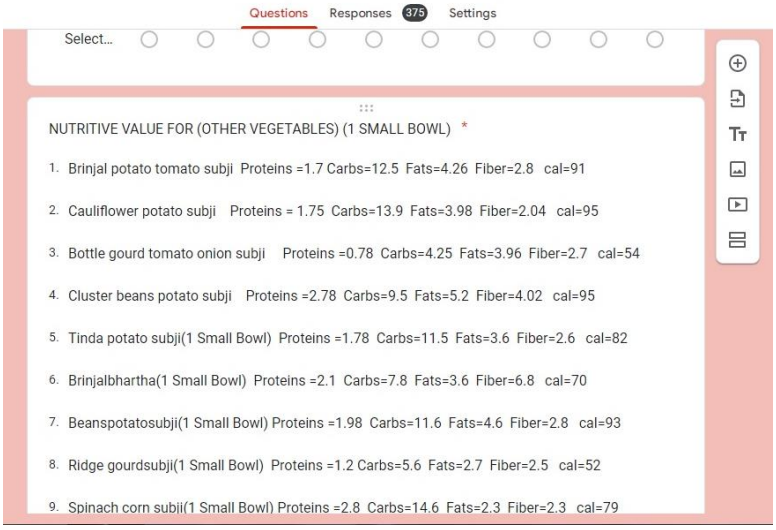

Figure 26 Online Collection of Food Preference of Cardiac Patients

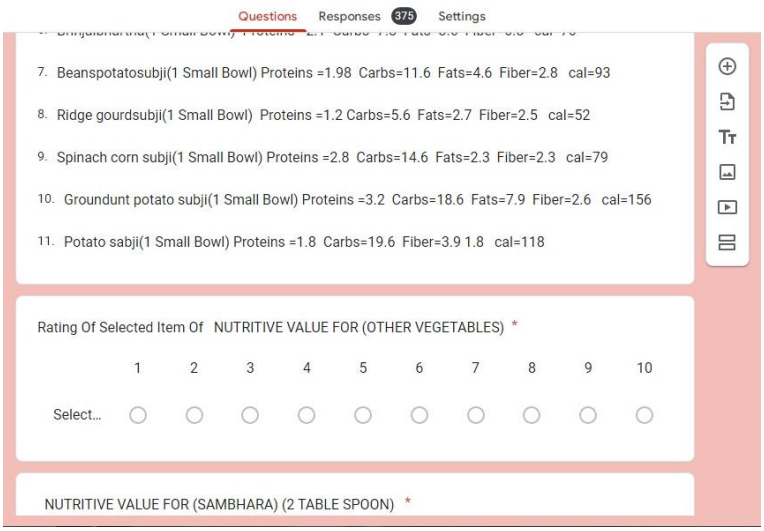

Figure 27 Online Collection of Food Preference of Cardiac Patients

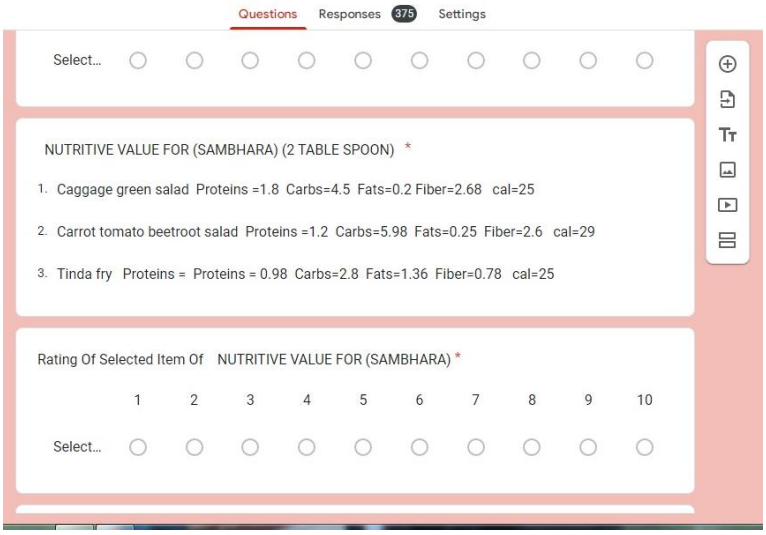

Figure 28 Online Collection of Food Preference of Cardiac Patients

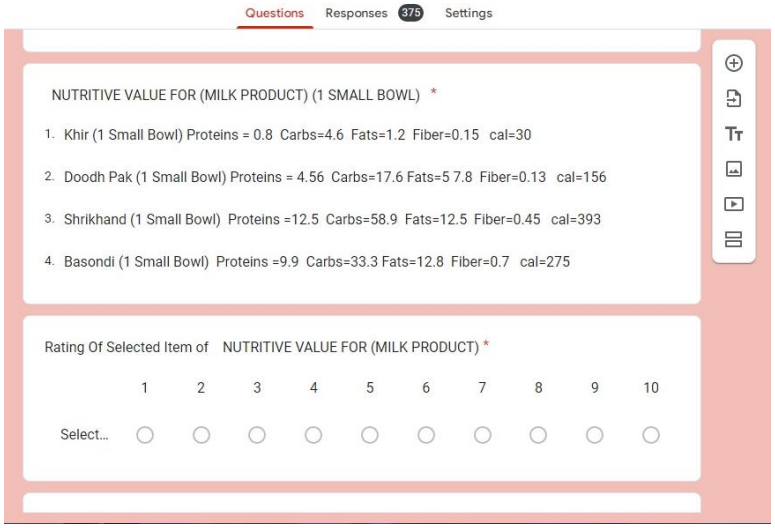

Figure 29 Online Collection of Food Preference of Cardiac Patients

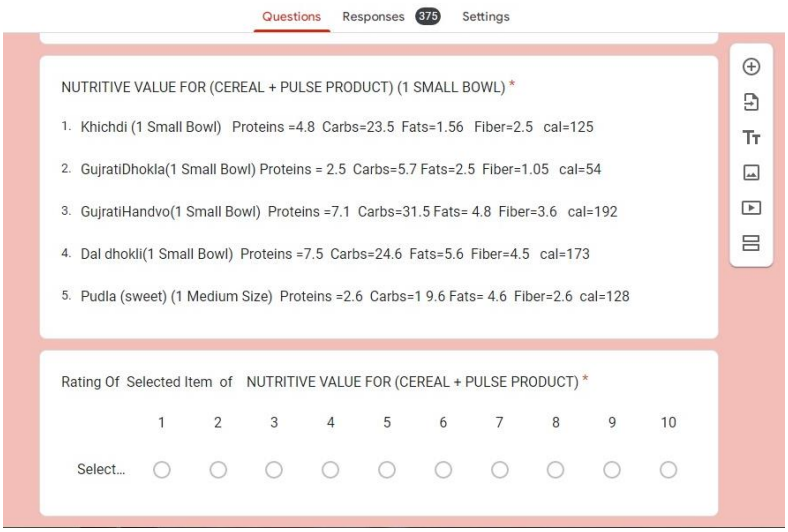

Figure 30 Online Collection of Food Preference of Cardiac Patients

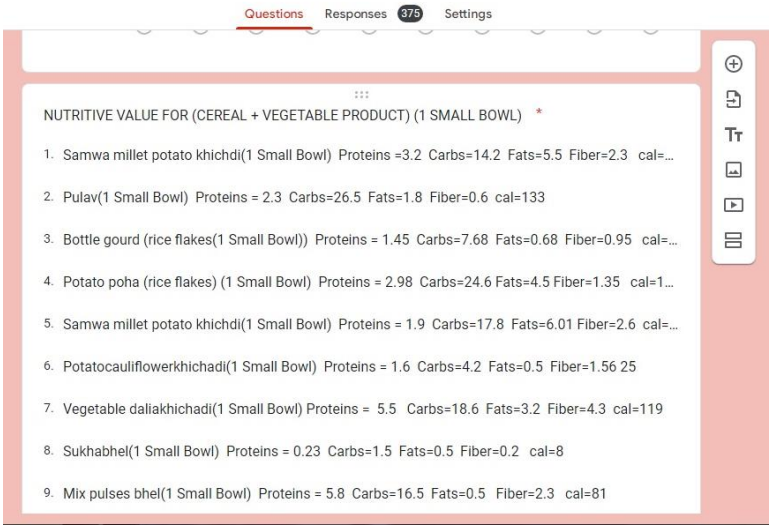

Figure 31 Online Collection of Food Preference of Cardiac Patients

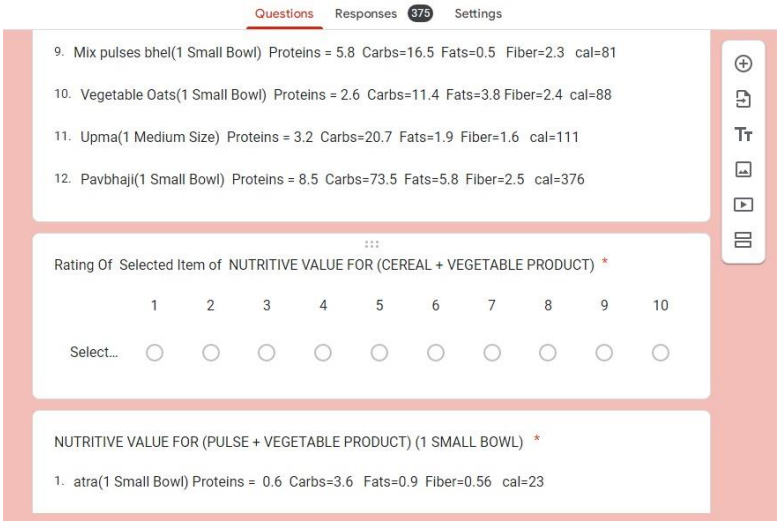

Figure 32 Online Collection of Food Preference of Cardiac Patients

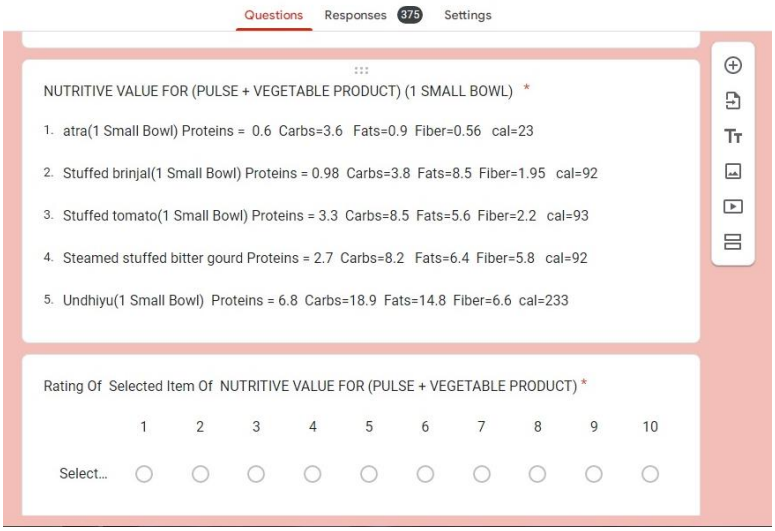

Figure 33 Online Collection of Food Preference of Cardiac Patients

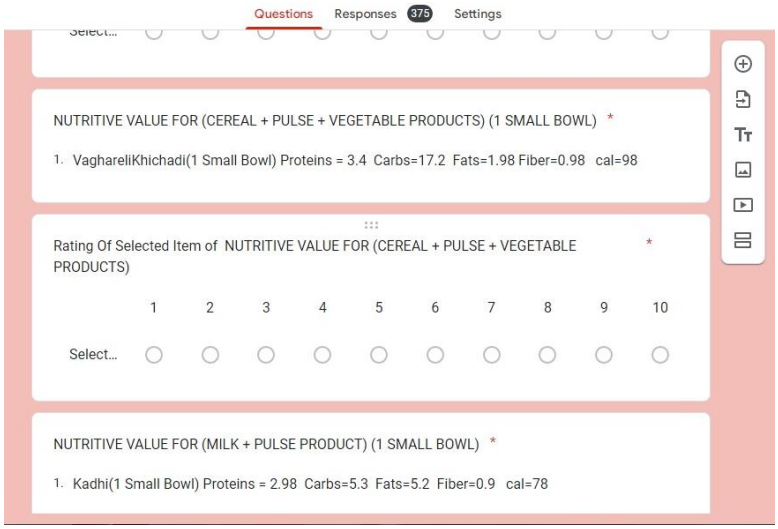

Figure 34 Online Collection of Food Preference of Cardiac Patients

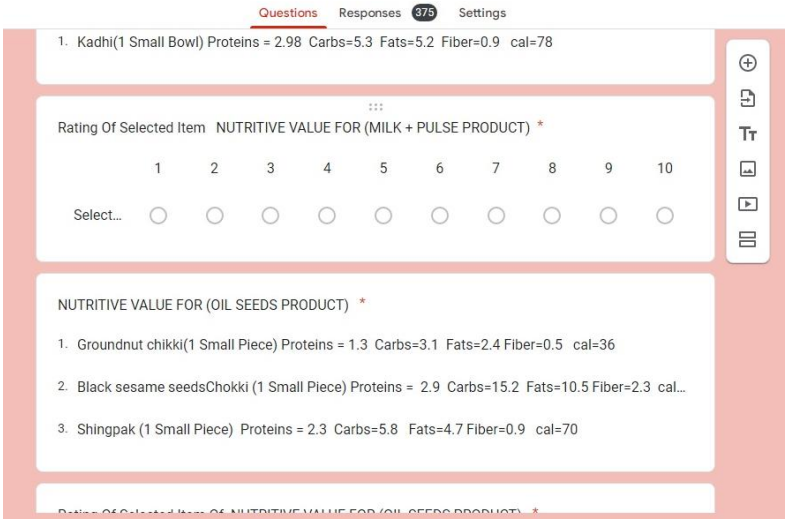

Figure 35 Online Collection of Food Preference of Cardiac Patients

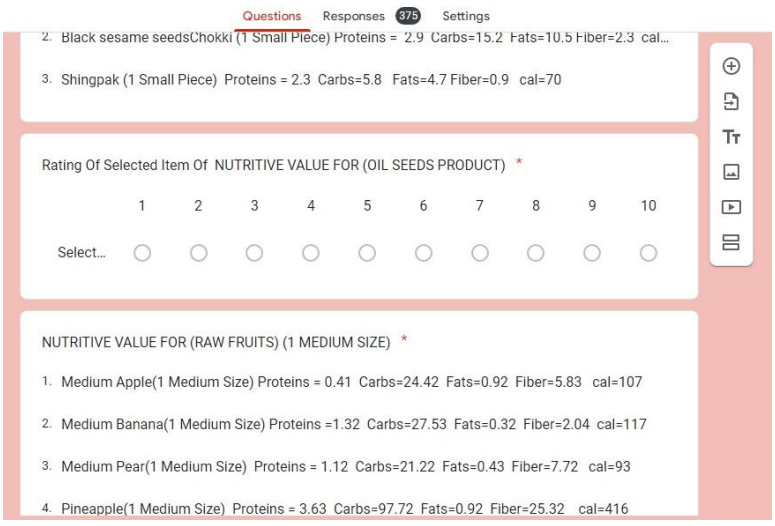

Figure 36 Online Collection of Food Preference of Cardiac Patients

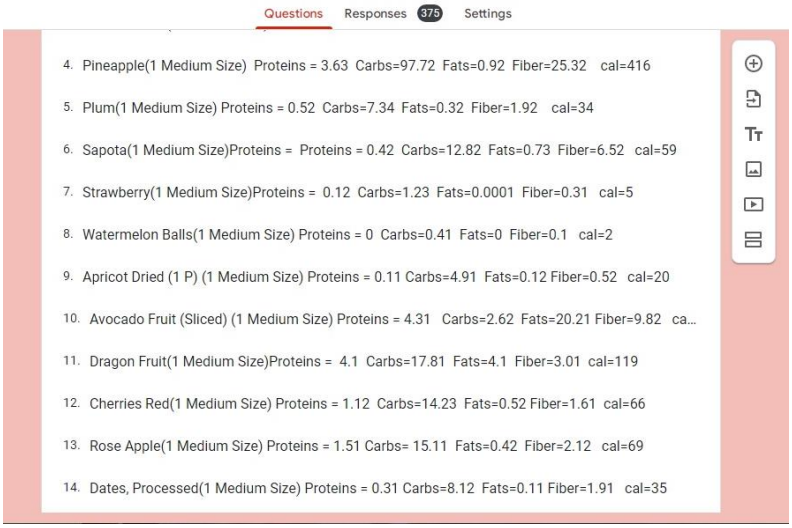

Figure 37 Online Collection of Food Preference of Cardiac Patients

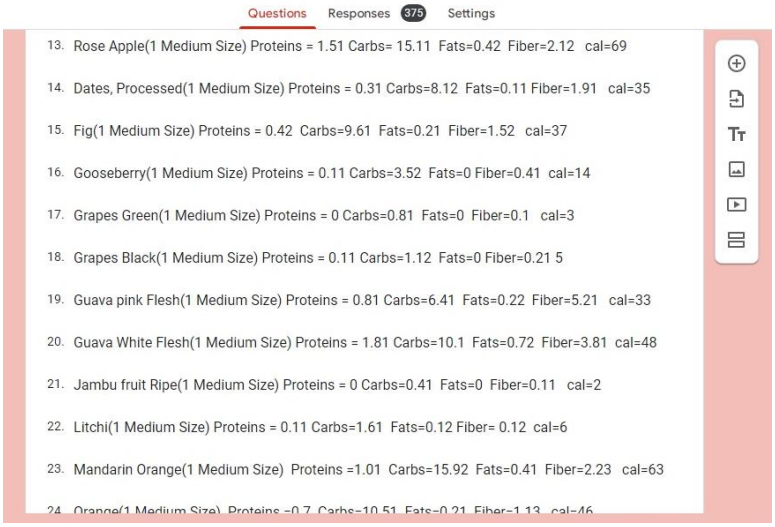

Figure 38 Online Collection of Food Preference of Cardiac Patients

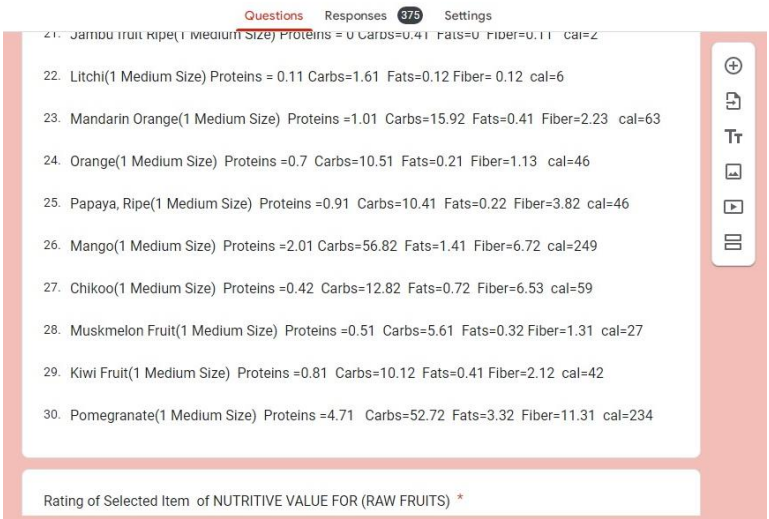

Figure 39 Online Collection of Food Preference of Cardiac Patients

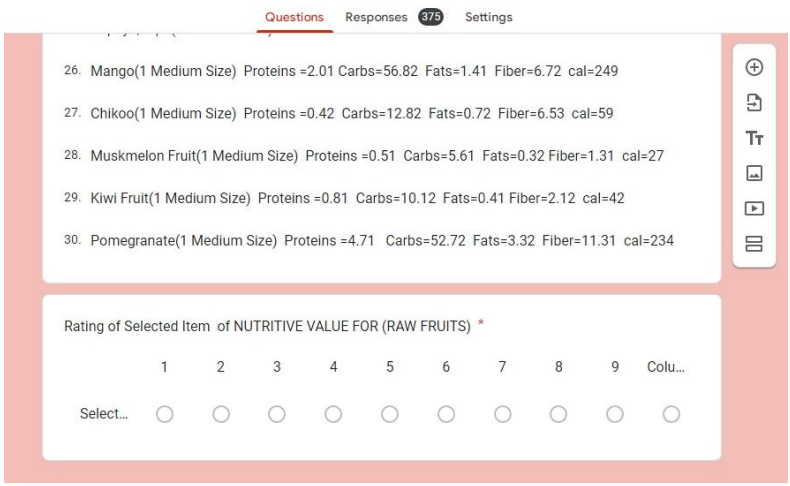

Figure 40 Online Collection of Food Preference of Cardiac Patients

4.2.2 Secondary Data Collection

Secondary data collection is a vital component of our research, providing comprehensive background information on the nutritional values and calorie specifications of various Gujarati food and fruit items. This process involved gathering data from multiple reputable sources, including nutritional databases, scientific publications, and government health resources. By compiling detailed nutritional profiles for a wide range of Gujarati dishes and fruits, we can better understand the dietary habits of cardiac patients. This information is crucial for developing targeted dietary recommendations and interventions aimed at improving the health outcomes of these patients. The secondary data also includes graphical representations, which help visualize and compare the nutritional content of different food items, enhancing our analysis and communication of findings.

4.2.2.1 Database for Gujarati Food & Fruit Items Nutritional Values & Calorie Specification

4.2.2.1.1 Gujarati Food

In this nutrition-based study of Gujarati food, we analyze the nutritional values of various traditional dishes to provide personalized dietary recommendations for cardiac patients. The research involves detailed examination of the nutritional content, including proteins, carbohydrates, fats, fiber, and calories, across 14 different categories of Gujarati food. Each category is meticulously evaluated to ensure that the foods included are heart-healthy and suitable for managing cardiovascular health. The following tables present the specifications of these 14 categories, outlining their nutritive values and providing descriptions of each item.

Nutritional Value for Main Meals in Gujarati Cuisine

To ensure the development of personalized and nutritious diets for cardiac patients, the following table outlines the nutritional values of common main meals in Gujarati cuisine. These values provide essential information about the content of proteins, carbohydrates, fats, fiber, and calories in each serving.

Item Name	Proteins (g)	Carbs (g)	Fats (g)	Fiber (g)	Calories (Cal)
Plain Steamed Rice (1 Small Bowl)	2.61	26.75	0.45	0.55	120
Roti (1 Medium Size)	3.01	17.45	0.45	2.75	85
Bhakhri (1 Medium Size)	2.01	18.05	6.05	1.04	130
Paratha (1 Medium Size)	4.25	23.92	0.65	3.75	118
Rotla (Bajra) (1 Medium Size)	3.65	21.10	1.67	3.58	113

Table 3 Nutritional Value for Main Meals[97], [98]

Plain Steamed Rice: A staple in many diets, plain steamed rice provides a good source of carbohydrates, which are essential for energy. Although it is low in protein, fat, and fiber, it serves as a versatile base for various dishes.

Roti: This traditional Indian flatbread is made from whole wheat flour and is a significant source of carbohydrates and fiber. It also contains a moderate amount of protein, making it a healthier option compared to refined breads.

Bhakhri: Bhakhri is a thicker, crispier flatbread that contains higher fat content due to the use of oil in its preparation. It offers a moderate amount of protein and carbohydrates, along with a bit of fiber.

Paratha: A popular choice, paratha is a layered flatbread often made with whole wheat flour and can be stuffed with various fillings. It provides a good balance of protein, carbohydrates, and fiber, with slightly higher calories due to its fat content.

Rotla (Bajra): Made from pearl millet, rotla is rich in fiber and provides a moderate amount of protein. It is a nutritious alternative to wheat-based breads, offering a unique flavor and beneficial nutrients like magnesium and iron.

These main meals are integral to Gujarati cuisine and offer diverse nutritional benefits, making them suitable for creating balanced and heart-healthy diets for cardiac patients. By understanding the nutritional content of these foods, healthcare providers can better dietary recommendations to meet individual patient needs. The graphical representation of the above data is as follows:

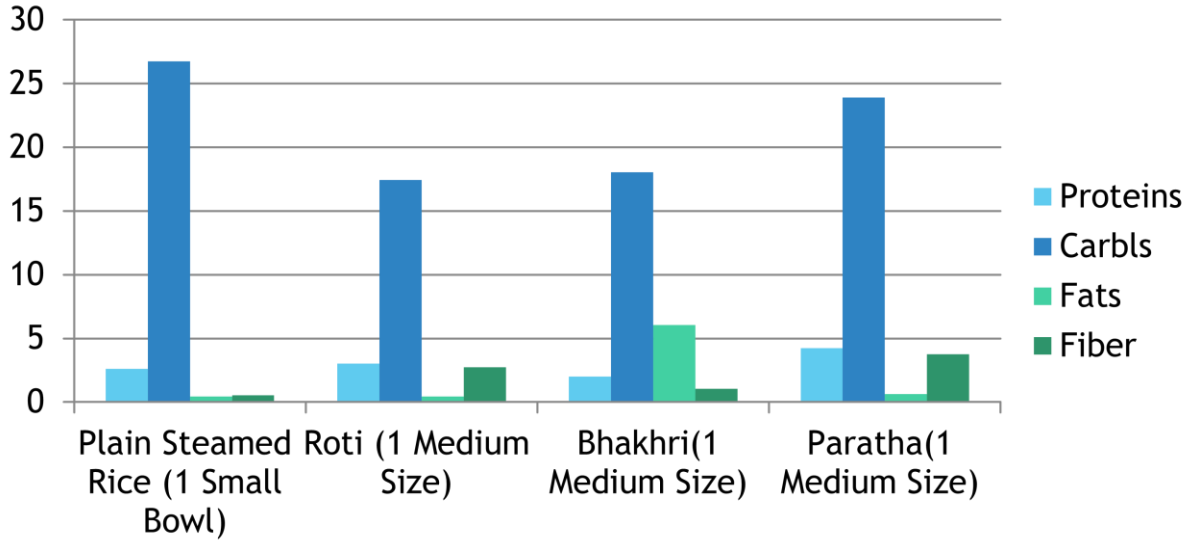

Figure 41 Nutritional Values for Main Meals.

Nutritive Values for Dry Snacks in Gujarati Cuisine

To ensure the development of personalized and nutritious diets for cardiac patients, the following table outlines the nutritional values of common snacks in Gujarati cuisine. These values provide essential information about the content of proteins, carbohydrates, fats, fiber, and calories in each serving.

Item Name	**Proteins (g)**	**Carbs (g)**	**Fats (g)**	**Fiber (g)**	**Calories (Cal)**
Khakhra (1 Piece, Medium Size)	3.55	1.85	3.05	2.06	89

Table 4 Nutritive Values for Dry Snacks[97], [98]

Khakhra: is a traditional Indian snack made from whole wheat flour and various spices. It is typically crisp and thin, often enjoyed as a healthy snack option. The nutritional profile of a medium-sized piece of Khakhra in graphical form is as follows:

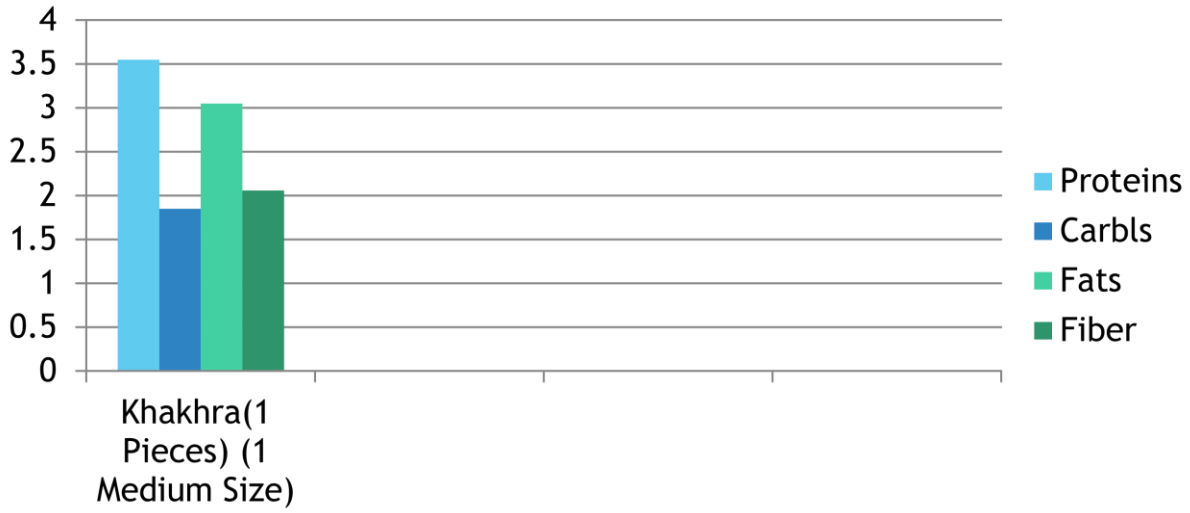

Figure 42 Nutritive Values for Dry Snacks

Nutritive Values for Main Meal Dal & Subji in Gujarati Cuisine

To ensure the development of personalized and nutritious diets for cardiac patients, the following table outlines the nutritional values of common Main Meal Dal & Subji in Gujarati cuisine. These values provide essential information about the content of proteins, carbohydrates, fats, fiber, and calories in each serving.

Item Name Nutritive Values for Dal & Subji (1 Small Bowl)	**Proteins (g)**	**Carbs (g)**	**Fats (g)**	**Fiber (g)**	**Calories (Cal)**
Red gram dal	7.25	18.75	1.4	3.15	116
Green gram dal	48.35	118.9	2.45	16.25	686
Horse gram dal	6.35	16.25	2.95	3.56	126
Black gram dal	47.35	117.4	2.85	23.1	684
Green gram subji	5.95	14.96	2.14	4.53	102
Sprouted green gram subji	3.75	11.89	3.5	3.9	87

Sprouted muth subji	0.89	2.65	3.12	0.95	40

Table 5 Nutritive Values for Dal & Subji (1 Small Bowl)[97], [98]

Red gram dal (1 Small Bowl): Red gram dal, also known as toor dal, is a popular Indian lentil, rich in proteins and fiber. It is commonly used in various curries and soups.

Green gram dal (1 Small Bowl): Green gram dal, also known as mung bean, is highly nutritious, offering high protein content and significant carbohydrates, ideal for energy.

Horse gram dal (1 Small Bowl): Horse gram dal is known for its health benefits, including aiding in weight loss and managing diabetes, rich in protein and dietary fiber.

Black gram dal (1 Small Bowl): Black gram dal, or urad dal, is essential in South Indian cuisine, providing high protein and fiber, making it beneficial for digestive health.

Green gram subji (1 Small Bowl): Green gram subji is a vegetable dish made with mung beans, offering a balanced mix of proteins, carbs, and fiber, making it a healthy side dish.

Sprouted green gram subji (1 Small Bowl): Sprouted green gram subji is a nutritious option, enhanced in protein and fiber content due to sprouting, which also aids in digestion.

Sprouted muth subji (1 Small Bowl): Sprouted muth subji is a light, low-calorie dish, featuring muth beans that have been sprouted, making it rich in proteins and healthy fats.

Graphically represent the data showing the nutritional content of each item with separate bars for Proteins, Carbs, Fats, Fiber, and Calories for each type of dal and subji.

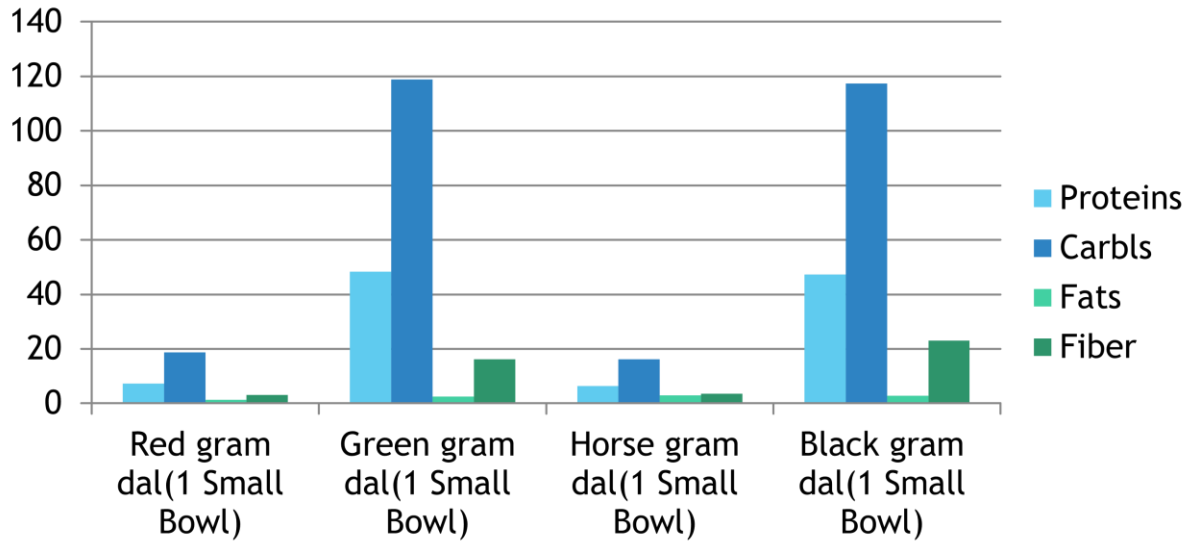

Figure 43 Nutritive Values for Dal & Subji

Nutritive Values for Gujarati Snacks in Gujarati Cuisine

To ensure the development of personalized and nutritious diets for cardiac patients, the following table outlines the nutritional values of common Snacks in Gujarati cuisine. These values provide essential information about the content of proteins, carbohydrates, fats, fiber, and calories in each serving.

Item Name	Proteins (g)	Carbs (g)	Fats (g)	Fiber (g)	Calories (Cal)
Pudla (spicy) (1 Medium Size)	4.17	10.9	5.46	2.22	109
Idli – Sambar	8.26	39.5	5.6	4.36	239
Dosa (1 Medium Size)	3.65	21.4	5.9	1.56	154

Table 6 Nutritive Values for Gujarati Snacks[97], [98]

Pudla (spicy): Pudla is a savory pancake made from a batter of gram flour and spices. It is a popular Gujarati snack known for its balanced nutritional content. It provides a good mix of macronutrients and digestive benefits, making it a healthy option.

Idli – Sambar: Idli is a steamed rice cake, commonly paired with sambar, a lentil-based vegetable stew. This combination is a staple breakfast item in many Indian households, including Gujarati. It offers a high protein content and is rich in carbohydrates, making it a wholesome meal option.

Dosa: Dosa is a thin, crispy pancake made from fermented rice and lentil batter. It is a popular breakfast and snack item. A medium-sized dosa is nutritious and filling, making it a relatively low-calorie and healthy option.

Graphically represent the data showing the nutritional content of each item with separate bars for Proteins, Carbs, Fats, Fiber, and Calories for each type of dal and subji

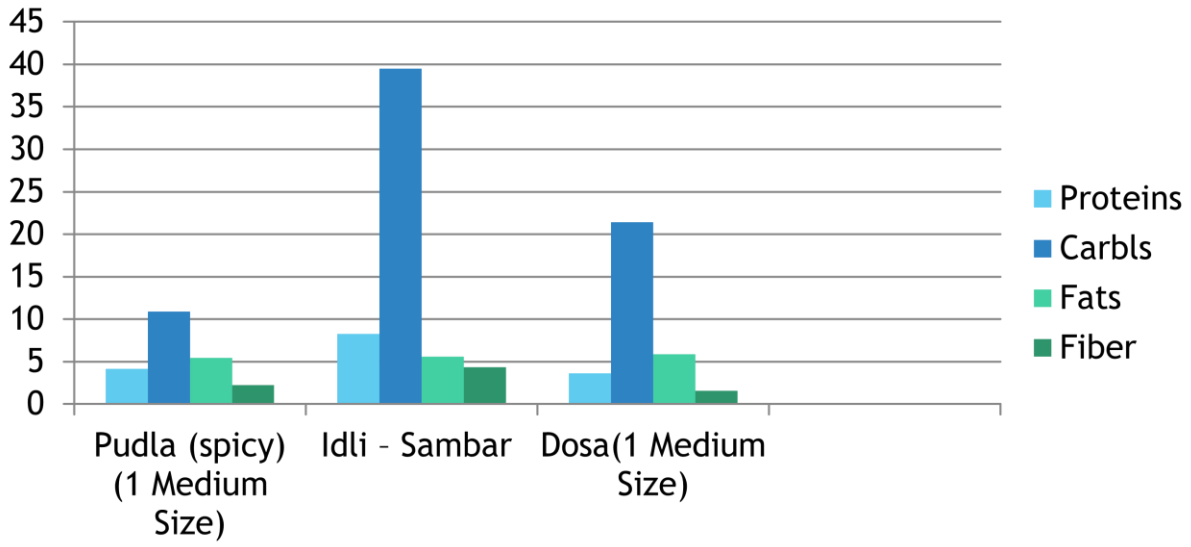

Figure 44 Nutritive Values for Gujarati Snacks

Nutritive Values for Leafy Vegetables in Gujarati Cuisine

To ensure the development of personalized and nutritious diets for cardiac patients, the following table outlines the nutritional values of Leafy Vegetables in Gujarati cuisine. These values provide essential information about the content of proteins, carbohydrates, fats, fiber, and calories in each serving.

Name	Proteins (g)	Carbs (g)	Fats (g)	Fiber (g)	Calories (Cal)
Cabbage Potato Subji	1.75	13.78	4.25	2.25	99
Fenugreek Leaves Brinjal Subji	1.35	5.36	4.255	2.26	63
Tomato Subji	1.45	6.2	3.7	2.6	63
Radish Leaves	3.97	2.9	2.6	0.8	47

Table 7 Nutritive Values for Leafy Vegetables[97], [98]

Cabbage Potato Subji: This is a vegetable dish made with cabbage and potatoes. It is a common Gujarati preparation that provides a moderate amount of carbohydrates and fats. It is a filling and nutritious side dish that pairs well with main meals.

Fenugreek Leaves Brinjal Subji: This dish combines fenugreek leaves (methi) and brinjal (eggplant). Fenugreek leaves are known for their slightly bitter taste and numerous health benefits. This subji is low in carbohydrates but rich in essential fats and fiber, making it a healthy choice.

Tomato Subji: This simple dish is made primarily from tomatoes and is commonly served as a side dish. It offers a good balance of proteins, fats, and fiber while being low in calories. The tangy flavor of tomatoes makes this subji a refreshing addition to any meal.

Radish Leaves: Radish leaves are often used in Gujarati cuisine for their unique flavor and nutritional benefits. They are high in protein and fiber while being very low in carbohydrates and calories. Radish leaves are typically cooked with spices to create a healthy and flavorful dish.

Graphically represent the data showing the nutritional content of each item with separate bars for Proteins, Carbs, Fats, Fiber, and Calories for each type of Leafy Vegetables.

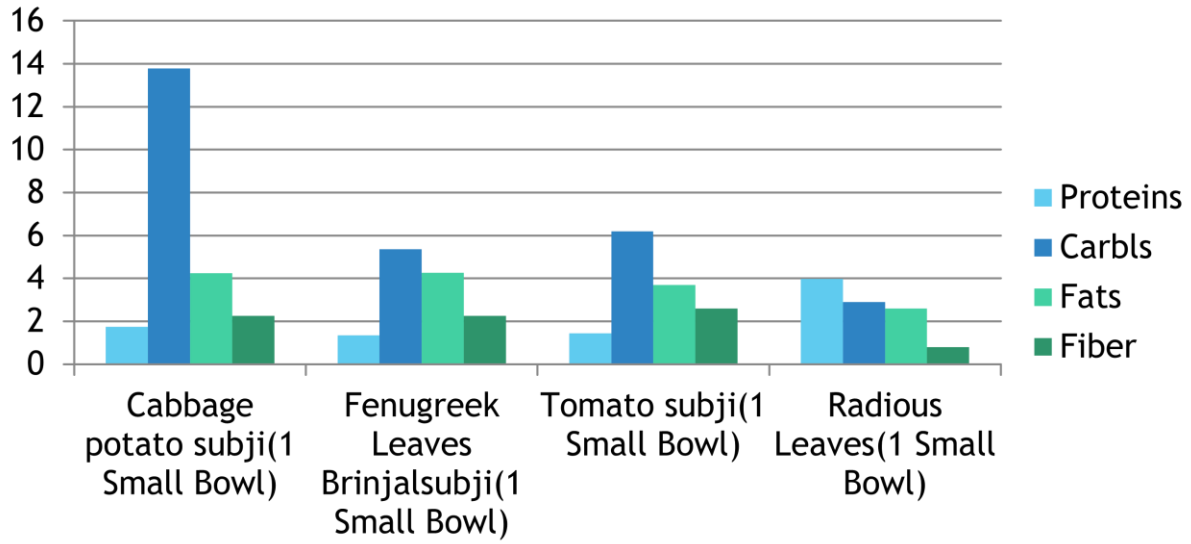

Figure 45 Nutritive Values for Leafy Vegetables

Nutritive Values for Other Vegetables in Gujarati Cuisine

To ensure the development of personalized and nutritious diets for cardiac patients, the following table outlines the nutritional values of Other Vegetables in Gujarati cuisine. These values provide essential information about the content of proteins, carbohydrates, fats, fiber, and calories in each serving.

Name **(1 SMALL BOWL)**	**Proteins (g)**	**Carbs (g)**	**Fats (g)**	**Fiber (g)**	**Calories (Cal)**

Brinjal Potato Tomato Subji	1.7	12.5	4.26	2.8	91
Cauliflower Potato Subji	1.75	13.9	3.98	2.04	95
Bottle Gourd Tomato Onion Subji	0.78	4.25	3.96	2.7	54
Cluster Beans Potato Subji	2.78	9.5	5.2	4.02	95
Tinda Potato Subji	1.78	11.5	3.6	2.6	82
Brinjal Bhartha	2.1	7.8	3.6	6.8	70
Beans Potato Subji	1.98	11.6	4.6	2.8	93
Ridge Gourd Subji	1.2	5.6	2.7	2.5	52
Spinach Corn Subji	2.8	14.6	2.3	2.3	79
Groundnut Potato Subji	3.2	18.6	7.9	2.6	156
Potato Subji	1.8	19.6	3.9	1.8	118

Table 8 Nutritive Values for Other Vegetables[97], [98]

Brinjal Potato Tomato Subji: A mix of brinjal (eggplant), potatoes, and tomatoes. This dish is nutritious with a balanced amount of carbohydrates, fats, and fiber, making it a hearty addition to meals.

Cauliflower Potato Subji: This subji combines cauliflower and potatoes. It is rich in carbohydrates and fats, providing a satisfying and filling vegetable dish that is commonly enjoyed in Gujarati cuisine.

Bottle Gourd Tomato Onion Subji: Made with bottle gourd, tomatoes, and onions, this dish is low in carbs and calories but still provides essential fats and fiber, making it a light yet nutritious option.

Cluster Beans Potato Subji: A combination of cluster beans and potatoes, this dish is rich in protein and fiber, offering a good balance of nutrients and making it a healthy choice.

Tinda Potato Subji: This subji includes tinda (apple gourd) and potatoes. It is a moderately nutritious dish with a good amount of carbohydrates and fats.

Brinjal Bhartha: A mashed brinjal dish that is high in fiber and provides a moderate amount of carbohydrates and fats. It is a flavorful and healthy vegetable preparation.

Beans Potato Subji: This dish combines beans and potatoes, providing a good amount of protein, carbohydrates, and fats. It is a nutritious and filling option.

Ridge Gourd Subji: Made with ridge gourd, this dish is low in carbohydrates and calories but still provides essential fats and fiber, making it a healthy and light option.

Spinach Corn Subji: A mix of spinach and corn, this dish is rich in carbohydrates and provides a moderate amount of proteins and fats, making it a nutritious and tasty vegetable preparation.

Groundnut Potato Subji: This subji includes groundnuts (peanuts) and potatoes. It is high in fats and calories but also provides a good amount of protein and fiber, making it a hearty and energy-dense dish.

Potato Subji: A simple potato dish that is rich in carbohydrates and provides a moderate amount of fats and fiber. It is a common and filling vegetable preparation in Gujarati cuisine.

Graphically represent the data showing the nutritional content of each item with separate bars for Proteins, Carbs, Fats, Fiber, and Calories for each type of Other Vegetables.

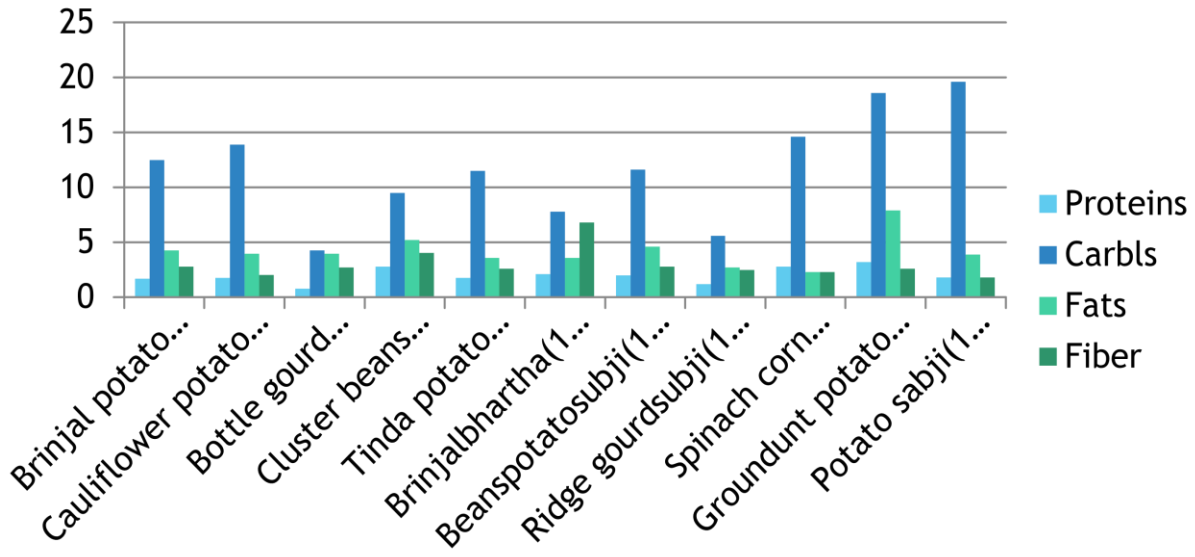

Figure 46 Nutritive Values for Other Vegetables

Nutritive Values for Sambhara(2 Table Spoon) in Gujarati Cuisine

To ensure the development of personalized and nutritious diets for cardiac patients, the following table outlines the nutritional values of Sambhara in Gujarati cuisine. These values provide essential information about the content of proteins, carbohydrates, fats, fiber, and calories in each serving.

Item Name	Proteins (g)	Carbs (g)	Fats (g)	Fiber (g)	Calories (Cal)
Cabbage Green Salad	1.8	4.5	0.2	2.68	25
Carrot Tomato Beetroot Salad	1.2	5.98	0.25	2.6	29
Tinda Fry	0.98	2.8	1.36	0.78	25

Table 9 Nutritive Values for Sambhara(2 Table Spoon)[97], [98]

Cabbage Green Salad: This fresh salad is made primarily with cabbage. It's low in calories and fats, but rich in fiber and provides a moderate amount of proteins and carbohydrates. It's a healthy, crunchy addition to meals.

Carrot Tomato Beetroot Salad: A colorful mix of carrots, tomatoes, and beetroot, this salad is slightly higher in carbohydrates and fiber, with a touch of protein and minimal fats. It is nutritious and vibrant, perfect for adding a burst of flavor and health benefits.

Tinda Fry: This dish consists of fried tinda (apple gourd). It's relatively low in calories and carbs but has a moderate amount of fats due to frying. It offers a small amount of protein and fiber, making it a tasty and crunchy side dish.

Graphically represent the data showing the nutritional content of each item with separate bars for Proteins, Carbs, Fats, Fiber, and Calories for each type of Sambhara.

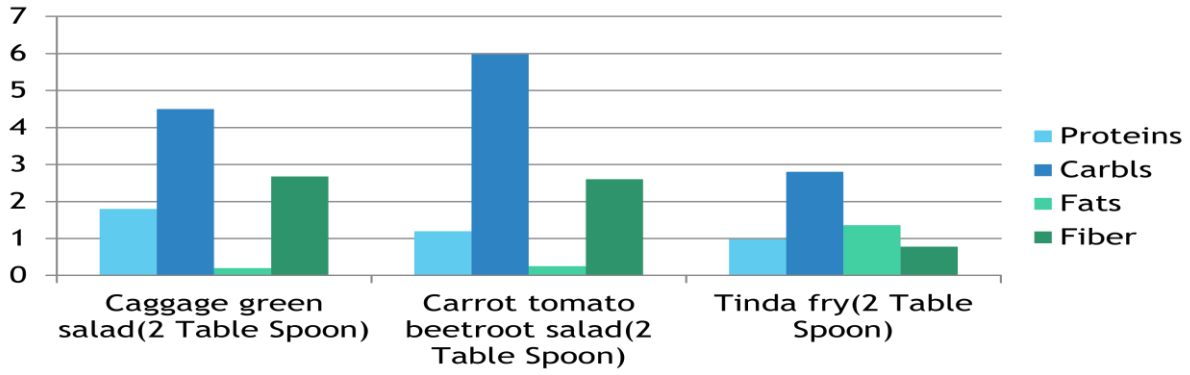

Figure 47 Nutritive Values for Sambhara(2 Table Spoon)

Nutritive Values for (Milk Product) (1 Small Bowl) in Gujarati Cuisine

To ensure the development of personalized and nutritious diets for cardiac patients, the following table outlines the nutritional values of Milk Product in Gujarati cuisine. These values provide essential information about the content of proteins, carbohydrates, fats, fiber, and calories in each serving

Item Name	Proteins (g)	Carbs (g)	Fats (g)	Fiber (g)	Calories (Cal)
Khir	0.8	4.6	1.2	0.15	30
Doodh Pak	4.56	17.65	7.8	0.13	156
Shrikhand	12.5	58.9	12.5	0.45	393
Basondi	9.9	33.3	12.8	0.7	275

Table 10 Nutritive Values for (Milk Product) (1 Small Bowl)[97], [98]

Khir: A sweet milk-based dish, Khir is light with minimal calories and fats. It contains a small amount of protein and carbohydrates, making it a mild, sweet treat suitable for a light dessert.

Doodh Pak: This is a richer, sweetened milk preparation. It has a higher content of proteins, carbs, and fats compared to Khir, resulting in a more calorie-dense dish. Doodh Pak is creamy and often flavored with nuts and cardamom.

Shrikhand: A popular dessert made from strained yogurt, Shrikhand is high in proteins, carbohydrates, and fats, leading to its substantial calorie content. It's sweet and creamy, often flavored with saffron and cardamom.

Basondi: Another rich milk-based dessert, Basondi has a significant amount of proteins, carbs, and fats, contributing to its high-calorie content. It's thickened milk, often garnished with nuts and spices, making it a decadent treat.

Graphically represent the data showing the nutritional content of each item with separate bars for Proteins, Carbs, Fats, Fiber, and Calories for each type of Milk Product.

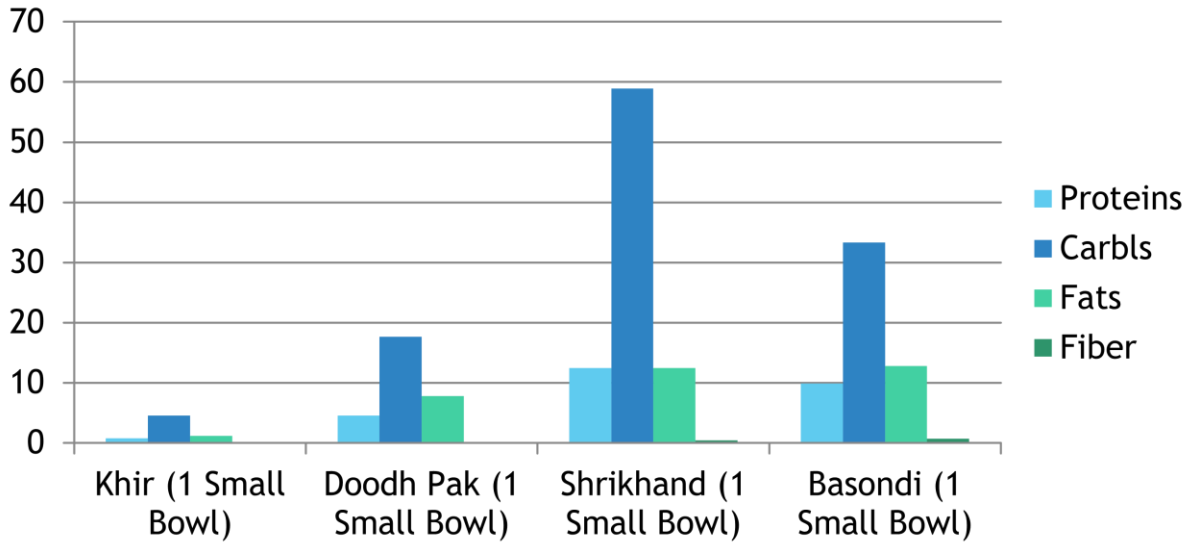

Figure 48 Nutritive Values for (Milk Product) (1 Small Bowl)

Nutritive Values for (Cereal + Pulse Product) (1 Small Bowl) in Gujarati Cuisine

To ensure the development of personalized and nutritious diets for cardiac patients, the following table outlines the nutritional values of (Cereal + Pulse Product) in Gujarati cuisine. These values provide essential information about the content of proteins, carbohydrates, fats, fiber, and calories in each serving

Name	Proteins (g)	Carbs (g)	Fats (g)	Fiber (g)	Calories (Cal)
Khichdi	4.8	23.5	1.56	2.5	125
Gujarati Dhokla	2.5	5.7	2.5	1.05	54
Gujarati Handvo	7.1	31.5	4.8	3.6	192
Dal Dhokli	7.5	24.6	5.6	4.5	173
Pudla (sweet)	2.6	19.6	4.6	2.6	128

Table 11 Nutritive Values for (Cereal + Pulse Product) (1 Small Bowl)[97], [98]

Khichdi: A comforting and simple dish made with rice and lentils, Khichdi is rich in proteins and carbohydrates, with a moderate amount of fiber and fats. It is light yet nutritious, making it a wholesome meal.

Gujarati Dhokla: A popular steamed snack made from fermented rice and chickpea batter, Gujarati Dhokla is low in calories and fats but provides a good amount of proteins and carbs. It's light and fluffy, often served with chutney.

Gujarati Handvo: A savory cake made from a mix of rice, lentils, and vegetables, Handvo is high in proteins, carbs, and fats. It is rich in fiber, making it a filling and nutritious dish often enjoyed as a meal or snack.

Dal Dhokli: A hearty dish consisting of wheat flour dumplings simmered in a spicy lentil soup. Dal Dhokli is high in proteins, carbohydrates, fats, and fiber, making it a balanced and satisfying meal.

Pudla (sweet): A sweet variation of the traditional Pudla, made with a mixture of flours and sweetened with sugar or jaggery. It provides a moderate amount of proteins, carbs, and fats, along with some fiber, making it a sweet yet nutritious snack.

Graphically represent the data showing the nutritional content of each item with separate bars for Proteins, Carbs, Fats, Fiber, and Calories for each type of (Cereal + Pulse Product).

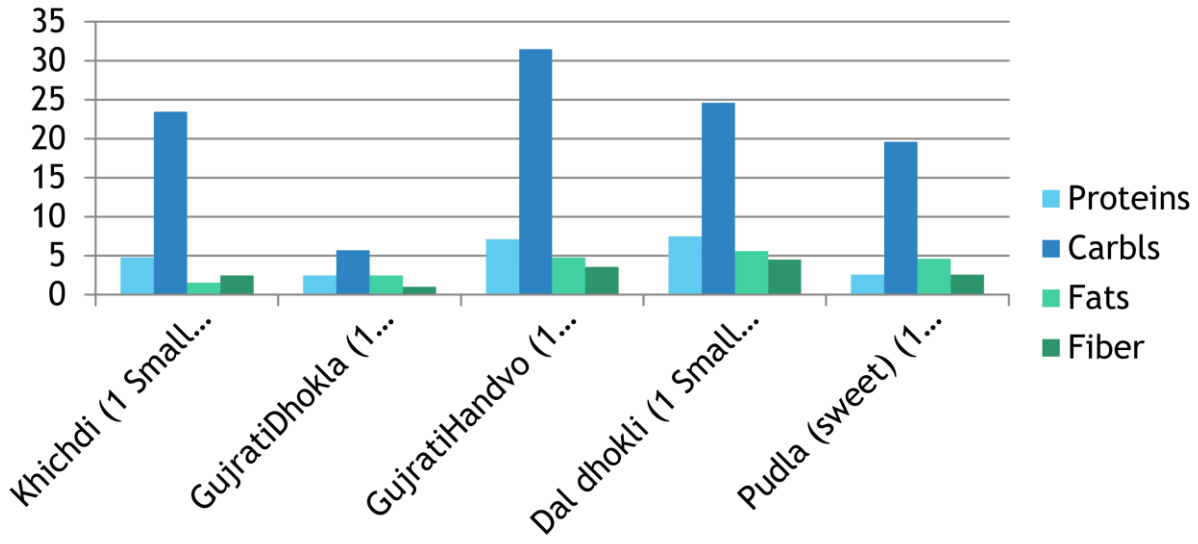

Figure 49 Nutritive Values for (Cereal + Pulse Product) (1 Small Bowl)

Nutritive Values for (Cereal + Vegetable Product) (1 Small Bowl) in Gujarati Cuisine

To ensure the development of personalized and nutritious diets for cardiac patients, the following table outlines the nutritional values of (Cereal + Vegetable Product) in Gujarati cuisine. These values provide essential information about the content of proteins, carbohydrates, fats, fiber, and calories in each serving

Item Name	Proteins (g)	Carbs (g)	Fats (g)	Fiber (g)	Calories (Cal)
Samwa millet potato khichdi	3.2	14.2	5.5	2.3	114
Pulav	2.3	26.5	1.8	0.6	133
Bottle gourd (rice flakes)	1.45	7.68	0.68	0.95	43
Potato poha (rice flakes)	2.98	24.6	4.5	1.35	143
Samwa millet potato khichdi	1.9	17.8	6.01	2.6	133
Potato cauliflower khichadi	1.6	4.2	0.5	1.56	25
Vegetable dalia khichadi	5.5	18.6	3.2	4.3	119
Sukha bhel	0.23	1.5	0.5	0.2	8
Mix pulses bhel	5.8	16.5	0.5	2.3	81
Vegetable Oats	2.6	11.4	3.8	2.4	88
Upma	3.2	20.7	1.9	1.6	111
Pav bhaji	8.5	73.5	5.8	2.5	376

Table 12 Nutritive Values for (Cereal + Vegetable Product) (1 Small Bowl)[97], [98]

Samwa Millet Potato Khichdi: A nutritious dish made with Samwa millet and potatoes, offering a balance of proteins, carbs, and fats, with a good amount of fiber. It's a wholesome meal that's light on calories.

Pulav: A flavorful rice dish cooked with vegetables and spices. It is rich in carbohydrates with moderate protein and fat content, making it an energy-dense meal.

Bottle Gourd (Rice Flakes): This dish combines bottle gourd with rice flakes, providing a light and nutritious option with low calories, moderate carbs, and minimal fats.

Potato Poha (Rice Flakes): A popular breakfast item made from flattened rice and potatoes. It is rich in carbs, providing a good amount of protein and fats, making it a filling and tasty dish.

Potato Cauliflower Khichadi: A simple yet nutritious dish with potatoes and cauliflower. It is low in calories and fats, making it a light and healthy meal option.

Vegetable Dalia Khichadi: Made from broken wheat and mixed vegetables, this dish is high in proteins, carbs, and fiber, offering a balanced and nutritious meal.

Sukha Bhel: A light and crunchy snack made from puffed rice and a mix of spices. It is very low in calories, with minimal fats and carbs, making it a light snack option.

Mix Pulses Bhel: A nutritious snack made with a mix of pulses and spices, providing high protein and fiber content, with moderate carbs and very low fats.

Vegetable Oats: A healthy dish made with oats and mixed vegetables, providing a good amount of proteins, carbs, and fiber. It's a light yet filling meal option.

Upma: A popular South Indian breakfast dish made from semolina and vegetables. It is rich in carbs, with moderate proteins and fats, making it a nutritious start to the day.

Pav Bhaji: A popular street food dish made with mixed vegetables and spices, served with buttered bread rolls (pav). It is high in carbs and fats, making it a calorie-dense and indulgent meal.

Graphically represent the data showing the nutritional content of each item with separate bars for Proteins, Carbs, Fats, Fiber, and Calories for each type of (Cereal + Vegetable Product).

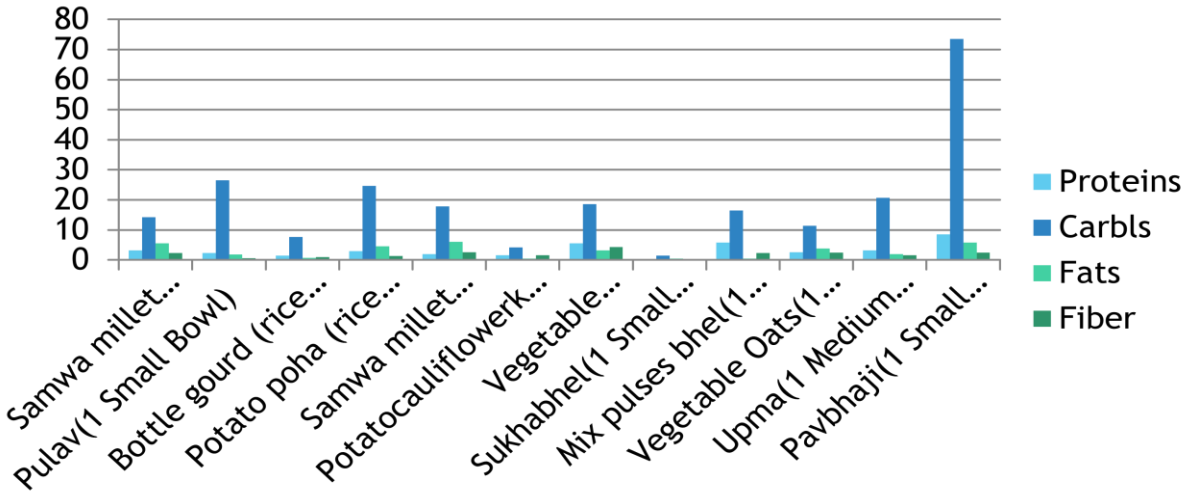

Figure 50 Nutritive Values for (Cereal + Vegetable Product) (1 Small Bowl)

Nutritive Values for (Pulse + Vegetable Product) (1 Small Bowl) in Gujarati Cuisine

To ensure the development of personalized and nutritious diets for cardiac patients, the following table outlines the nutritional values of (Pulse + Vegetable Product) in Gujarati

cuisine. These values provide essential information about the content of proteins, carbohydrates, fats, fiber, and calories in each serving

Name	Proteins (g)	Carbs (g)	Fats (g)	Fiber (g)	Calories (Cal)
Atra	0.6	3.6	0.9	0.56	23
Stuffed Brinjal	0.98	3.8	8.5	1.95	92
Stuffed Tomato	3.3	8.5	5.6	2.2	93
Steamed Stuffed Bitter Gourd	2.7	8.2	6.4	5.8	92
Undhiyu	6.8	18.9	14.8	6.6	233

Table 13 Nutritive Values for (Pulse + Vegetable Product) (1 Small Bowl)[97], [98]

Patra: A light and nutritious dish with low calories, carbohydrates, and fats. It has minimal protein content and a moderate amount of fiber, making it a healthy choice for a light meal or snack.

Stuffed Brinjal: A rich and flavorful dish made with brinjal (eggplant) stuffed with spices. It offers a balance of carbs and proteins but is higher in fats, making it a more calorie-dense option.

Stuffed Tomato: This dish features tomatoes stuffed with a mixture of spices and vegetables. It is moderately rich in proteins and fats, with a good amount of carbs and fiber, providing a balanced and nutritious meal.

Steamed Stuffed Bitter Gourd: Bitter gourd stuffed with a variety of spices and steamed to perfection. This dish is high in fiber and has a moderate amount of proteins and fats, making it a nutritious and healthy option.

Undhiyu: A traditional Gujarati mixed vegetable dish cooked with various spices. It is rich in proteins, carbohydrates, and fats, and has a high fiber content, making it a filling and nutritious meal, though it is relatively high in calories.

Graphically represent the data showing the nutritional content of each item with separate bars for Proteins, Carbs, Fats, Fiber, and Calories for each type of (Pulse + Vegetable Product).

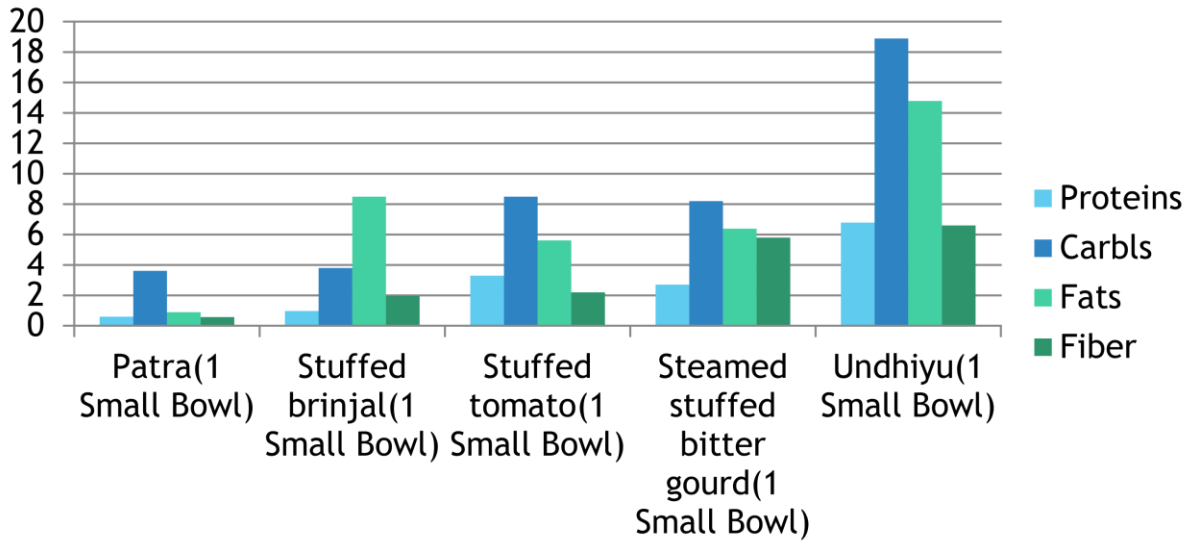

Figure 51 Nutritive Values for (Pulse + Vegetable Product) (1 Small Bowl)

Nutritive Values for (Cereal + Pulse + Vegetable Products) (1 Small Bowl) in Gujarati Cuisine

To ensure the development of personalized and nutritious diets for cardiac patients, the following table outlines the nutritional values of (Cereal + Pulse + Vegetable Products) in Gujarati cuisine. These values provide essential information about the content of proteins, carbohydrates, fats, fiber, and calories in each serving

Name	Proteins (g)	Carbs (g)	Fats (g)	Fiber (g)	Calories (Cal)
Vaghareli Khichadi	3.4	17.2	1.98	0.98	98

Table 14 Nutritive Values for (Cereal + Pulse + Vegetable Products) (1 Small Bowl)[97], [98]

Vaghareli Khichadi: This is a flavorful and nutritious dish made from a combination of rice, lentils, and vegetables, seasoned with various spices. It provides a balanced mix of proteins and carbohydrates with a moderate amount of fats and fiber. With only 98 calories per small bowl, it's a healthy and satisfying meal option.

Graphically represent the data showing the nutritional content of each item with separate bars for Proteins, Carbs, Fats, Fiber, and Calories for each type of (Cereal + Pulse + Vegetable Products).

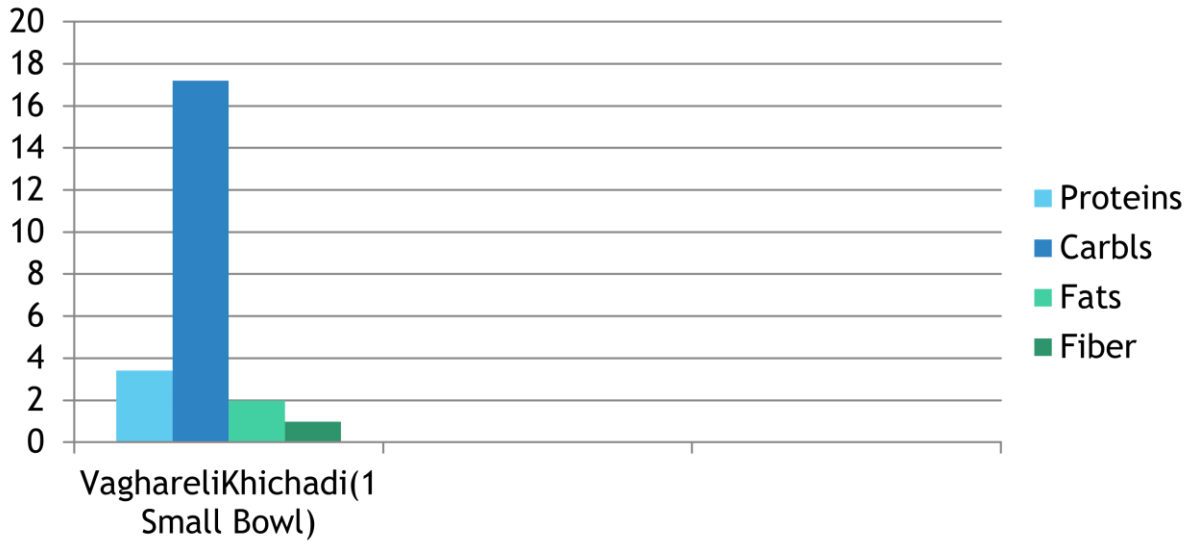

Figure 52 Nutritive Values for (Cereal + Pulse + Vegetable Products) (1 Small Bowl)

Nutritive Values for (Milk + Pulse Product) (1 Small Bowl) in Gujarati Cuisine

To ensure the development of personalized and nutritious diets for cardiac patients, the following table outlines the nutritional values of (Milk + Pulse Product) in Gujarati cuisine. These values provide essential information about the content of proteins, carbohydrates, fats, fiber, and calories in each serving

Name	Proteins (g)	Carbs (g)	Fats (g)	Fiber (g)	Calories (Cal)
Kadhi	2.98	5.3	5.2	0.9	78

Table 15 Nutritive Values for (Milk + Pulse Product) (1 Small Bowl)[97], [98]

Kadhi: Kadhi is a traditional Gujarati dish made from yogurt and gram flour (besan). It is usually flavored with spices such as turmeric and cumin, and sometimes includes vegetables. Kadhi is known for its tangy and savory taste. It provides a good amount of proteins and fats, along with moderate carbohydrates and fiber, making it a nourishing and comforting meal. With only 78 calories per small bowl, it's a light yet satisfying option.

Graphically represent the data showing the nutritional content of each item with separate bars for Proteins, Carbs, Fats, Fiber, and Calories for each type of (Milk + Pulse Product).

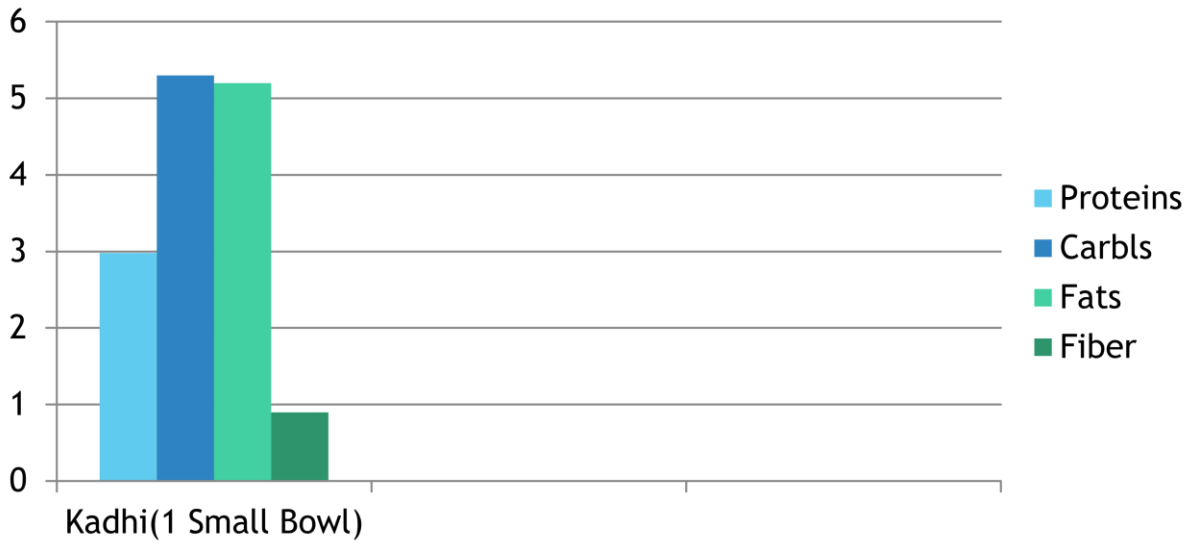

Figure 53 Nutritive Values for (Milk + Pulse Product) (1 Small Bowl)

Nutritive Value for (Oil Seeds Product) (1 Small Piece) in Gujarati Cuisine

To ensure the development of personalized and nutritious diets for cardiac patients, the following table outlines the nutritional values of (Oil Seeds Product) in Gujarati cuisine. These values provide essential information about the content of proteins, carbohydrates, fats, fiber, and calories in each serving

Name	Proteins (g)	Carbs (g)	Fats (g)	Fiber (g)	Calories (Cal)
Groundnut chikki	1.3	3.1	2.4	0.5	36
Black sesame seeds Chokki	2.9	15.2	10.5	2.3	157
Shingpak	2.3	5.8	4.7	0.9	70

Table 16 Nutritive Value for (Oil Seeds Product) (1 Small Piece)[97], [98]

Groundnut Chikki: Groundnut chikki is a popular sweet snack made from roasted peanuts and jaggery. This crunchy treat is high in fats and moderate in protein, providing quick energy. A small piece has just 36 calories, making it a light and tasty option for a quick snack.

Black Sesame Seeds Chokki: Black sesame seeds chokki is a sweet made from black sesame seeds and jaggery. Rich in proteins and fats, this snack offers a substantial calorie count of 157 per small piece, making it both nutritious and energy-dense. It's also high in fiber, contributing to digestive health.

Shingpak: Shingpak is another traditional sweet made from peanuts, sugar, and sometimes ghee. It is higher in fats and proteins compared to groundnut chikki, with a moderate amount of carbohydrates. Each small piece provides 70 calories, making it a hearty and satisfying snack option.

Graphically represent the data showing the nutritional content of each item with separate bars for Proteins, Carbs, Fats, Fiber, and Calories for each type of (Oil Seeds Product)

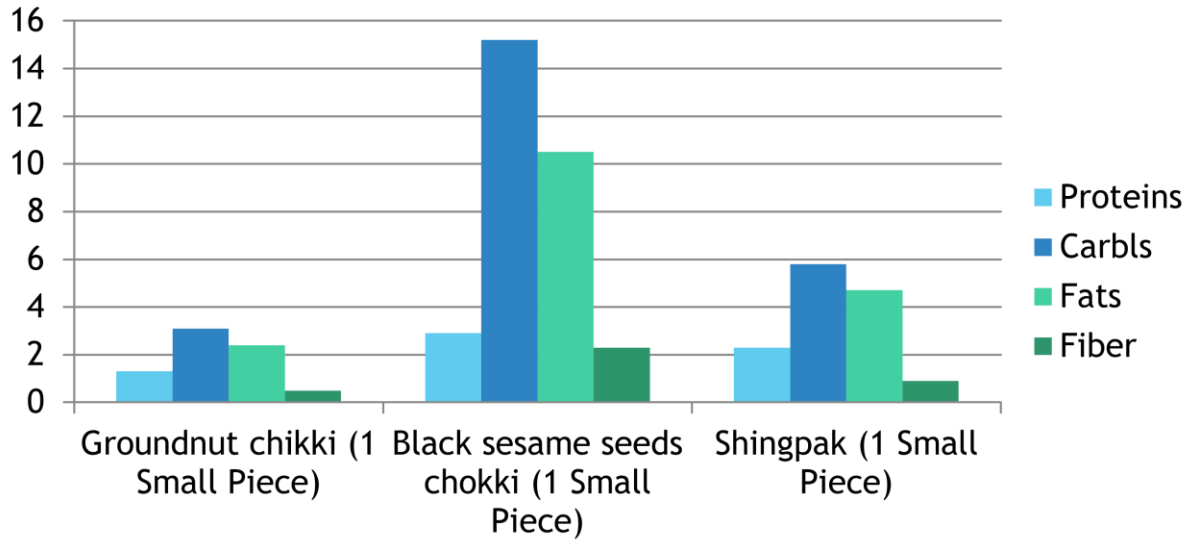

Figure 54 Nutritive Value for (Oil Seeds Product) (1 Small Piece)

4.2.2.1.2 Raw Fruits

In the context of a nutrition-based study, fruits play a pivotal role due to their rich content of essential vitamins, minerals, antioxidants, and dietary fiber. Fruits are nature's powerhouse, offering a wide range of nutrients that are crucial for maintaining optimal health. They are a significant source of vitamin C, potassium, and dietary fiber, which contribute to the prevention of chronic diseases such as heart disease, diabetes, and certain cancers. Consuming a variety of fruits ensures an intake of diverse phytonutrients, which have anti-inflammatory and immune-boosting properties. Additionally, the natural sugars in fruits provide a healthier alternative to refined sugars, making them an ideal component of a balanced diet. Including fruits in daily meals can improve digestion, support weight management, and enhance overall well-being. The following table presents the nutritive values of various fruits, highlighting their contribution to a nutritious diet.

Nutritive Value for (Raw Fruits) (1 Medium Size) in Gujarati Cuisine

To ensure the development of personalized and nutritious diets for cardiac patients, the following table outlines the nutritional values of (Raw Fruits) in Gujarati cuisine. These values provide essential information about the content of proteins, carbohydrates, fats, fiber, and calories in each serving

Name	Proteins (g)	Carbs (g)	Fats (g)	Fiber (g)	Calories (Cal)
Medium Apple	0.41	24.42	0.92	5.83	107
Medium Banana	1.32	27.53	0.32	2.04	117
Medium Pear	1.12	21.22	0.43	7.72	93
Pineapple	3.63	97.72	0.92	25.32	416
Plum	0.52	7.34	0.32	1.92	34
Sapota	0.42	12.82	0.73	6.52	59
Strawberry	0.12	1.23	0.0001	0.31	5
Watermelon Balls	0	0.41	0	0.1	2
Apricot Dried (1 P)	0.11	4.91	0.12	0.52	20
Avocado Fruit (Sliced)	4.31	2.62	20.21	9.82	211
Dragon Fruit	4.1	17.81	4.1	3.01	119
Cherries Red	1.12	14.23	0.52	1.61	66
Rose Apple	1.51	15.11	0.42	2.12	69
Dates, Processed	0.31	8.12	0.11	1.91	35
Fig	0.42	9.61	0.21	1.52	37
Gooseberry	0.11	3.52	0	0.41	14
Grapes Green	0	0.81	0	0.1	3
Grapes Black	0.11	1.12	0	0.21	5
Guava Pink Flesh	0.81	6.41	0.22	5.21	33
Guava White Flesh	1.81	10.1	0.72	3.81	48
Jambu Fruit Ripe	0	0.41	0	0.11	2
Litchi	0.11	1.61	0.12	0.12	6
Mandarin Orange	1.01	15.92	0.41	2.23	63
Orange	0.7	10.51	0.21	1.13	46

Papaya, Ripe	0.91	10.41	0.22	3.82	46
Mango	2.01	56.82	1.41	6.72	249
Chikoo	0.42	12.82	0.72	6.53	59
Muskmelon Fruit	0.51	5.61	0.32	1.31	27
Kiwi Fruit	0.81	10.12	0.41	2.12	42
Pomegranate	4.71	52.72	3.32	11.31	234

Table 17 Nutritive Value for (Raw Fruits) (1 Medium Size)[97], [98]

Medium Apple: Apples are a rich source of dietary fiber and vitamin C. They are known for their ability to reduce cholesterol and promote heart health.

Medium Banana: Bananas provide a quick energy boost and are packed with potassium and vitamin B6, supporting muscle function and hydration.

Medium Pear: Pears are highly nutritious, offering significant dietary fiber which aids in digestion and helps maintain healthy blood sugar levels.

Pineapple: Pineapples are rich in vitamin C and bromelain, an enzyme that aids in digestion and reduces inflammation.

Plum: Plums are low in calories and rich in vitamins, minerals, and antioxidants, which help improve digestive health.

Sapota: Also known as chikoo, this fruit is high in dietary fiber and essential vitamins, promoting digestive health and boosting immunity.

Strawberry: Strawberries are low in calories but high in vitamin C and antioxidants, supporting immune function and skin health.

Watermelon Balls: Watermelon is hydrating and contains vitamins A and C, which are beneficial for skin health and hydration.

Apricot Dried: Dried apricots are a concentrated source of nutrients including fiber, vitamins A and C, and potassium, promoting overall health.

Avocado Fruit (Sliced): Avocados are high in healthy fats, particularly monounsaturated fats, which are good for heart health. They are also rich in fiber and various vitamins.

Dragon Fruit: Dragon fruits are rich in antioxidants, fiber, and vitamin C, supporting immune function and digestion.

Cherries Red: Cherries are high in antioxidants and anti-inflammatory compounds, beneficial for reducing muscle soreness and promoting heart health.

Rose Apple: Rose apples are rich in vitamin C and dietary fiber, which help boost immunity and improve digestion.

Dates, Processed: Processed dates are an excellent source of natural sugars, fiber, and various essential minerals, providing quick energy and digestive benefits.

Fig: Figs are high in fiber and essential minerals such as magnesium and calcium, supporting digestive health and bone strength.

Gooseberry: Gooseberries are low in calories but rich in vitamins C and A, supporting immune function and skin health.

Grapes Green: Green grapes are a good source of vitamins K and C, providing antioxidant and anti-inflammatory benefits.

Grapes Black: Black grapes are rich in antioxidants, particularly resveratrol, which supports heart health.

Guava Pink Flesh: Pink-fleshed guavas are high in fiber and vitamin C, promoting healthy digestion and boosting immunity.

Guava White Flesh: White-fleshed guavas offer a good amount of fiber and vitamin C, aiding in digestion and immune support.

Jambu Fruit Ripe: Ripe jambu fruits are hydrating and provide essential vitamins and minerals, supporting overall health.

Litchi: Litchis are rich in vitamin C and various antioxidants, supporting immune function and skin health.

Mandarin Orange: Mandarin oranges are packed with vitamin C and fiber, promoting immune health and digestion.

Orange: Oranges are well-known for their high vitamin C content, supporting immune function and skin health.

Papaya, Ripe: Ripe papayas contain digestive enzymes, fiber, and vitamins, which aid in digestion and boost immunity.

Mango: Mangoes are rich in vitamins A and C, supporting skin health and boosting immunity.

Chikoo: Chikoos are high in dietary fiber and vitamins, promoting digestive health and boosting immune function.

Muskmelon Fruit: Muskmelons are low in calories but rich in vitamins A and C, supporting hydration and skin health.

Kiwi Fruit: Kiwis are rich in vitamin C, fiber, and antioxidants, promoting immune function and digestive health.

Pomegranate: Pomegranates are loaded with antioxidants, fiber, and vitamins, supporting heart health and reducing inflammation.

Graphically represent the data showing the nutritional content of each item with separate bars for Proteins, Carbs, Fats, Fiber, and Calories for each type of Raw Fruits.

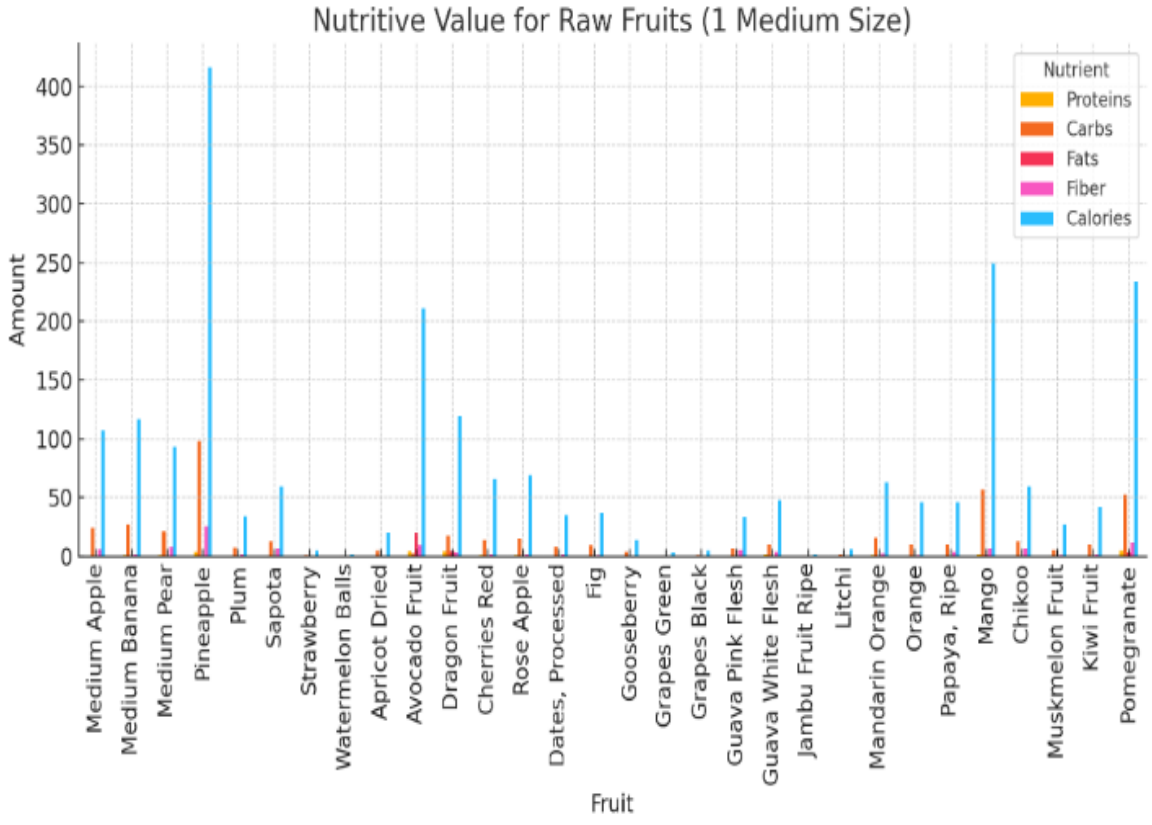

Figure 55 Nutritive Value for (Raw Fruits) (1 Medium Size)

4.3 Data Analysis

4.3.1 Introduction to Data Analysis

Data analysis is a crucial phase in research process, as it involves systematically applying statistical and logical techniques to describe and evaluate data. For researcher's study, which focuses on cardiac patients' dietary habits and nutritional needs, data analysis enables us to extract meaningful insights from the collected data, identify patterns, and make informed recommendations. Through a combination of various algorithms and models, we aim to understand the dietary preferences of cardiac patients and assess the nutritional values of different food items, particularly those prevalent in Gujarati cuisine.

4.3.1.1 Overview of Data Analysis Process

The data analysis process in this research is comprehensive and complex. It begins with data cleaning and preprocessing, where we ensure the integrity and quality of our data. This step involves handling missing values, removing duplicates, and normalizing data. Next, we conduct Exploratory Data Analysis (EDA) to uncover initial patterns, relationships, and anomalies in the data. EDA includes descriptive statistics and visualizations that help in understanding the distributions and correlations among variables.

Following EDA, we employ various classification and modelling techniques to predict outcomes and generate recommendations. Specifically, we use nine different algorithms: Baseline, KNN Basic, KNN Z-Score, Co-Clustering, NMF, SVD, SVD++, Slope One, and KNN with Means. Each algorithm offers unique strengths and insights, allowing us to compare their performance and effectiveness. Additionally, we use Random Forest and create a hybrid model, known as NBRS (Nutrition-Based Recommender System), to enhance the accuracy and reliability of our recommendations. The NBRS model works in three categories based on the details of cardiac patients: popularity-based recommendations, personalized recommendations based on the researcher's model, and recommendations for new users.

4.3.1.2 Importance of Data Analysis in Research

Data analysis is vital in research for several reasons. It allows researchers to test hypotheses, validate assumptions, and derive conclusions based on empirical evidence. In this research, data analysis is particularly important because it helps us understand the complex dietary patterns of cardiac patients and the nutritional impact of various food items. By applying advanced algorithms and models, we can provide tailored dietary recommendations that may improve the health outcomes of cardiac patients.

Moreover, data analysis enhances the credibility and reliability of our findings. Using a robust analytical framework, we can ensure that our recommendations are based on rigorous scientific methods. This is especially important in the healthcare field, where evidence-based recommendations can significantly impact patient care and treatment outcomes. Through our detailed data analysis process, we aim to contribute valuable insights to the field of nutrition and cardiac health, ultimately benefiting patients and healthcare.

4.3.2 Data Cleaning and Preprocessing

Data cleaning and preprocessing are critical steps in preparing our dataset for analysis. In this research, these steps ensure that the data used for modeling is accurate, consistent, and suitable for the algorithms employed. This section outlines the key techniques used in data cleaning, including handling missing values, removing duplicates, and normalizing data.

4.3.2.1 Data Cleaning Techniques

Data cleaning involves detecting and correcting errors and inconsistencies in the data to improve its quality. In our research, we implemented various techniques to clean the data collected from cardiac patients regarding their dietary preferences and nutritional information. These techniques are crucial for ensuring that the analysis results are reliable and valid.

4.3.2.2 Handling Missing Values

Missing values can significantly affect the performance of machine learning models. Therefore, it is essential to address them appropriately. In our dataset, missing values were handled by imputing the median for numerical columns and the mode for categorical columns. This approach helps in maintaining the integrity of the data without introducing significant biases.

Code Example:

```python
# Handling missing values
data.fillna(data.median(), inplace=True)
data.fillna(data.mode().iloc[0], inplace=True)
```

Figure 56 Handling Missing Values [Code of Python]

4.3.2.3 Removing Duplicates

Duplicates in the dataset can lead to overfitting and misleading results. We identified and removed duplicate entries to ensure that each data point is unique and contributes meaningfully to the analysis.

Code Example:

```python
# Removing duplicates
data.drop_duplicates(inplace=True)
```

Figure 57 3.6.2.3 Removing Duplicates [Code of Python]

4.3.2.4 Data Normalization and Transformation

Normalization and transformation are essential steps to scale the data and convert it into a suitable format for analysis. Normalization ensures that all features contribute equally to the model, preventing any single feature from disproportionately influencing the results.

Code Example:

```python
# Normalizing the data
from sklearn.preprocessing import StandardScaler

scaler = StandardScaler()
data[['age', 'height', 'weight']] = scaler.fit_transform(data[['age', 'height', 'weight']]
```

Figure 58 Data Normalization and Transformation [Code of Python]

In this research, the normalization process included scaling the age, height, and weight of cardiac patients. This step was crucial to ensure that these features were on a comparable scale, facilitating more effective analysis and modeling.

4.3.3 Data Classification and Modeling

Data classification and modeling are key steps in transforming raw data into meaningful insights. This involves selecting appropriate algorithms, training and testing models, and evaluating their performance using various metrics. In this research, researcher apply multiple algorithms to build robust models for predicting cardiac patients' dietary preferences and nutritional needs.

4.3.3.1 Selection of Classification Algorithms

Choosing the right classification algorithm is crucial for building effective models. For our research, we implemented the following algorithms

Sr. No.	Algorithm Name
1	BaselineOnly
2	KNN Basic
3	KNN With Z-Score
4	Co-Clustering
5	NMF (Non-Negative Matrix Factorization)
6	SVD (Singular Value Decomposition)
7	SVD++
8	SlopeOne
9	KNNWithMeans
10	Random Forest (Hybrid Model)

Table 18 List of Classification Algorithms

These algorithms were chosen to provide a comprehensive analysis, each offering unique advantages for capturing different aspects of the data.

4.3.3.2 Model Training and Testing

Once the algorithms are selected, the next step is to train and test the models. The dataset is split into training and testing sets to validate the model's performance on unseen data. The Surprise library in Python was used to implement and test these algorithms.

4.3.3.3 Evaluation Metrics for Model Performance

To assess the performance of the models, we use several evaluation metrics. These metrics help us understand how well the models predict the actual outcomes and identify areas for improvement.

Key Metrics:

Mean Squared Error (MSE), Root Mean Squared Error (RMSE) & R-Squared (R^2)

4.3.3.4 Mean Squared Error (MSE)

Mean Squared Error measures the average of the squares of the errors. It represents the difference between the predicted and actual values.

Code Example:

```python
mse = recmetrics.mse(test_df.actual, test_df.predictions)
print(f"MSE: {mse}")
```

Figure 59 Mean Squared Error (MSE) [Code of Python]

4.3.3.5 Root Mean Squared Error (RMSE)

Root Mean Squared Error is the square root of MSE. It provides an estimate of the standard deviation of the prediction errors.

Code Example:

```python
rmse = recmetrics.rmse(test_df.actual, test_df.predictions)
print(f"RMSE: {rmse}")
```

Figure 60 Root Mean Squared Error (RMSE) [Code of Python]

4.3.3.6 R-Squared (R^2)

R-squared, or the coefficient of determination, indicates the proportion of the variance in the dependent variable that is predictable from the independent variables.

Code Example:

```python
r2 = r2__score(test_df.actual, test_df.predictions)
print(f"R-Squared (R²): {r2}")
```

Figure 61 R-Squared (R^2) [Code of Python]

By applying these algorithms and evaluation metrics, we aim to develop a robust model that accurately predicts the nutritional preferences of cardiac patients, aiding in personalized dietary recommendations and improved health.

4.3.4 Visualization of Results

Visualizing the results of our analysis is critical in understanding the outcomes and deriving meaningful insights. This section will cover the graphical representation of our findings, the comparison between actual and predicted ratings, and visual insights from the recommender systems. Additionally, we will present user preferences for Gujarati food items based on ratings collected through Google Forms and physical surveys.

4.3.4.1 Graphical Representation of Findings

Graphical representations are essential tools for summarizing and communicating research findings. In this research, various charts and graphs were utilized to depict the food preferences of cardiac patients. These visualizations provide a clear overview of the data, making it easier to identify patterns and trends. The graphical representation of the data for rating of food preferences is Shawn as the following:

Gender Distribution

A pie chart displayed the gender distribution of the cardiac patients who participated in the study. This chart helps in understanding the proportion of male and female participants.

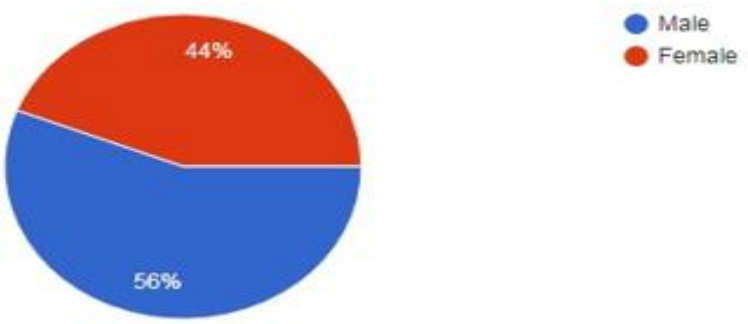

Figure 62 Gender Distribution based on Google Form Survey

Work Criteria

The distribution of work criteria among the cardiac patients was depicted using a bar chart. This chart helps in understanding the different levels of activity of the participants.

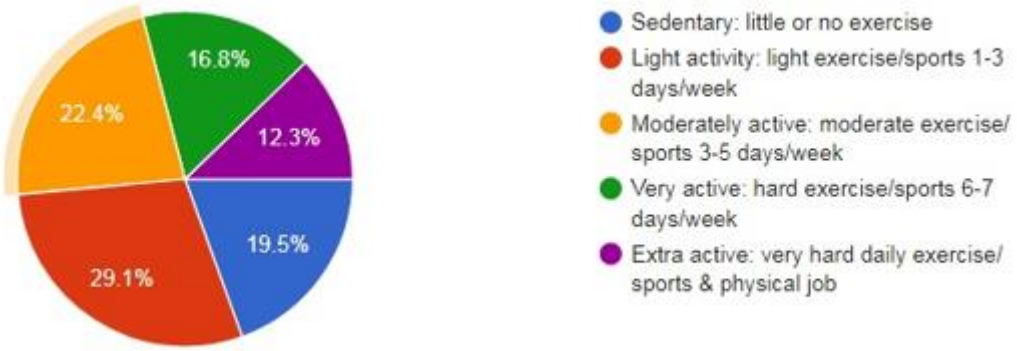

Figure 63 Work Criteria Distribution based on Google Form Survey

Food Preferences for 90+ Different Food Items

For each of the 15 food items tables, a separate pie chart was created to display the rating distribution from 1 to 10. This helps in understanding the specific preferences for each food item among cardiac patients.

Figure 64 Main Meal User Preference Based on Google Form Survey

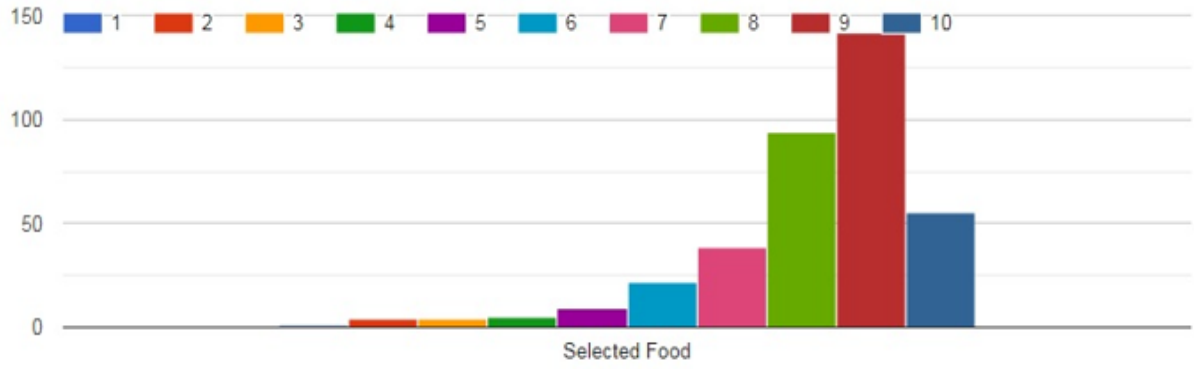

Figure 65 Main Meal Rating of Food Preference Based on Google Form Survey

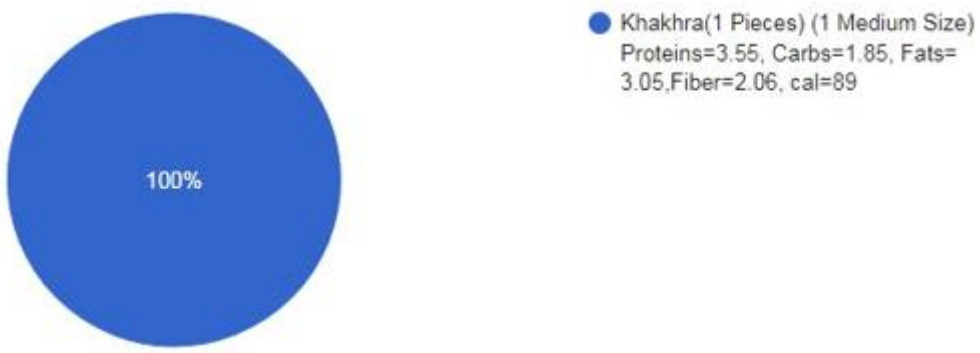

Figure 66 Dry Snack User Preference Based on Google Form Survey

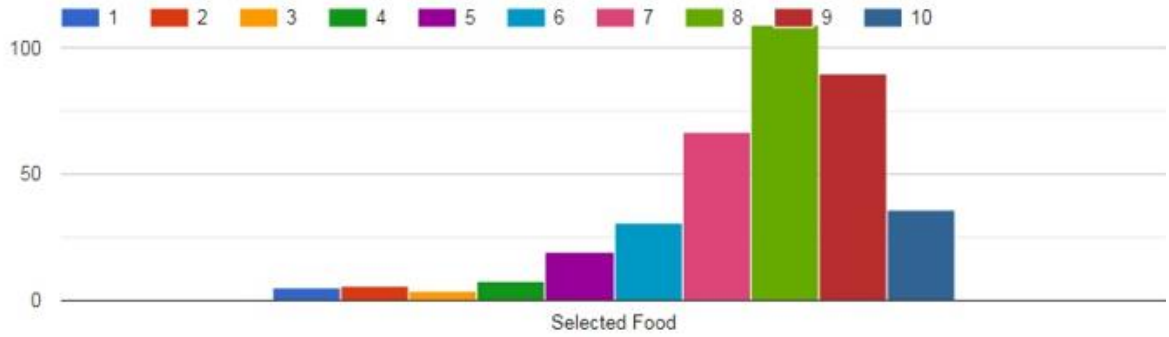

Figure 67 Dry Snack Rating of Food Preference Based on Google Form Survey

Figure 68 Main Meal (Dal & Subji) User Preference Based on Google Form Survey

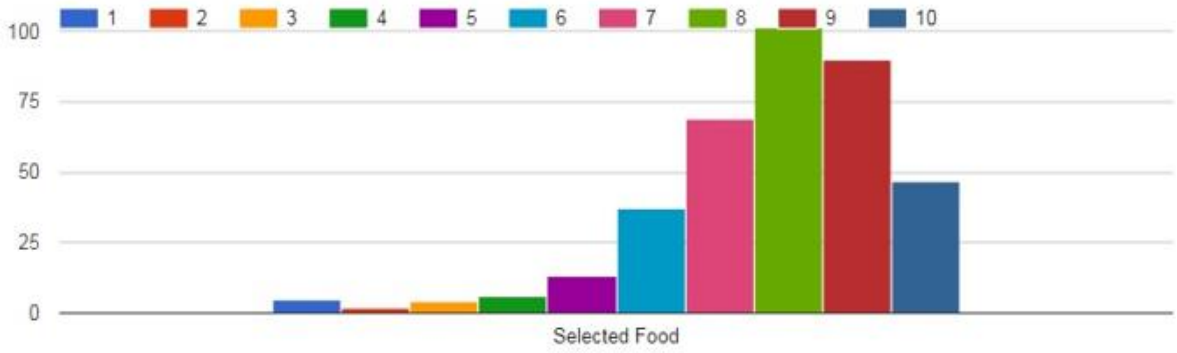

Figure 69 Main Meal (Dal & Subji) Rating of Food Preference Based on Google Form Survey

Figure 70 Snacks User Preference Based on Google Form Survey

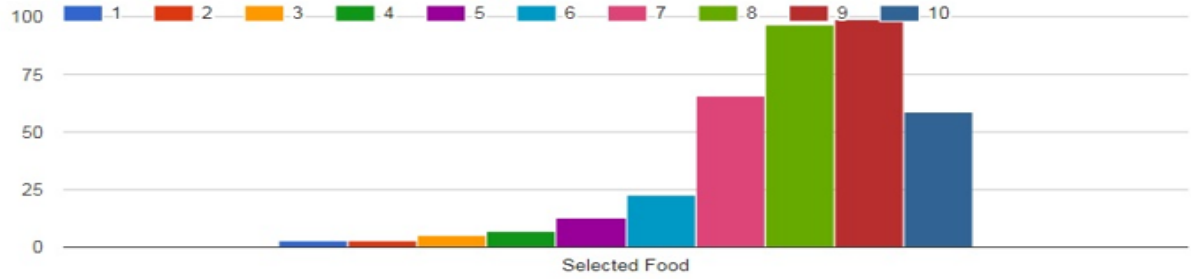

Figure 71 Snacks Rating of Food Preference Based on Google Form Survey

Figure 72 Leafy Vegetables User Preference Based on Google Form Survey

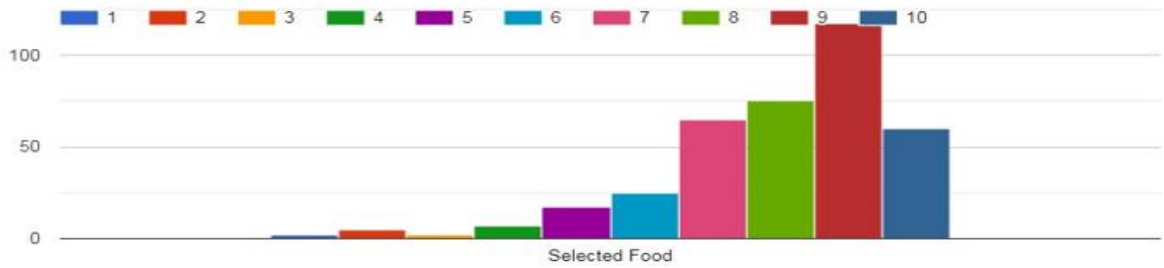

Figure 73 Leafy Vegetables Rating of Food Preference Based on Google Form Survey

Figure 74 Other Vegetables User Preference Based on Google Form Survey

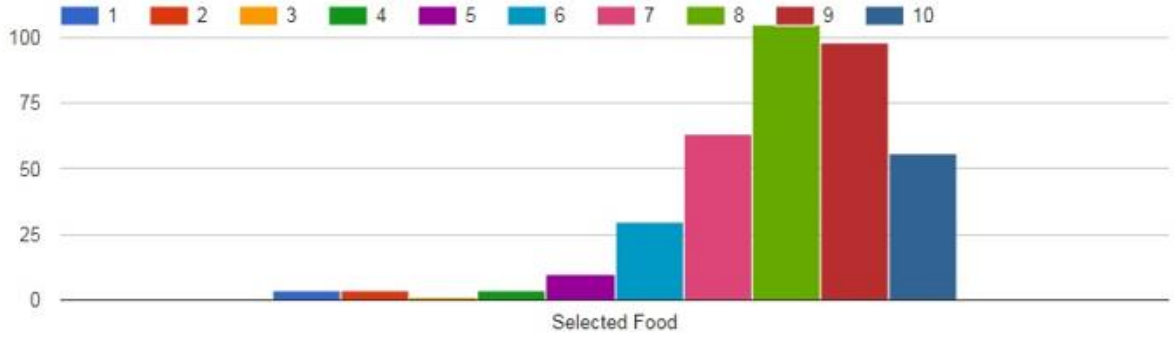

Figure 75 Other Vegetables Rating of Food Preference Based on Google Form Survey

Figure 76 Sambhara User Preference Based on Google Form Survey

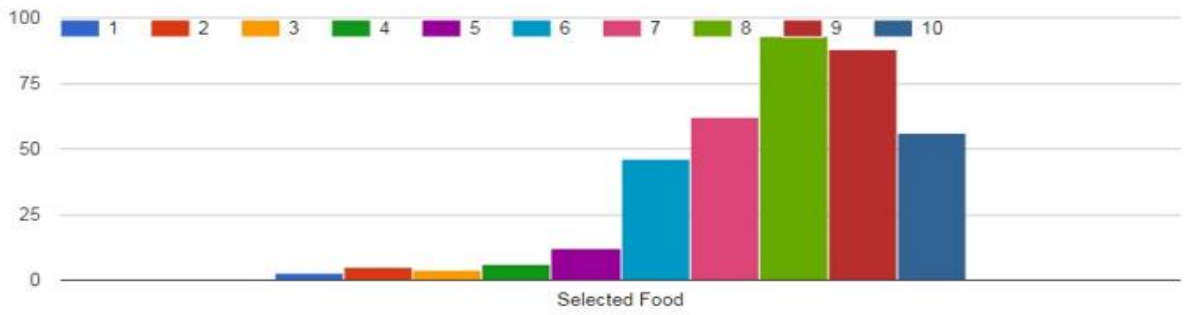

Figure 77 Sambhara Rating of Food Preference Based on Google Form Survey

Figure 78 Milk Product User Preference Based on Google Form Survey

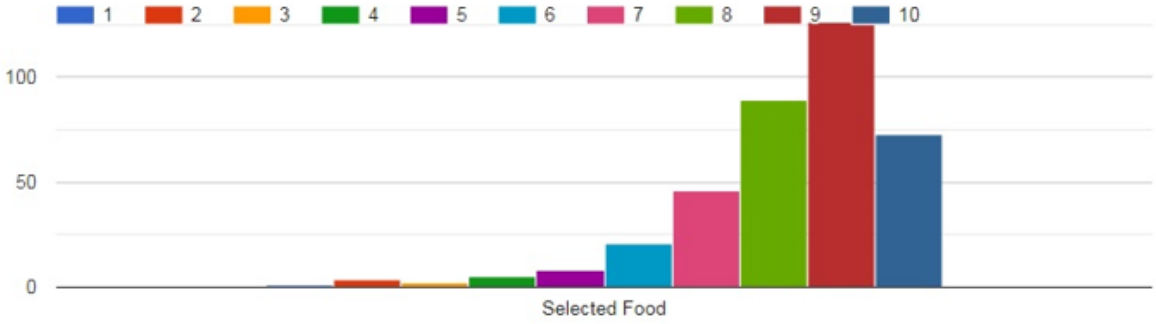

Figure 79 Milk Product Rating of Food Preference Based on Google Form Survey

Figure 80 (Cereal + Pulse) Product User Preference Based on Google Form Survey

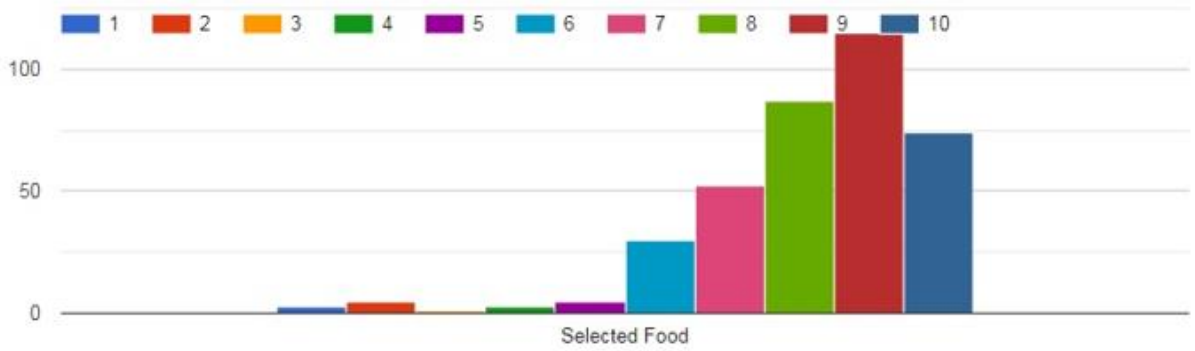

Figure 81 (Cereal + Pulse) Product Rating of Food Preference Based on Google Form Survey

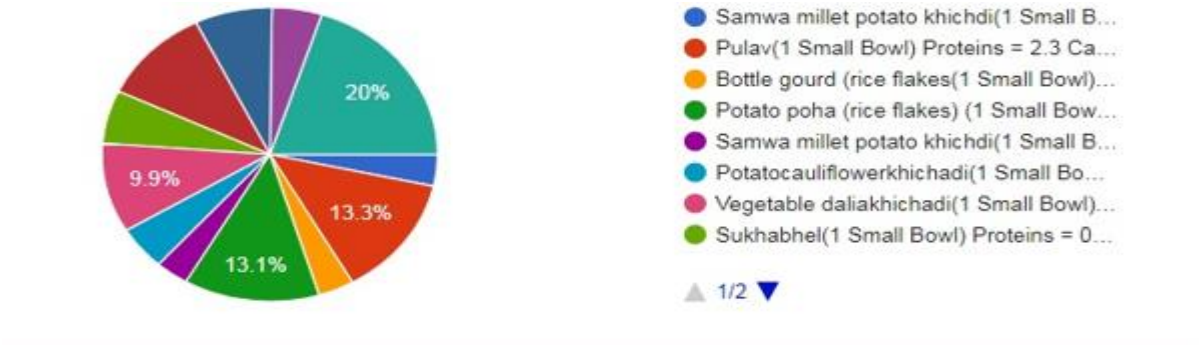

Figure 82 (Cereal + Vegetable) Product User Preference Based on Google Form Survey

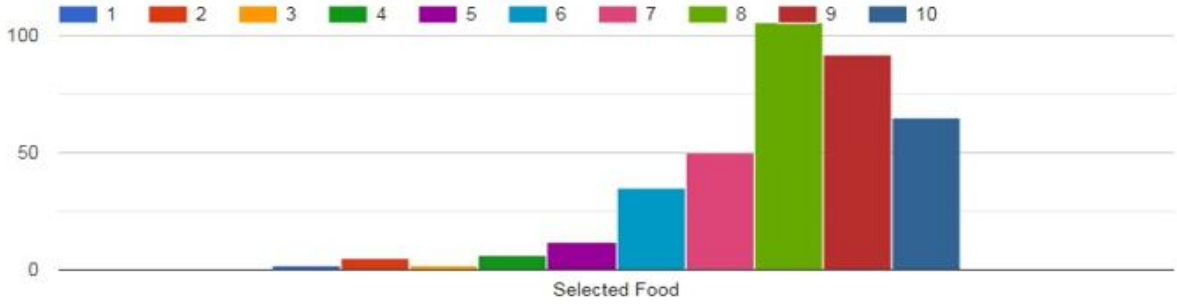

Figure 83 (Cereal + Vegetable) Product Rating of Food Preference Based on Google Form Survey

Figure 84 (Pulse + Vegetable) Product User Preference Based on Google Form Survey

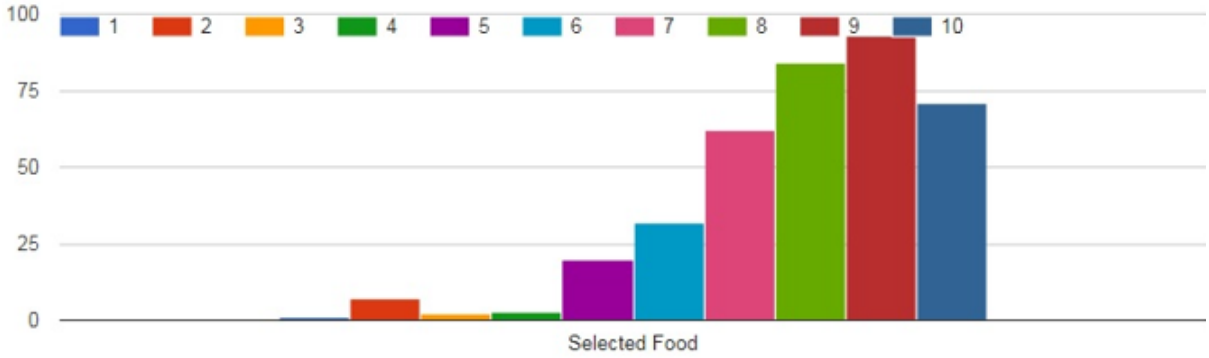

Figure 85 (Pulse + Vegetable) Product Rating of Food Preference Based on Google Form Survey

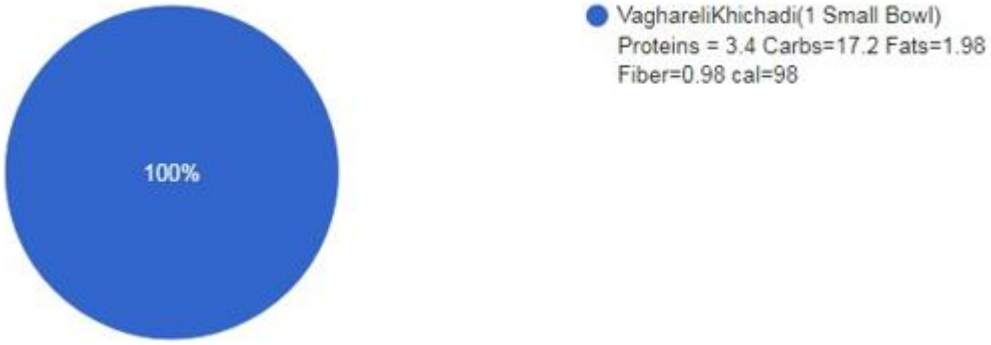

Figure 86 (Cereal + Pulse + Vegetable) Product User Preference Based on Google Form Survey

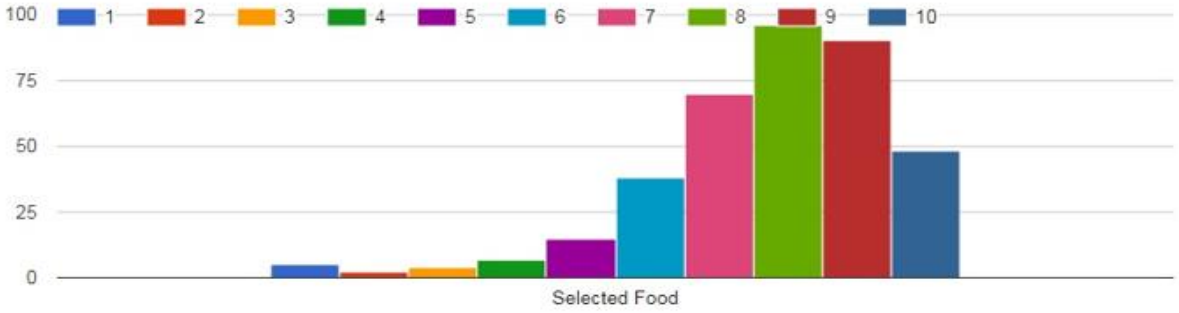

Figure 87 (Cereal + Pulse + Vegetable) Product Rating of Food Preference Based on Google Form Survey

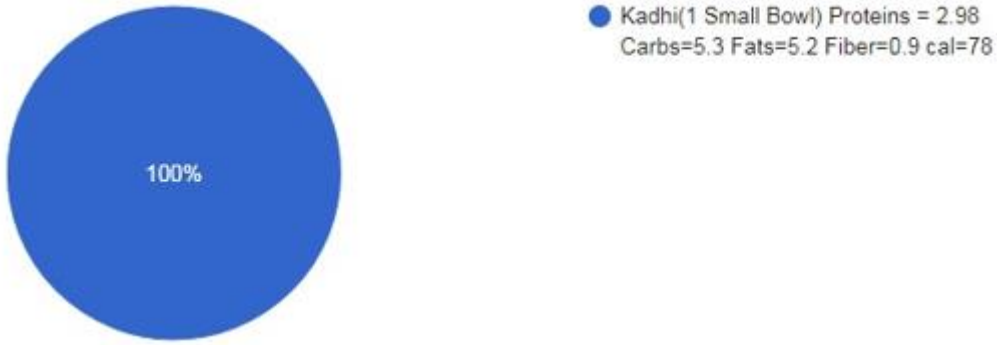

Figure 88 (Milk + Pulse) Product User Preference Based on Google Form Survey

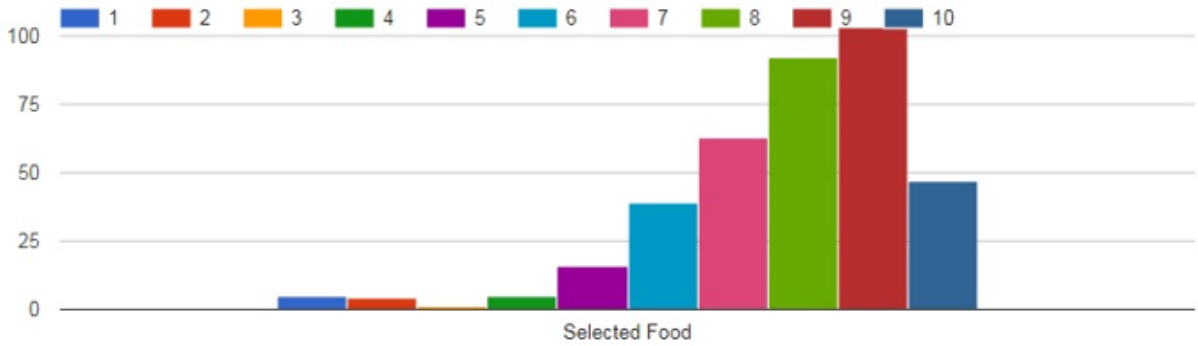

Figure 89 (Milk + Pulse) Product Rating of Food Preference Based on Google Form Survey

Figure 90 Oil Seeds Product User Preference Based on Google Form Survey

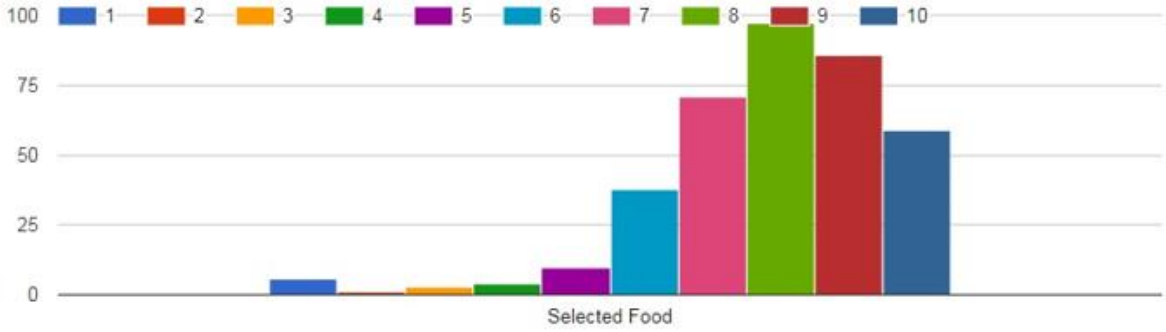

Figure 91 Oil Seeds Product Rating of Food Preference Based on Google Form Survey

Figure 92 Raw Fruits User Preference Based on Google Form Survey

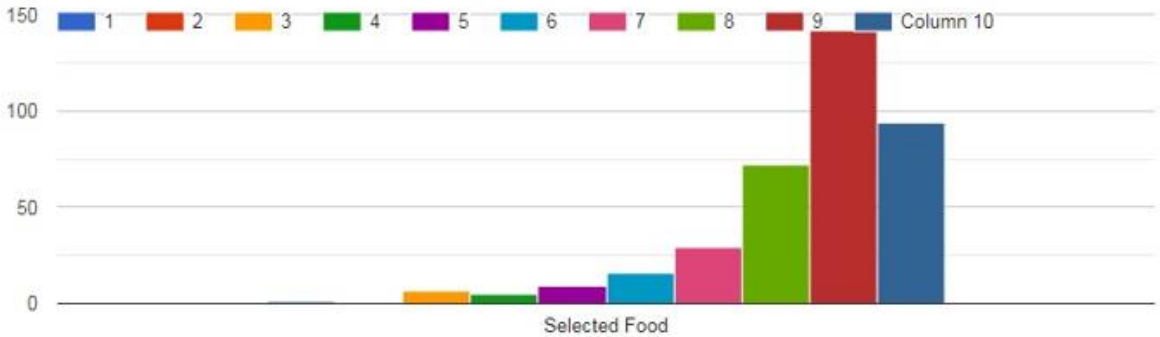

Figure 93 Raw Fruits Rating Based on Google Form Survey

4.4 Tools Used

In this research, the researcher utilized a combination of advanced web development and machine learning tools to create a comprehensive dietary recommendation system for cardiac patients. For the front-end development, we employed the Django framework, known for its high-level, easy-to-use features that support rapid development and a clean, pragmatic design. Django facilitated the creation of a user-friendly interface for data collection, ensuring a seamless user experience. On the back end, we leveraged Python and its powerful machine-learning libraries, including Scikit-learn, Pandas, NumPy, and Surprise. These tools enabled us to preprocess data, train various predictive models, and evaluate their performance. Multiple algorithms such as Baseline, KNN Basic, KNN with Means, KNN with Z-Score, Co-Clustering, NMF, SVD, SVD++, and SlopeOne were implemented and tested. Additionally, a hybrid model named NBRS (Nutrition-Based Recommender System) was developed to provide personalized dietary recommendations, combining collaborative filtering, popularity-based, and new-user recommendation approaches. This integration of Django for the front end and robust machine learning tools for the back end ensured the system was scalable, efficient, and capable of delivering accurate, real-time dietary recommendations.

4.4.1 Utilization of Django Framework for Front-End Development

This research employed the Django framework for front-end development due to its versatility and ease of use. Django, a high-level Python web framework, encourages rapid development and clean, pragmatic design. Its comprehensive nature allows developers to build robust web applications with minimal effort. By leveraging Django’s powerful built-in features, such as the admin interface, ORM (Object-Relational Mapping), and templating engine, we efficiently managed the user interface and interactions.

The front-end interface was designed to facilitate data collection from cardiac patients, allowing them to input their details, daily activities, and food preferences. The user-friendly forms created using Django's form-handling capabilities ensured that the data collection process was seamless and straightforward for users. This data was then stored securely in the database for further analysis.

4.4.2 Utilization of Machine Learning Techniques & Tools for Back-End Development

For the back-end development, various machine-learning techniques and tools were utilized to analyze the collected data and generate dietary recommendations for cardiac patients. The

primary tool used was Python, alongside several machine learning libraries including Scikit-learn, Pandas, NumPy, and Surprise. These libraries provided the necessary functions and algorithms to preprocess the data, train models, and evaluate their performance.

Multiple machine learning algorithms were implemented to predict the dietary needs of cardiac patients based on their BMR, activity level, and food preferences. Algorithms such as Baseline, KNN Basic, KNN with Means, KNN with Z-Score, Co-Clustering, NMF, SVD, SVD++, and SlopeOne were evaluated. A hybrid model named NBRS (Nutrition-Based Recommender System) was also developed to provide personalized dietary recommendations. This hybrid model combined the strengths of collaborative filtering, popularity-based, and new-user recommendation approaches to enhance the accuracy and relevance of the predictions.

The machine learning models were integrated with the front end using Django's powerful integration capabilities. This allowed the seamless presentation of personalized dietary recommendations to the users based on analyzing their inputs. The entire system was designed to be scalable, efficient, and easy to maintain, ensuring that it could handle a large volume of data and provide accurate predictions in real time.

4.5 Conclusion

In conclusion, three detailed the comprehensive methodology employed in this research. It outlined the processes of data collection, preprocessing, and classification, emphasizing the hybrid model approach that integrated various machine learning algorithms to enhance prediction accuracy. The use of the Django framework for front-end development and advanced machine learning techniques for back-end processing demonstrated a robust and scalable system. This methodology ensured reliable, personalized dietary recommendations for cardiac patients, contributing significantly to the field of nutrition-based healthcare solutions.