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Fuzzy Logic Driven Nutrition-based Recommendation System for Gujarati Cardiac Patients: Integrating Cultural Preferences and Patient Feedback

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Abstract

This article focuses on developing a comprehensive dataset for accurate dietary recommendations tailored to Gujarati cardiac patients' needs. The dataset comprises nutritional details of over 90 Gujarati food and fruit products, meticulously collected through primary and secondary data collection methods. Each food item's nutritive values, including proteins, carbohydrates, fats, fiber, and calories, are meticulously recorded to facilitate precise dietary recommendations. The dataset integrates cultural preferences and seasonal variations in food availability to ensure relevance and adherence to dietary guidelines. Additionally, the research incorporates feedback from cardiac patients, who rate food preferences on a scale of 1 to 10, enhancing the dataset's accuracy and relevance. By leveraging this rich dataset, the research aims to develop an effective recommendation system that provides personalized and culturally sensitive dietary guidance to improve the cardiac health management of Gujarati patients.

Keyword: Nutrition-based recommendation system, fuzzy logic, Gujarati cuisine, cardiac patients, dietary management, cultural preferences, personalized recommendations, nutritive values, dataset, feedback integration

INTRODUCTION

Cardiovascular diseases (CVDs) remain a significant health concern globally, with a substantial burden on populations worldwide. In regions like Gujarat, India, where cultural dietary preferences play a pivotal role in daily food choices, effective management of CVDs requires personalized dietary recommendations tailored to the local context. This paper presents a novel approach to addressing this challenge by developing a fuzzy logic-driven nutrition-based recommendation system (NBRS) for Gujarati cardiac patients.

The proposed NBRS model aims to provide accurate and culturally sensitive dietary recommendations based on individual patient characteristics, such as age, weight, height, blood pressure, and gender. Leveraging a comprehensive dataset comprising nutritional details of over 90 Gujarati food and fruit products, the model integrates fuzzy logic techniques to account for the inherent uncertainties and complexities in dietary recommendations.

Furthermore, the dataset incorporates feedback from cardiac patients, who rate food preferences on a scale of 1 to 10, enhancing the model's accuracy and relevance. By integrating cultural preferences, seasonal variations in food availability, and patient feedback, the NBRS model offers personalized dietary guidance that aligns with the specific health needs and cultural practices of Gujarati cardiac patients. Through this article, we aim to contribute

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to the advancement of personalized dietary management strategies for CVDs in Gujarat, ultimately improving patient outcomes and reducing the burden of cardiovascular diseases on the population.

LITERATURE REVIEW

This review underscores the necessity for tailored post-cardiac arrest care in patients undergoing extracorporeal cardiopulmonary resuscitation (ECPR), emphasizing the need for further research. It highlights the importance of optimizing management strategies, establishing physiological targets, refining prognostication tools, and addressing ethical considerations to standardize post–cardiac arrest intensive care unit (ICU) management in ECPR [1]. This comprehensive review elucidates the pivotal role of a balanced diet in bolstering the immune system and preventing various diseases, contrasting it with the detrimental effects of poor dietary choices like the Western diet. Highlighting the influence of gut microbiota, the paper underscores the importance of incorporating polyphenols and probiotics from natural sources to promote gut health. It provides valuable insights into the interplay between diet, gut health, and the risk of obesity and inflammatory diseases, advocating for standardized research methods and practical dietary recommendations for improved public health outcomes [2].

The cross-sectional study by Murayama [3] delves into the impact of industry-sponsored meal payments on the prescribing patterns of brand-name colchicines among Medicare physicians from 2014 to 2021. Findings reveal a significant association between receiving meal payments and increased likelihood of prescribing both Colcrys and Mitigare, along with elevated Medicare expenditures. The study underscores potential implications of such interactions on prescribing behavior and healthcare costs, warranting further examination and potential regulatory interventions [3]. This paper introduces a novel recommendation system, K-DLRS, which employs k-clique embedded deep learning classifiers to suggest personalized diets for patients based on their health conditions and nutritional needs. By integrating k-clique into the deep learning framework, the system aims to enhance precision and accuracy in diet recommendations. Empirical analysis utilizing patient and product datasets demonstrates superior performance compared to traditional machine learning techniques and other deep learning classifiers, highlighting the potential of K-DLRS in improving healthcare recommendations [4].

This paper presents a deep learning-driven solution for personalized diet recommendations based on patient health data, leveraging features such as age, gender, and nutritional parameters. By employing various machine and deep learning algorithms, including logistic regression and long short-term memory (LSTM), the study aims to enhance the accuracy and effectiveness of diet recommendations. Results indicate that LSTM outperforms other techniques, achieving high accuracy and precision in predicting suitable diets for patients, demonstrating promising potential for improving healthcare through artificial intelligence (AI)-driven dietary guidance [5]. This article addresses the crucial issue of inadequate dietary intake and its impact on health, emphasizing the necessity for precise dietary recommendations, especially for patients with medical conditions. Introducing Diet-Right, a cloud-based food recommendation system utilizing ant colony algorithm, the paper proposes a promising solution to optimize diet selection based on pathological reports. Experimental results demonstrate the system's efficiency and potential in improving disease management through personalized dietary guidance, showcasing notable advancements in convergence time and accuracy through cloud-based parallel execution [6].

This project addresses the pressing need for personalized dietary interventions to combat non-communicable diseases, leveraging internet technologies to overcome challenges in delivering effective dietary recommendations. By utilizing a validated Food Frequency Questionnaire (FFQ) and incorporating individual preferences, population data, and expert knowledge, the proposed recommender system aims to provide tailored nutrition advice at scale. The study's design, including an online randomized control trial (RCT) and expert surveys, promises to provide valuable insights into the efficacy and usability of personalized dietary recommendations in improving population-level diet quality [7].

This paper emphasizes the importance of healthy eating habits in preventing and managing various health conditions, particularly among children and young people for cognitive development. It explores

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the landscape of applications aimed at promoting healthy behaviors, with a focus on those providing healthy meal recommendations. The paper highlights the challenges in eliciting food preferences effectively, addressing limitations in existing approaches such as on-boarding surveys and food journaling, crucial for developing personalized and effective healthy eating recommendations [8]. This paper explores the realm of personalized recommendation systems, focusing on optimization techniques like ant colony and particle swarm optimization to enhance accuracy and user satisfaction. Through theoretical analysis on web page recommendation and practical experimentation using diabetic patient health records, the study demonstrates the superiority of particle swarm optimization in suggesting appropriate nutrition for improving health outcomes, showcasing improved performance and accuracy compared to traditional methods [9].

This paper introduces MIKAS (menu construction using an incremental knowledge acquisition system), a novel menu construction system utilizing case-based reasoning (CBR) with incremental knowledge acquisition to tailor diets for individual client needs in hospitals and healthcare settings. Through expert-user interaction, MIKAS dynamically improves its competency over time, automating manual modifications made by dietitians and incorporating them into its knowledge base. Evaluation studies indicate its potential to enhance daily routine for dietitians, improve dietary advice quality, and pave the way for more cost-effective, specialized CBR systems in healthcare [10].

This paper addresses the challenge of navigating through abundant and potentially conflicting nutritional information on the web, particularly concerning the elderly population. It introduces NutElCare, an ontology-based recommender system designed to extract and represent relevant nutritional information from expert sources, enhancing the reliability and completeness of nutrition tips. Utilizing semantic similarity computation and an OWL (web ontology language) ontology built from AGROVOC FAO thesaurus, NutElCare offers a promising solution to provide tailored and reliable nutritional guidance for the elderly, addressing the complexities of knowledge sharing in the field of nutrition [11].

This paper introduces an expert system prototype focusing on nutrition and diet domains, developed using rules-based system techniques. Through knowledge elicitation from domain experts and recommended websites, the system organizes inputs, rules, and outputs to capture expert knowledge effectively. Verified by experts and evaluated by potential users, the prototype showcases potential benefits in aiding nutrition decisions, with user feedback offering insights for further enhancements [12].

This paper introduces an expert system tailored for elder nutrition care, leveraging a nutrition care process ontology to encode dietary knowledge and standardize nutrition care planning. With an inference engine facilitating semantic reasoning, the system assesses elders' dietary behaviors to detect malnutrition risks and provides personalized intervention plans. In-lab evaluation demonstrates the system's effectiveness, emphasizing its utility, computational efficiency, and the cohesion of the defined ontology in enhancing elder nutrition management [13].

This study examines how users evaluate food recommender systems beyond content accuracy, focusing on the influence of health consciousness levels, preference elicitation methods, and the use of nutrition label boosts. Through an online study comparing constraint-based and collaborative filtering recommendation methods with and without nutrition label boosts, results indicate boosts lead to healthier recipe choices regardless of preference elicitation method. Additionally, users exhibit varying levels of satisfaction with constraint-based preference elicitation, possibly influenced by their health consciousness [14].

This article introduces a nutrition deficiency decision support framework aimed at aiding doctors in analyzing laboratory test report data and prescribing appropriate treatments for patients. By leveraging ontology modeling and automatic nutrition deficiency classification, the proposed system offers a valuable tool for hospitals to streamline the classification process of nutritional deficiencies, potentially improving patient care and diagnosis accuracy in clinical setting [15].

This paper introduces a novel approach to drug recommendation utilizing sentiment analysis and machine learning techniques to enhance patient trust and treatment outcomes. By integrating patient-reported disease names and sentiment ratings from previous users, the proposed system offers personalized drug recommendations with insights drawn from real user experiences. This innovative approach harnesses the power of machine learning (ML) and natural language processing (NLP) to optimize drug recommendation processes, potentially improving patient satisfaction and adherence to treatment plans [16].

This paper highlights the challenges hindering the widespread use of recommender systems in health informatics and medical scenarios, emphasizing the importance of benchmarking criteria, end-user diversity, and data security concerns. It proposes a doctor-in-the-loop approach to address these challenges by integrating human expertise with computational efficiency, ultimately improving system acceptance and effectiveness. The suggested three-part research framework advocates for a comprehensive approach incorporating domain understanding, evaluation, and specific methodologies in the development of health recommender systems, aiming to enhance their applicability and impact in clinical settings [17].

This comprehensive review explores the burgeoning field of text data analysis in the food industry, highlighting its emerging significance alongside big data analytics. The paper discusses various text mining techniques and their applications, ranging from food safety and fraud surveillance to consumer opinion mining and new product development. By providing insights into intelligent decision-making, the review contributes to enhancing food production, safety, and human nutrition through informed strategies derived from textual data analysis [18].

This abstract introduces a timely topic of health consciousness and the impact of seasonal variations on the human body, emphasizing Ayurvedic principles and the significance of individualized prakriti energies. It acknowledges the limitations of manual diet recommendations and proposes leveraging computer science approaches for more efficient diet recommendations based on fuzzy logic, ontology, and knowledge representation methods. The paper promises a comprehensive review of existing approaches and proposes a method tailored to individual *prakriti* and seasonal considerations, offering potential advancements in personalized healthcare [19].

This abstract introduces a novel recommendation approach combining fuzzy logic and k-nearest neighbor algorithm, offering an alternative to traditional methods for personalized content recommendations. By addressing scenarios without extensive user feedback data, it provides a promising solution applicable in various domains. The evaluation within the context of nutrition recommendations for HIV/AIDS and malaria patients in Cameroon showcases its effectiveness, suggesting broader potential for application across different fields. Overall, this approach presents a robust framework for recommendation tasks where prior user feedback data is lacking [20].

This study addresses the critical challenge of managing diabetes effectively, highlighting the importance of balanced diet and physical activity. It emphasizes the necessity for technological interventions to assist both patients and doctors in controlling disease and mitigating complications. While existing techniques for diabetes diet recommendation exist, this work underscores the need for approaches capable of handling uncertainties arising from diverse individual opinions and preferences, suggesting a nuanced solution to enhance diabetes management strategies [21].

This article introduces an innovative food searching and recommendation engine that utilizes fuzzy logic to account for taste and user preferences, surpassing keyword-based systems. By incorporating AI and fuzzy logic, the system adeptly handles the abstract nature of taste and individual preferences. It considers additional parameters like restaurant environment, location, reviews, and budget, enhancing result accuracy. With a fuzzy database constantly updated by user feedback and individual user profiles, the system offers personalized recommendations, marking a significant advancement in food recommendation technology [22].

This article addresses the common issue of people neglecting calorie intake and proposes a solution leveraging fuzzy logic to calculate the suitability of food calories for individual health profiles. By employing TSK (Takagi, Sugeno, and Kang) and Tsukamoto inference models, the study effectively assesses daily calorie needs and resolves inconsistencies in calorie information. The findings suggest that fuzzy inference models can accurately model calorie needs and provide a satisfactory calorie value range, offering a potential tool for improved dietary management and health outcomes [23].

This paper introduces a fuzzy logic-based food recommendation system tailored to address malnutrition among rural populations in Bangladesh, incorporating factors such as BMI, age, recommended nutrients, and income. The research aims to bridge the gap in nutritional knowledge and budget constraints prevalent in these communities. By analyzing local food items categorized by cost and considering individual variations in food intake, the proposed model offers personalized recommendations to combat nutritional imbalances effectively, presenting a promising approach to improve dietary habits and health outcomes in rural areas [24].

This paper proposes a novel approach to enhance transparency in ambient intelligent environments by employing “Computing With Words” (CWWs) paradigm, facilitating natural interaction with networked devices. Focusing on kitchen tasks, particularly catering to users, including those with disabilities, the system predicts recipe difficulty and recommends personalized recipes based on mood, appetite, and spare time. Utilizing linear general type-2 (LGT2) fuzzy sets, the framework offers improved human-machine interaction, supported by real-world experiments. The comparison analysis highlights significant enhancement over traditional fuzzy sets, with both quantitative and qualitative evaluations affirming strong user acceptance and system effectiveness [25].

This article addresses the critical role of nutrition in managing diabetes and preventing associated complications. The nutrition diet expert system (NDES) described aims to assist healthcare professionals in determining daily calorie needs and recommending tailored diet plans for diabetic patients. By utilizing fuzzy logic to assess individual dietary requirements, the system shows promising results in achieving healthy body weight and optimizing diabetes control. The focus on prevention underscores the significance of personalized nutrition interventions in mitigating the global burden of diabetes-related diseases [26].

DATA COLLECTION

The researcher collected data from around 400 cardiac patients using Google Forms, obtaining ratings ranging from 1 to 10 for over 90 food items. This extensive dataset allowed for the establishment of user preferences based on individual ratings. By analyzing the responses, the researcher aimed to understand the dietary preferences and patterns of cardiac patients, essential for developing personalized dietary recommendations. The collected data encompassed a wide range of food choices, enabling comprehensive insight into the diverse preferences within the cardiac patient population. Through meticulous data collection and analysis, the researcher sought to uncover trends and correlations between food preferences and cardiac health, informing the development of effective dietary interventions tailored to individual needs.

The collected data showcases an extensive array of information, including age, gender, height, weight, and work category for cardiac patients. These parameters provide crucial insights into the demographic profile and lifestyle factors influencing dietary preferences and health outcomes. Through graphical representations, trends in food ratings across different age groups, genders, and work categories emerge, allowing for nuanced analysis and tailored recommendations. Visualizations depicting food preferences and ratings offer a comprehensive understanding of the dietary landscape within the cardiac patient population, enabling healthcare professionals to devise targeted interventions. By exploring correlations between demographic variables and food preferences, the research aims to uncover patterns that may inform personalized dietary strategies to optimize cardiac health and overall well-being as shown in Figures 1–18.

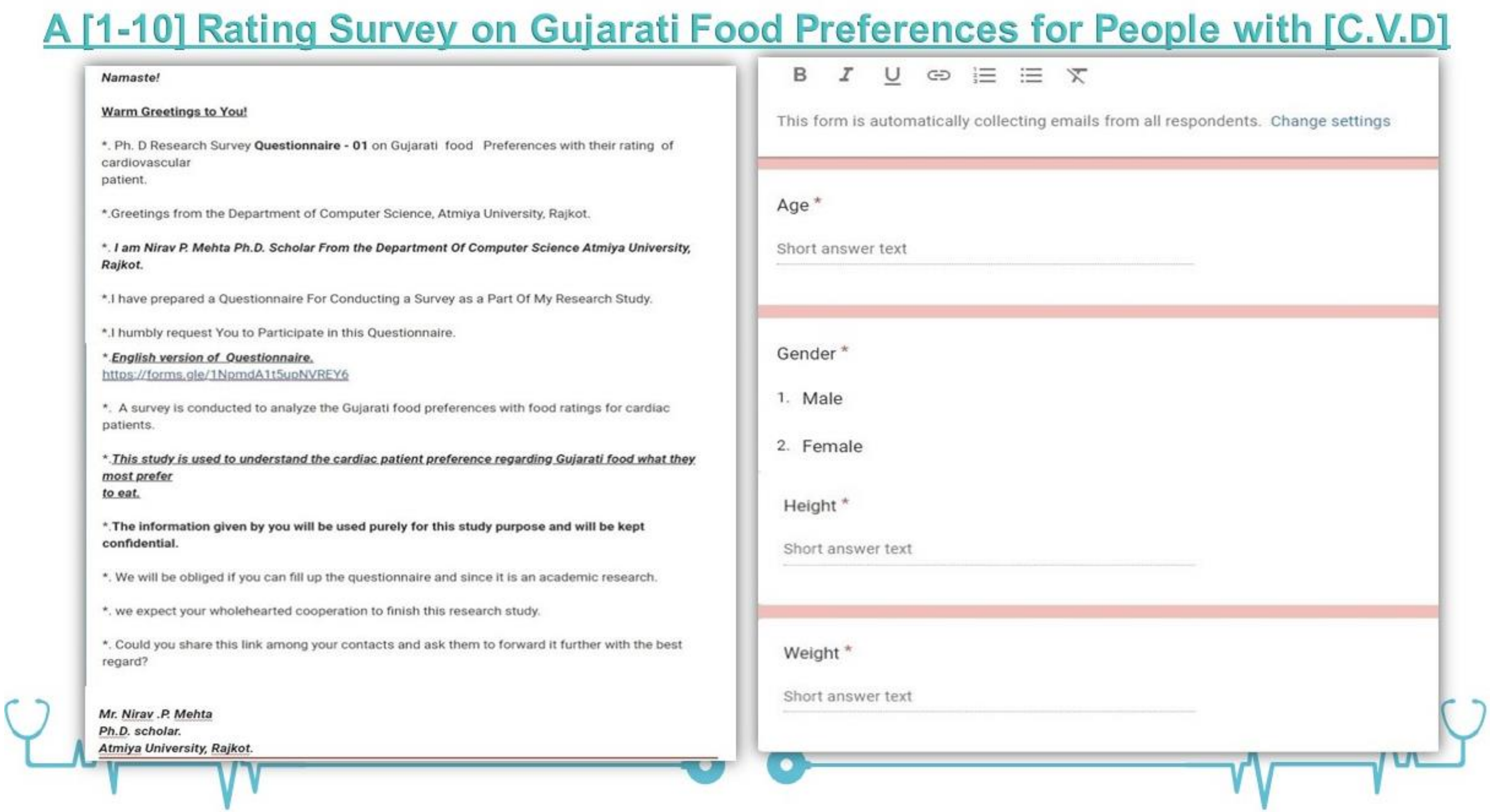

Figure 1. Instruction for google form.

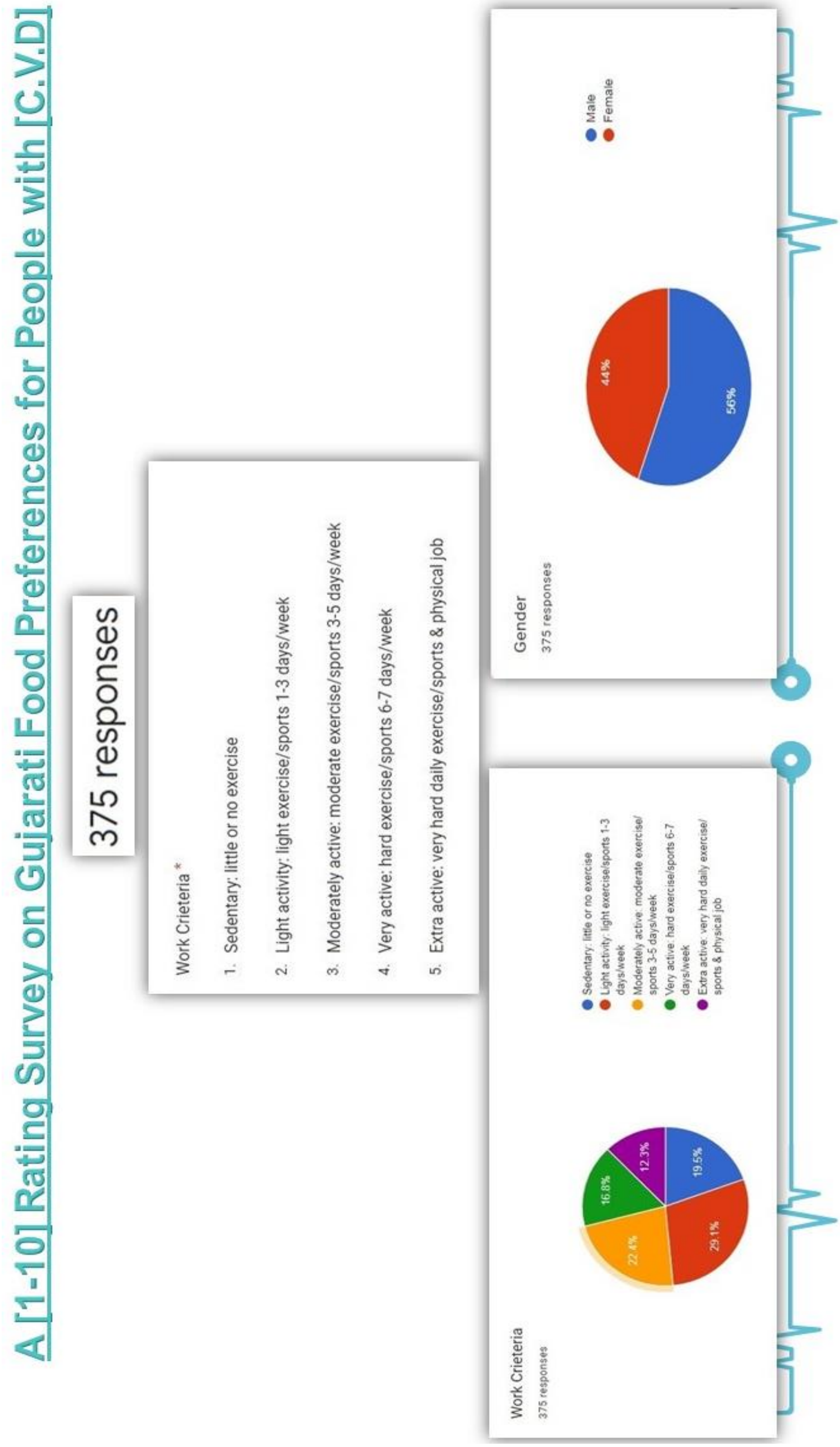

Figure 2. Work criteria.

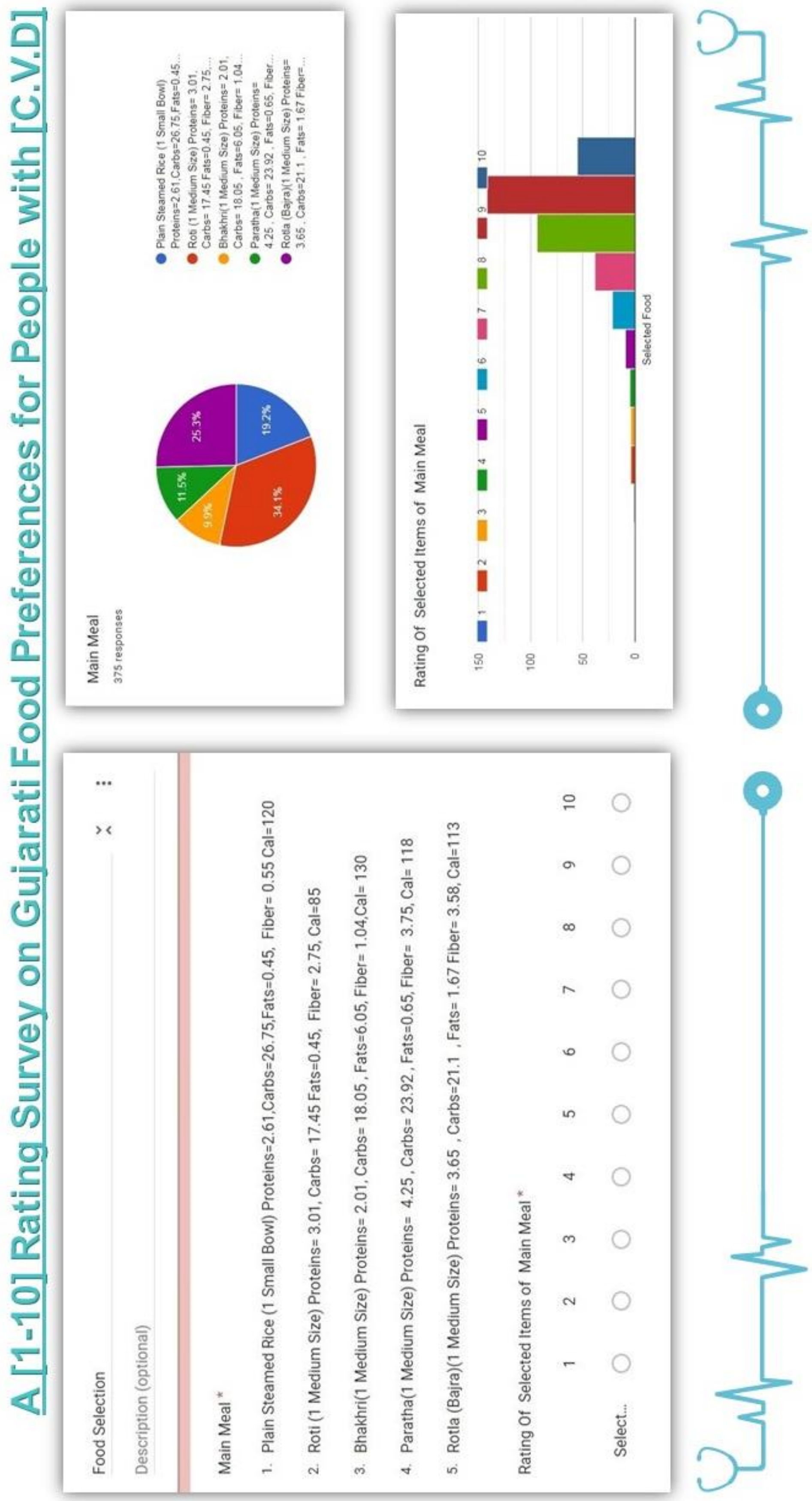

Figure 3. Main meal.

Figure 4. Nutritive value for snack.

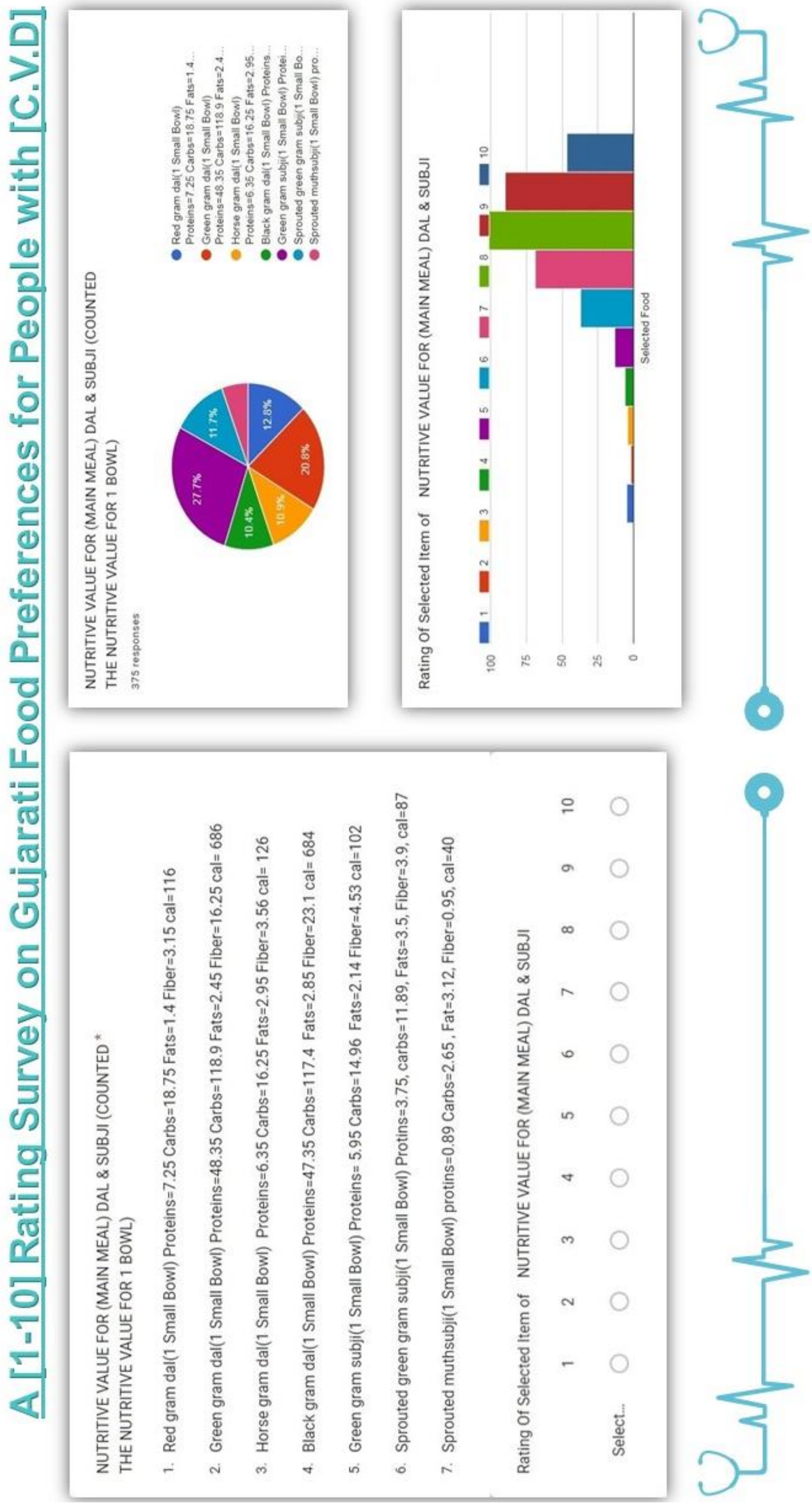

Figure 5. Nutritive value for (Main Meal) Dal and *subji* (counted the nutritive value for 1 bowl).

Figure 6. Rating of nutritive value for snacks.

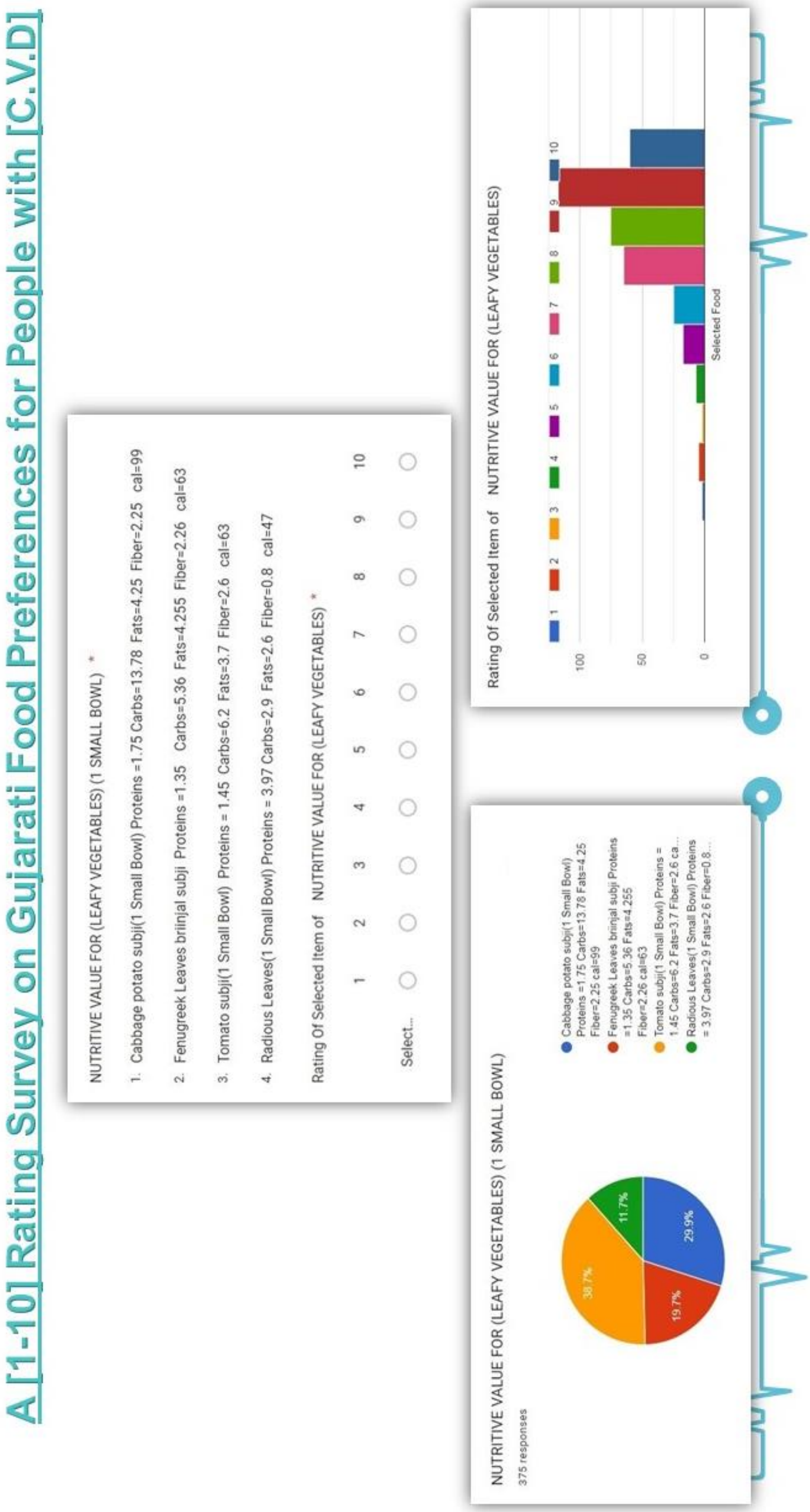

Figure 7. Nutritive value for leafy vegetables (1 small bowl).

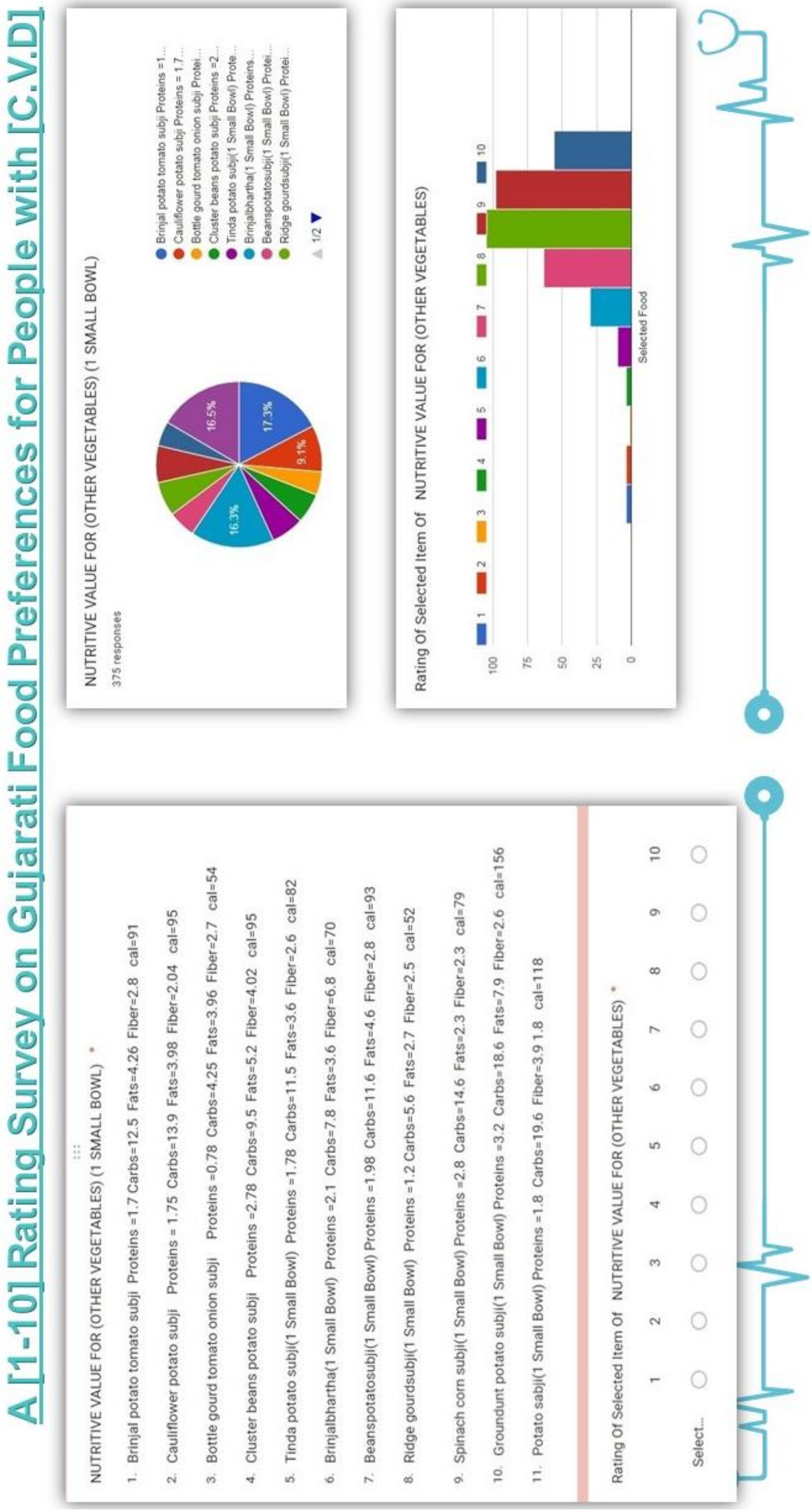

Figure 8. Nutritive value for other vegetables (1 Small Bowl).

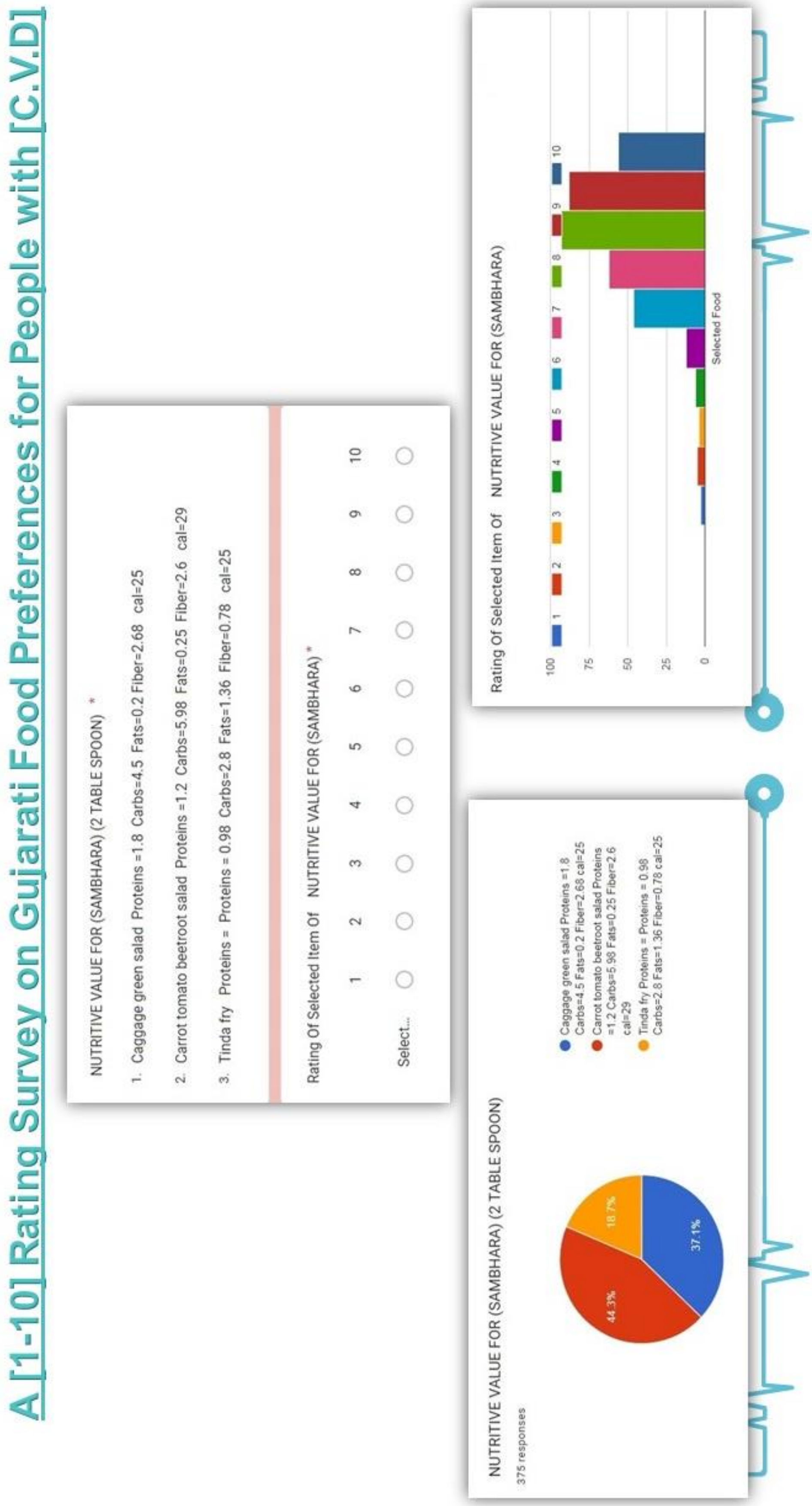

Figure 9. Nutritive value for *sambhara* (2 tablespoons).

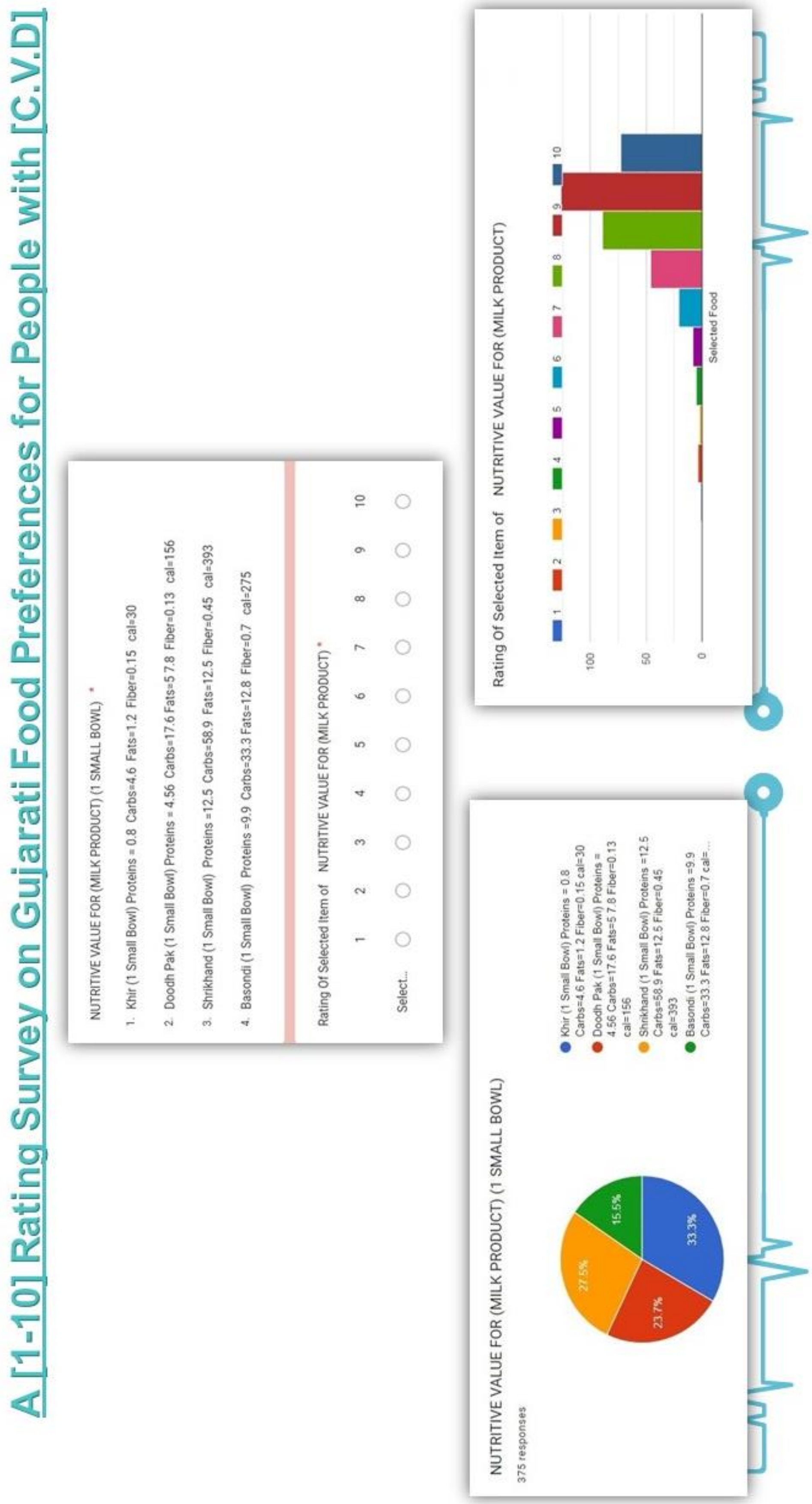

Figure 10. Nutritive value for milk product (1 small bowl).

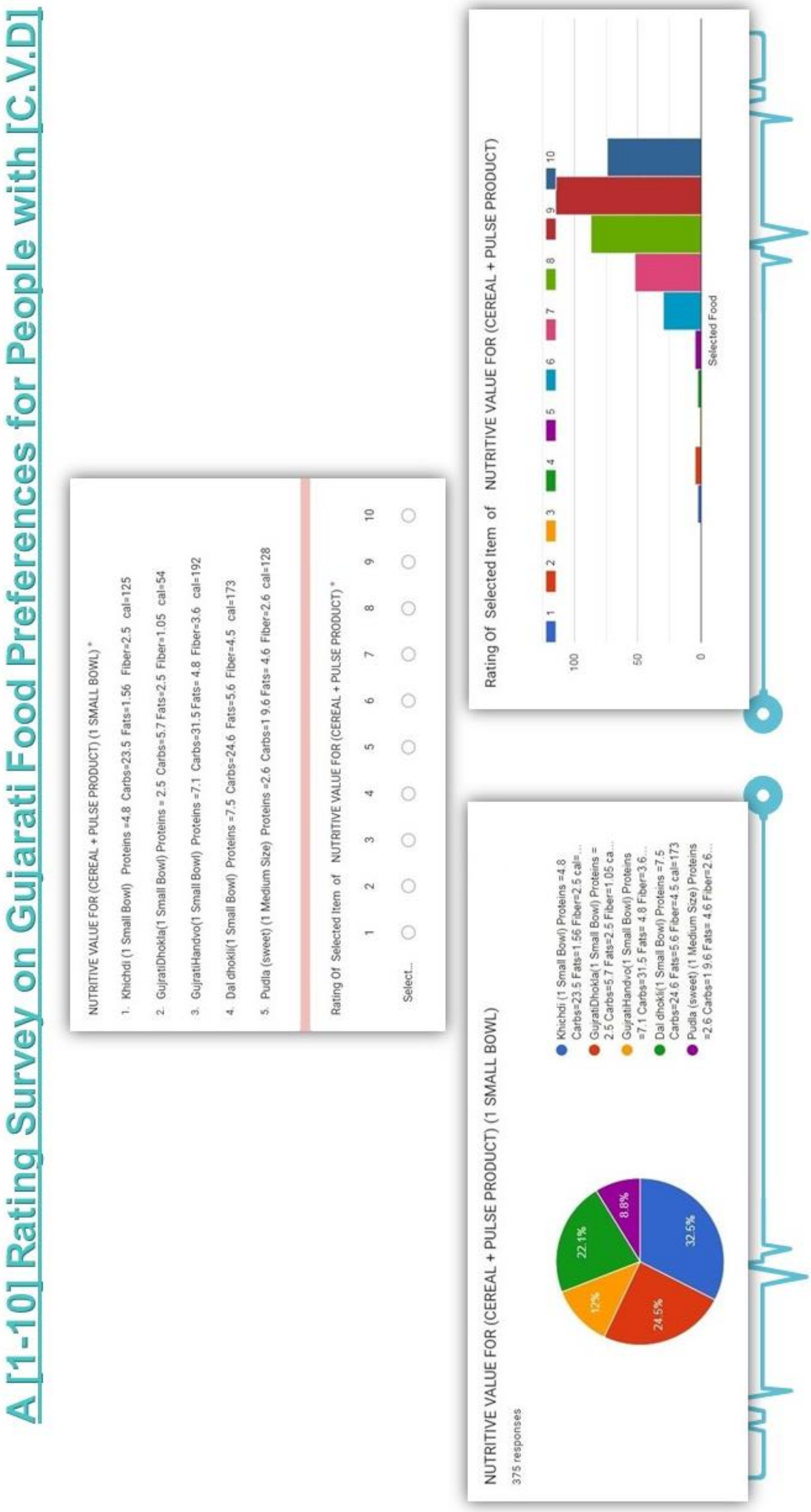

Figure 11. Nutritive value for cereal + pulse products (1 small bowl).

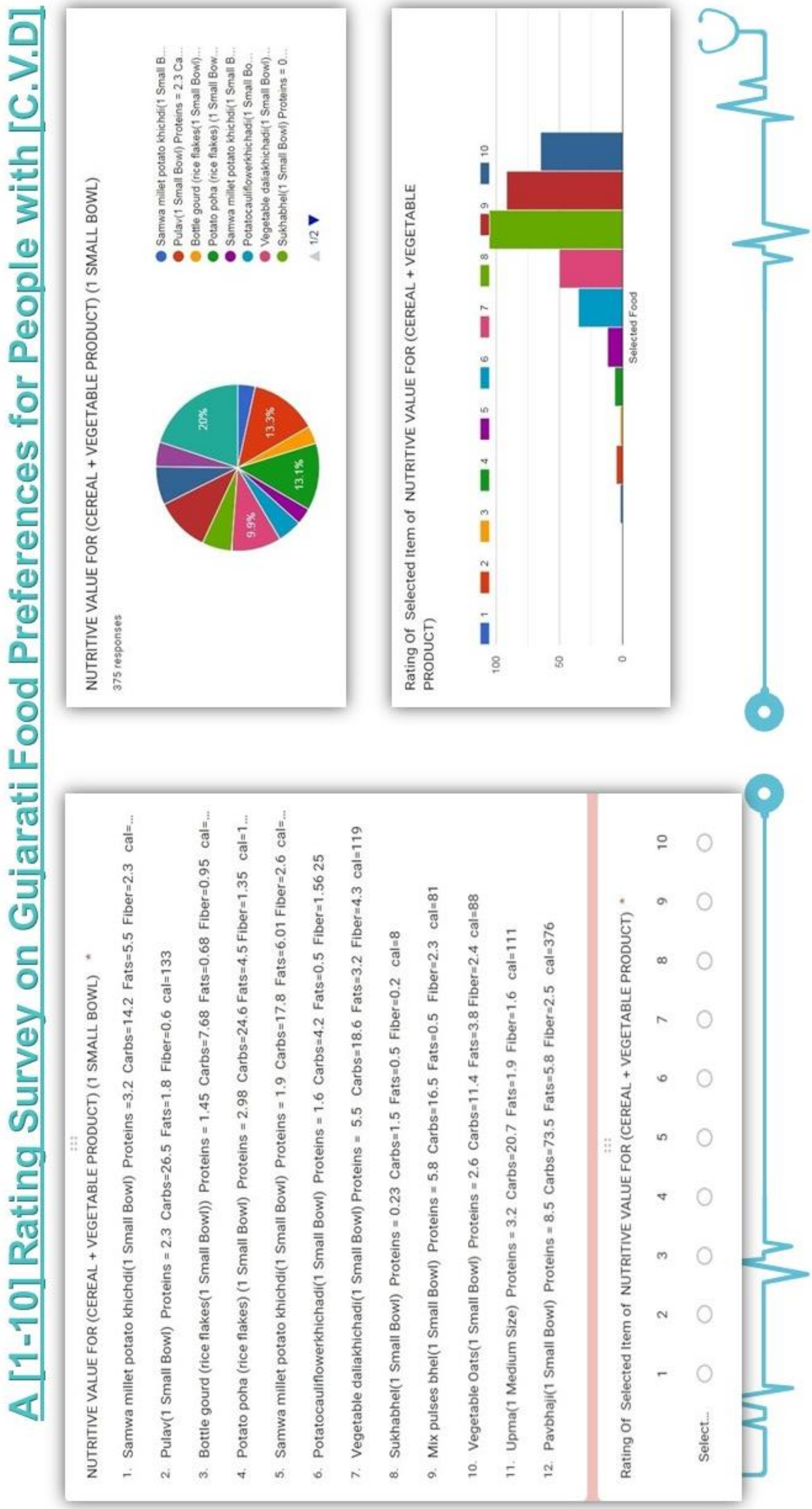

Figure 12. Nutritive value for cereal + vegetable product (1 small bowl).

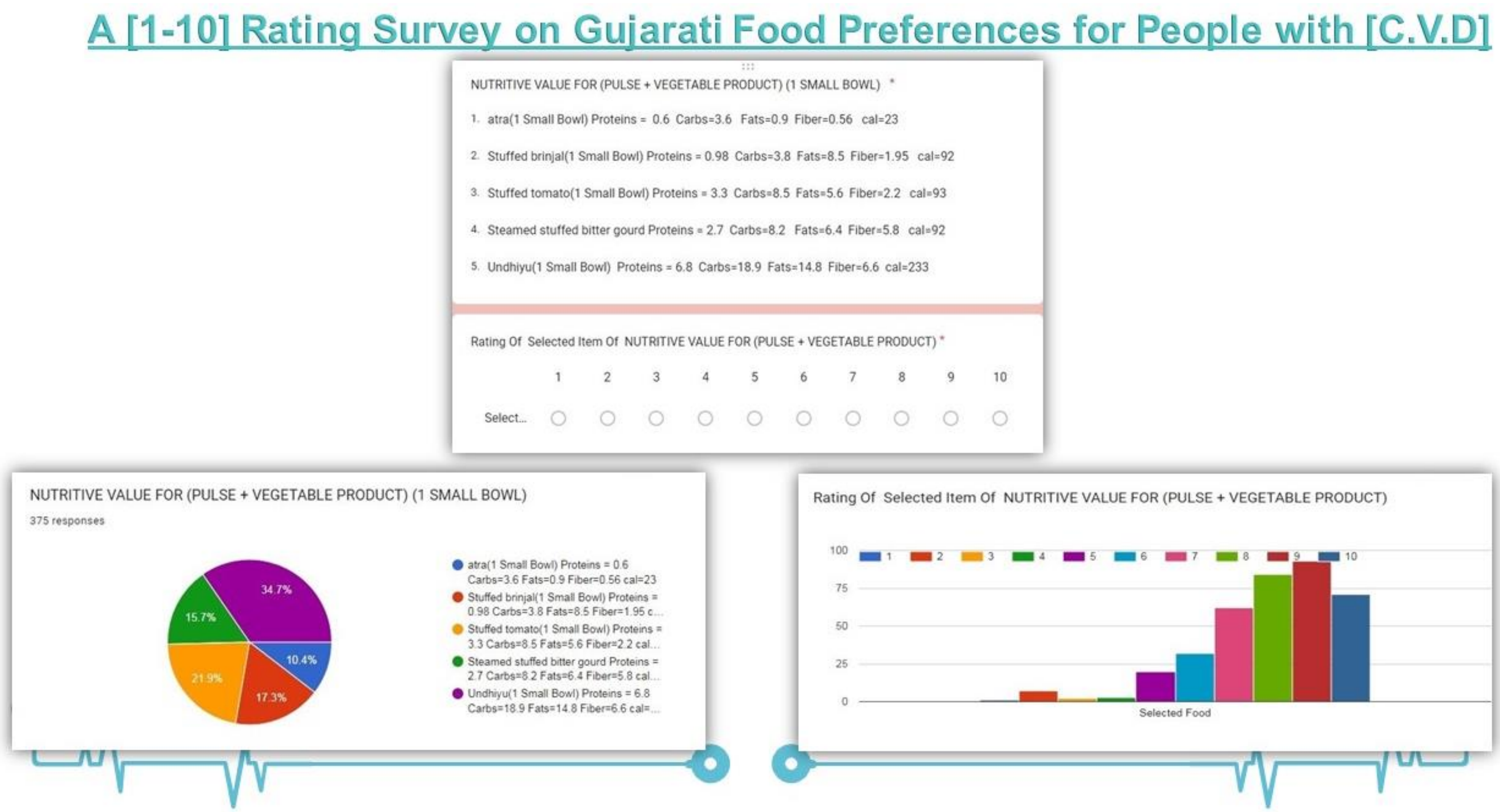

Figure 13. Nutritive value for pulse + vegetable product (1 small bowl).

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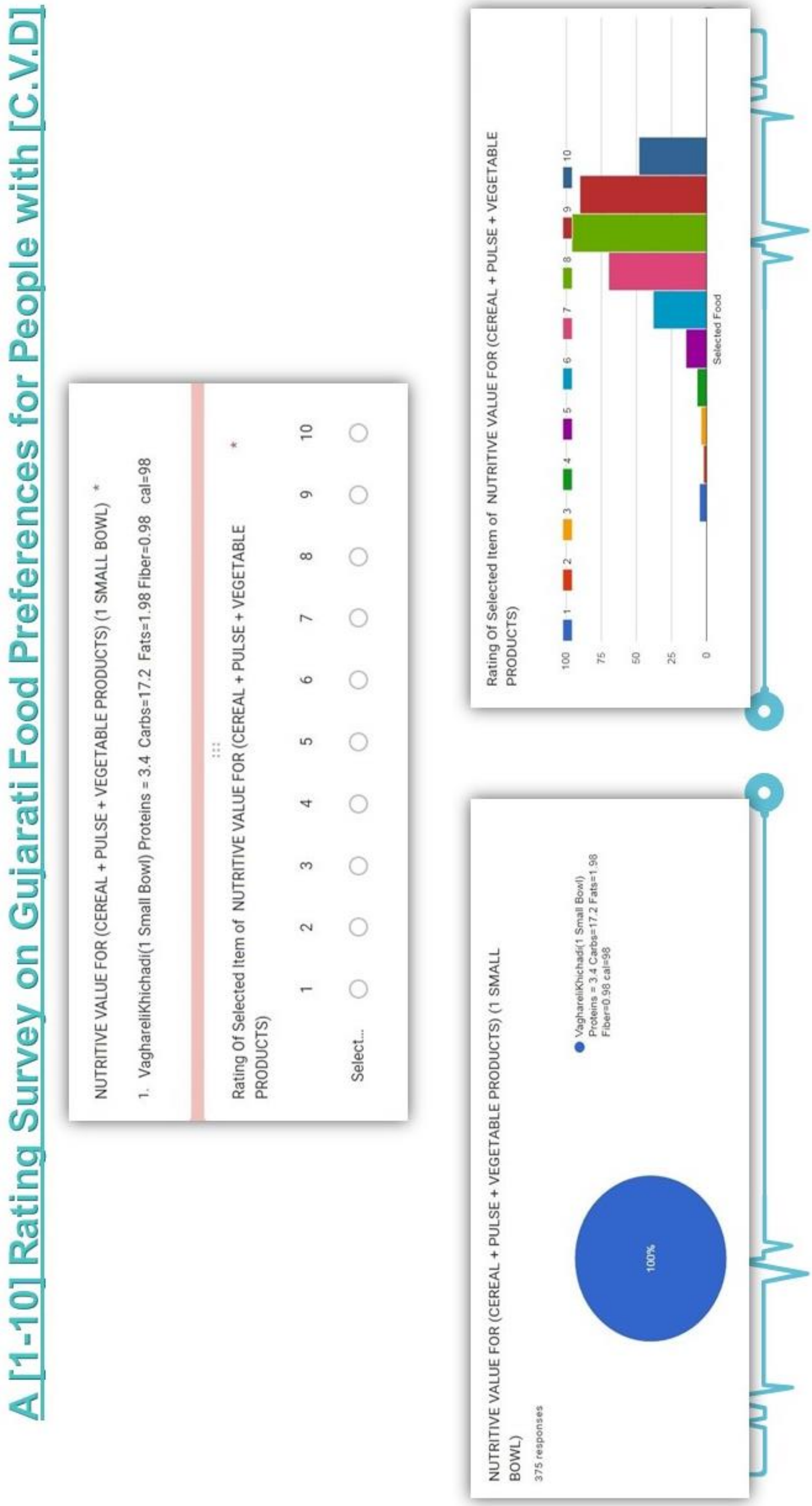


Figure 14. Nutritive value for cereal + pulse + vegetable products (1 small bowl).

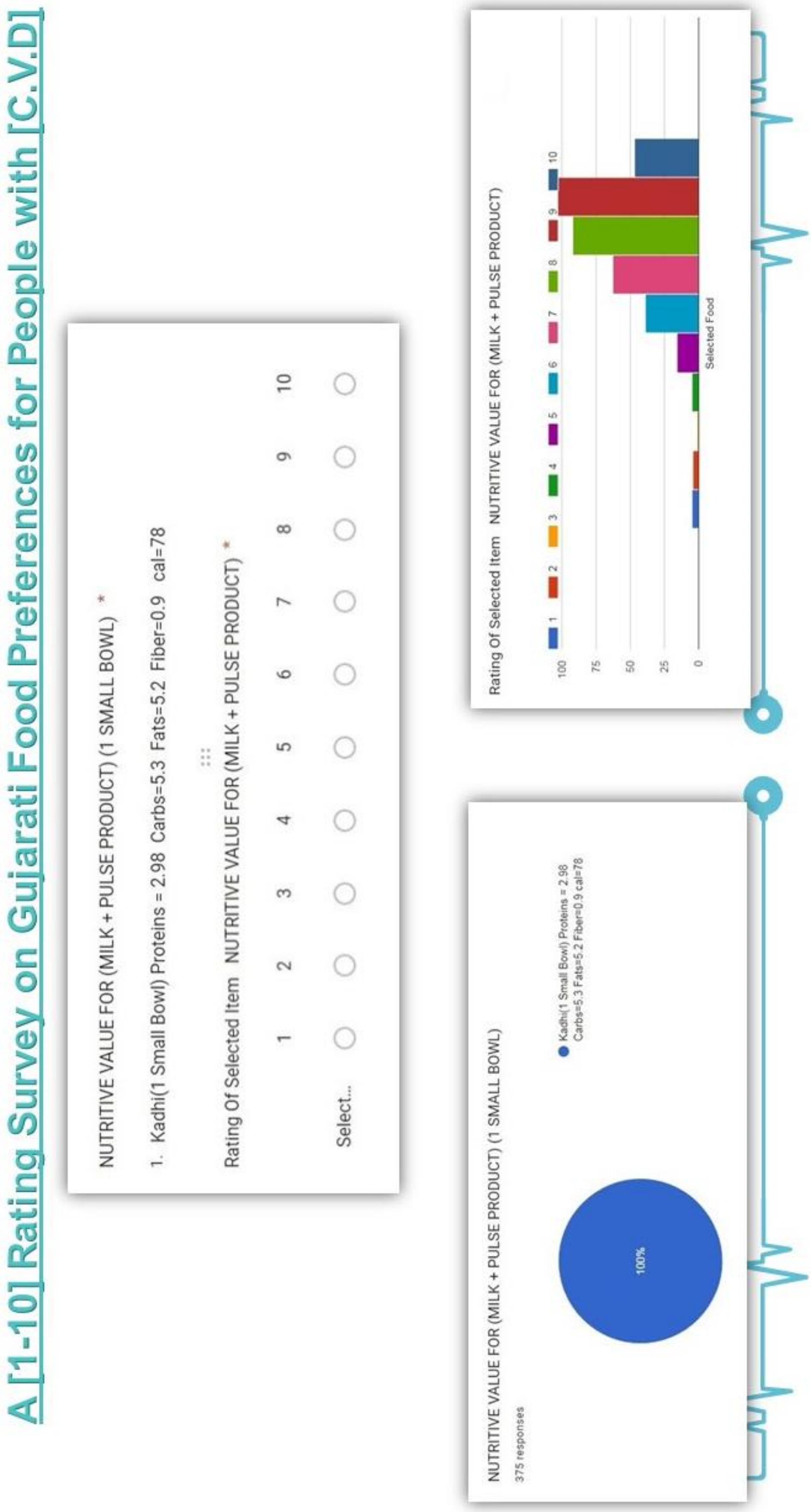


Figure 15. Nutritive value for milk + pulse product (1 small bowl).

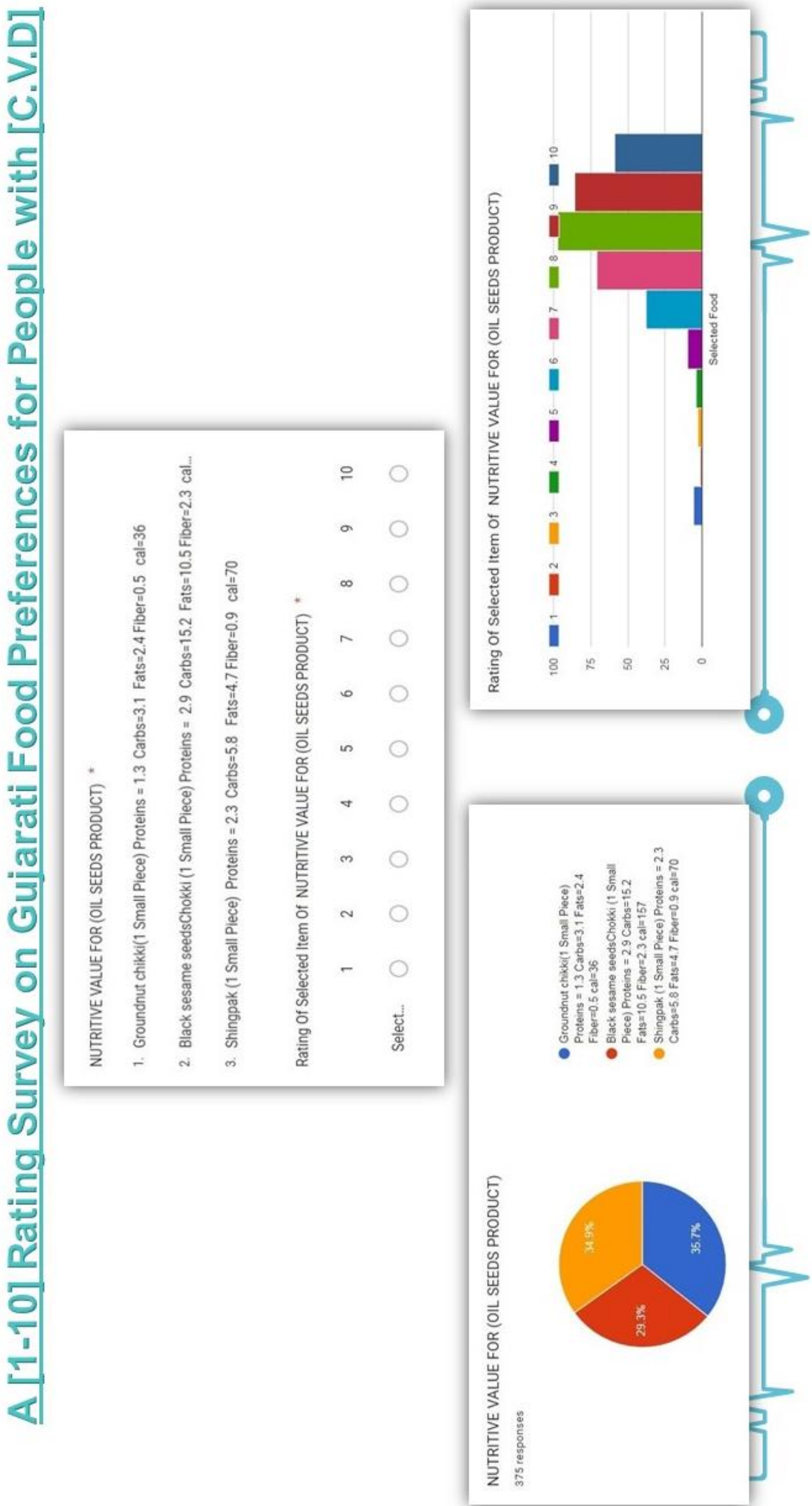
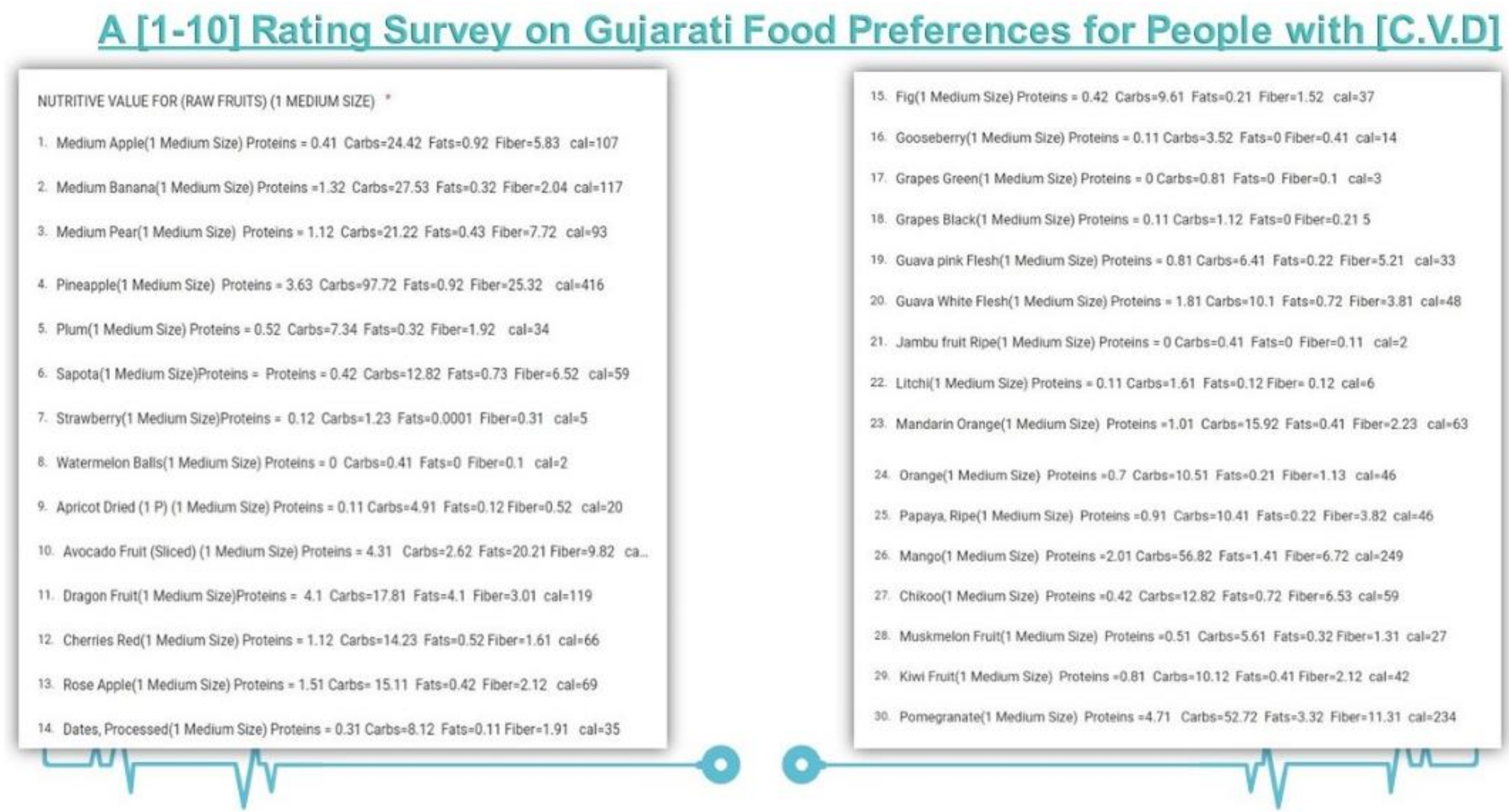


Figure 16. Nutritive value for oilseeds product.



A [1-10] Rating Survey on Gujarati Food Preferences for People with [C.V.D]

NUTRITIVE VALUE FOR (RAW FRUITS) (1 MEDIUM SIZE) *

1. Medium Apple(1 Medium Size) Proteins = 0.41 Carbs=24.42 Fats=0.92 Fiber=5.83 cal=107
2. Medium Banana(1 Medium Size) Proteins =1.32 Carbs=27.53 Fats=0.32 Fiber=2.04 cal=117
3. Medium Pear(1 Medium Size) Proteins = 1.12 Carbs=21.22 Fats=0.43 Fiber=7.72 cal=93
4. Pineapple(1 Medium Size) Proteins = 3.63 Carbs=97.72 Fats=0.92 Fiber=25.32 cal=416
5. Plum(1 Medium Size) Proteins = 0.52 Carbs=7.34 Fats=0.32 Fiber=1.92 cal=34
6. Sapota(1 Medium Size)Proteins = Proteins = 0.42 Carbs=12.82 Fats=0.73 Fiber=6.52 cal=59
7. Strawberry(1 Medium Size)Proteins = 0.12 Carbs=1.23 Fats=0.0001 Fiber=0.31 cal=5
8. Watermelon Balls(1 Medium Size) Proteins = 0 Carbs=0.41 Fats=0 Fiber=0.1 cal=2
9. Apricot Dried (1 P) (1 Medium Size) Proteins = 0.11 Carbs=4.91 Fats=0.12 Fiber=0.52 cal=20
10. Avocado Fruit (Sliced) (1 Medium Size) Proteins = 4.31 Carbs=2.62 Fats=20.21 Fiber=9.82 ca...
11. Dragon Fruit(1 Medium Size)Proteins = 4.1 Carbs=17.81 Fats=4.1 Fiber=3.01 cal=119
12. Cherries Red(1 Medium Size) Proteins = 1.12 Carbs=14.23 Fats=0.52 Fiber=1.61 cal=66
13. Rose Apple(1 Medium Size) Proteins = 1.51 Carbs= 15.11 Fats=0.42 Fiber=2.12 cal=69
14. Dates, Processed(1 Medium Size) Proteins = 0.31 Carbs=8.12 Fats=0.11 Fiber=1.91 cal=35
15. Fig(1 Medium Size) Proteins = 0.42 Carbs=9.61 Fats=0.21 Fiber=1.52 cal=37
16. Gooseberry(1 Medium Size) Proteins = 0.11 Carbs=3.52 Fats=0 Fiber=0.41 cal=14
17. Grapes Green(1 Medium Size) Proteins = 0 Carbs=0.81 Fats=0 Fiber=0.1 cal=3
18. Grapes Black(1 Medium Size) Proteins = 0.11 Carbs=1.12 Fats=0 Fiber=0.21 5
19. Guava pink Flesh(1 Medium Size) Proteins = 0.81 Carbs=6.41 Fats=0.22 Fiber=5.21 cal=33
20. Guava White Flesh(1 Medium Size) Proteins = 1.81 Carbs=10.1 Fats=0.72 Fiber=3.81 cal=48
21. Jambu fruit Ripe(1 Medium Size) Proteins = 0 Carbs=0.41 Fats=0 Fiber=0.11 cal=2
22. Litchi(1 Medium Size) Proteins = 0.11 Carbs=1.61 Fats=0.12 Fiber= 0.12 cal=6
23. Mandarin Orange(1 Medium Size) Proteins =1.01 Carbs=15.92 Fats=0.41 Fiber=2.23 cal=63
24. Orange(1 Medium Size) Proteins =0.7 Carbs=10.51 Fats=0.21 Fiber=1.13 cal=46
25. Papaya, Ripe(1 Medium Size) Proteins =0.91 Carbs=10.41 Fats=0.22 Fiber=3.82 cal=46
26. Mango(1 Medium Size) Proteins =2.01 Carbs=56.82 Fats=1.41 Fiber=6.72 cal=249
27. Chikoo(1 Medium Size) Proteins =0.42 Carbs=12.82 Fats=0.72 Fiber=6.53 cal=59
28. Muskmelon Fruit(1 Medium Size) Proteins =0.51 Carbs=5.61 Fats=0.32 Fiber=1.31 cal=27
29. Kiwi Fruit(1 Medium Size) Proteins =0.81 Carbs=10.12 Fats=0.41 Fiber=2.12 cal=42
30. Pomegranate(1 Medium Size) Proteins =4.71 Carbs=52.72 Fats=3.32 Fiber=11.31 cal=234

Figure 17. Nutritive value for raw fruits (1 medium size).

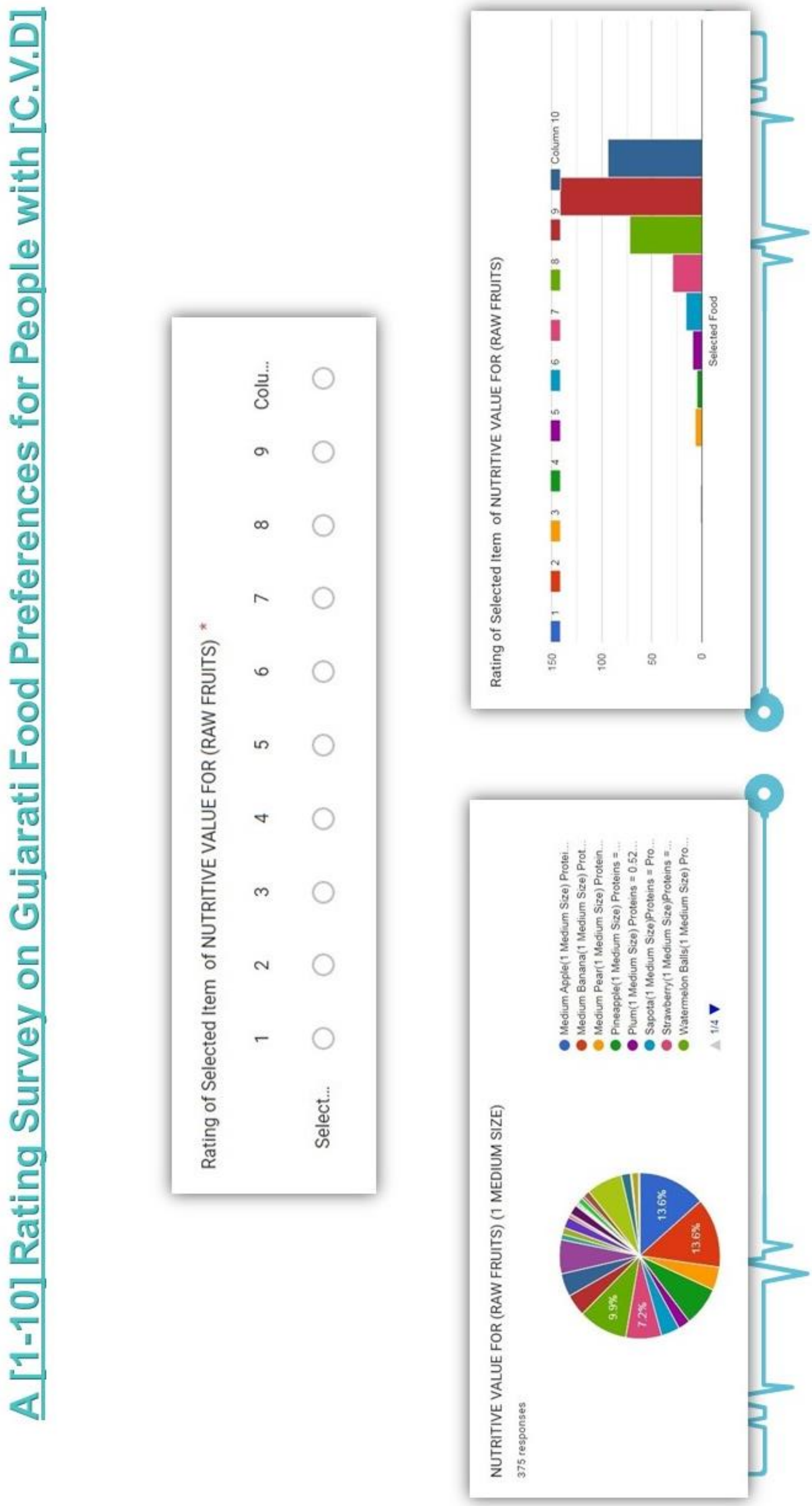


Figure 18. Rating of selected item of nutritive value for raw fruits.

CONCLUSION

In conclusion, this article has presented a novel approach to personalized dietary management for Gujarati cardiac patients through the development of a fuzzy logic-driven nutrition-based recommendation system (NBRS). By leveraging a comprehensive dataset comprising nutritional details of over 90 Gujarati food and fruit products, combined with fuzzy logic techniques and patient feedback integration, the NBRS model offers accurate and culturally sensitive dietary recommendations tailored to individual patient characteristics.

The integration of cultural preferences and seasonal variations in food availability ensures the relevance and adherence of dietary recommendations to Gujarati cardiac patients' specific health needs and cultural practices. Furthermore, the incorporation of patient feedback enhances the model's accuracy and relevance, fostering greater patient engagement and satisfaction with dietary recommendations.

Through this article, we have demonstrated the potential of the NBRS model to significantly improve the dietary management of cardiovascular diseases in Gujarat, ultimately leading to improved patient outcomes and reduced disease burden on the population. Future research directions may include further refinement and validation of the NBRS model, as well as exploration of its applicability to other cultural contexts and patient populations. Overall, the NBRS model represents a promising advancement in personalized dietary management strategies for cardiac patients, with implications for improving cardiovascular health outcomes globally.

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