RESEARCH ARTICLE

Optimizing Fruit Nutrition Data Presentation for Improved User Experience in the RSPG-Burapha Ecosystem

Pitak Sootanan[1,*], and **Chatchawin Petchlert**[1]

[1]Department of Biochemistry, Faculty of Science, Burapha University, Chonburi 20131, Thailand

*Corresponding author: Pitak Sootanan, pitak@go.buu.ac.th

Article Information

Article History:
Received: 25 January 2025
Revised: 8 August 2025
Accepted: 24 August 2025
Published: 26 October 2025

Keywords:
Database
Fruits
Learning Ecosystem
Nutrition Facts
RSPG-Burapha

Abstract

Nutrition facts enable consumers to clearly understand the nutritional content of each type of fruit, empowering them to make informed decisions when purchasing and consuming food. This article presents practical guidelines for developing and enhancing the display of fruit nutrition data within the RSPG-Burapha learning ecosystem. Our research was carefully designed to create user-friendly and efficient tools for displaying fruit nutrition data. These tools were rigorously evaluated for their effectiveness and user satisfaction to ensure practical relevance to end users. The study examined the nutritional information of 75 Eastern Thai fruits, representing at least 20 varieties and including product information for 141 types. The database homepage features an engaging motion graphic that allows users to easily explore organized fruit and product data. Detailed nutrition facts, radar charts for comparison, bar charts, and hierarchical clustering for analysis are provided, along with categorization of fruit products into groups. The database received overwhelmingly positive satisfaction ratings from 476 respondents, demonstrating the impact of our work on improving user satisfaction and access to nutritional information. This research highlights the importance of enhancing the presentation of nutrition data to facilitate informed choices in maintaining a balanced and healthy diet within the RSPG-Burapha learning ecosystem. The database can be accessed through the website `https://fruit.rspgburapha.com/`.

1. Introduction

The importance of nutrition labeling in Thailand has been highlighted in several studies examining its impact on consumer behavior and public health outcomes. Rimpeekool et al. (2017) investigated the association between nutrition label experience and the consumption of transitional foods among a large cohort of Thai adults, highlighting the potential influence of label awareness on dietary choices. Similarly, Pongutta et al. (2019) explored packaged food consumption and understanding of front-of-pack labels in urban Thailand, shedding light on consumer awareness and comprehension of nutritional information. Pettigrew et al. (2022) reviewed front-of-pack nutrition labeling in Southeast Asia, emphasizing industry interference and the need for improved labeling practices to promote healthier food choices. Additionally, epidemiological studies by Aekplakorn et al. (2011) and Techasuwanna et al. (2020) examined the prevalence and risk factors for type 2 diabetes mellitus in the Thai population, highlighting the importance of nutrition education and labeling in combating chronic diseases. These studies collectively underscore the critical role of nutrition labeling in shaping dietary behaviors and public health outcomes in Thailand.

The significance of fruit nutrition databases cannot be overstated, as they provide essential resources for accessing comprehensive information about the nutritional content of various fruits. The Thai Food Composition Database (ThaiFCD), developed by the Institute of Nutrition at Mahidol University (Judprasong et al., 2018), offers valuable insights into the nutritional profiles of Thai fruits, catering to local dietary needs and preferences. Conversely, the USDA National Nutrient Database for Standard Reference, maintained by the

ISSN 3088-1803

U.S. Department of Agriculture (U.S. Department of Agriculture, Agricultural Research Service, 2024), provides a broader scope, encompassing nutrition data for fruits worldwide. Nutritionix (2024) also offers a user-friendly platform with extensive coverage of local and international fruits, contributing to informed dietary choices. These databases differ in their display formats, with ThaiFCD primarily focusing on Thai fruits, the USDA database covering a wide range of fruits, and Nutritionix offering a versatile platform for accessing nutrition information.

While these databases serve important roles, they typically lack interactive features such as clustering analysis or radar charts, limiting their utility for comparative studies or dynamic learning environments. Additionally, they do not integrate seamlessly with local educational platforms to provide context-specific insights or support interactive learning experiences. Understanding the nutritional content of Thai fruits is crucial for promoting healthy eating habits and informing consumers' dietary decisions, emphasizing the importance of nutrition labels tailored explicitly to Thai fruits.

The RSPG-Burapha web application emerges as a pivotal tool within the learning ecosystem, leveraging its database and web-based platform to consolidate and disseminate information on Eastern local resources (Sootanan et al., 2022). Developed and continually improved by a team of researchers, including Sootanan, Dumrangrojwattana, Chewpreecha, and others, this resource serves as a comprehensive repository facilitating access to diverse local knowledge and cultural heritage. With its user-friendly interface and continuous updates, RSPG-Burapha offers students, educators, and researchers a dynamic platform for exploring and learning about the rich and varied resources of the Eastern region (Sootanan et al., 2023). The newly enhanced RSPG-Burapha learning ecosystem now features an accessible, user-friendly homepage with engaging activities for children, a robust database on biological, physical, and cultural resources, and a curriculum focused on biodiversity and ecosystems, all designed to facilitate enjoyable and educational learning experiences (Sootanan et al., 2024).

This study enhances the RSPG-Burapha platform by integrating interactive tools—such as radar charts and clustering—to provide localized, detailed nutrition data on Thai fruits through user-centered design. Existing databases such as ThaiFCD, USDA, and Nutritionix lack interactivity, offer static data, and are not tailored to local education. Our system addresses these gaps by offering an accessible, interactive platform that supports nutrition education, informed food choices, and future research within the RSPG-Burapha ecosystem.

This study aims to develop an interactive system for enhancing the display of fruit nutrition data within the RSPG-Burapha learning ecosystem, facilitating informed decision-making in food selection and consumption. The research focuses on developing user-friendly tools and evaluating their effectiveness in providing comprehensive nutritional insights for 75 Eastern Thai fruits, with the goal of promoting healthier dietary habits. The study highlights the significance of effective nutrition data display systems in supporting balanced and informed food choices within the RSPG-Burapha platform, which can be accessed through `https://fruit.rspgburapha.com/`.

2. Materials and Methods

A relational database was developed to organize nutrient and phytochemical data on Eastern Thai fruits such as durian, mangosteen, and rambutan, along with related product illustrations. Developer and user testing were conducted to assess satisfaction across content, design, usability, and display, as detailed below.

2.1 Materials

Nutrient and phytochemical data on Eastern Thai fruits such as durian, mangosteen, and rambutan were collected from various sources, including research articles and government publications, to develop a comprehensive database. This database, featuring nutritional information and photographs of multiple fruit varieties along with data on related products, serves as the foundation for illustrative fruit samples, with details provided as follows.

2.1.1 Collection of Nutrient and Phytochemical Contents

Information on the nutrient composition and phytochemical content of several Eastern Thai fruits, including durian, mangosteen, rambutan, and others, was collected from databases and research articles (Judprasong et al., 2018; U.S. Department of Agriculture, Agricultural Research Service, 2024). These fruits also include rose apple, mango, rakam, longkong, sapodilla, langsat, and lychee. The data are essential for understanding the dietary benefits of these tropical fruits. Additionally, research articles were reviewed to obtain insights into nutrient and phytochemical compositions specific to fruits such as durian (Kongkachuichai et al., 2010; A Aziz and Mhd Jalil, 2019), mangosteen (Kongkachuichai et al., 2010; Zarena and Sankar, 2011), rambutan (Kongkachuichai et al., 2019), and longkong (Klungsupya et al., 2015; Kongkachuichai et al., 2019). For product information, books and online publications from government agencies were consulted (Srimanee et al., 2004; Agricultural Product Processing Research and Development Group, 2014; Sirikarin et al., 2004). All collected data were used to design and create a comprehensive database. The data were newly compiled from multiple verified sources, as no single existing source offered comprehensive, consolidated information.

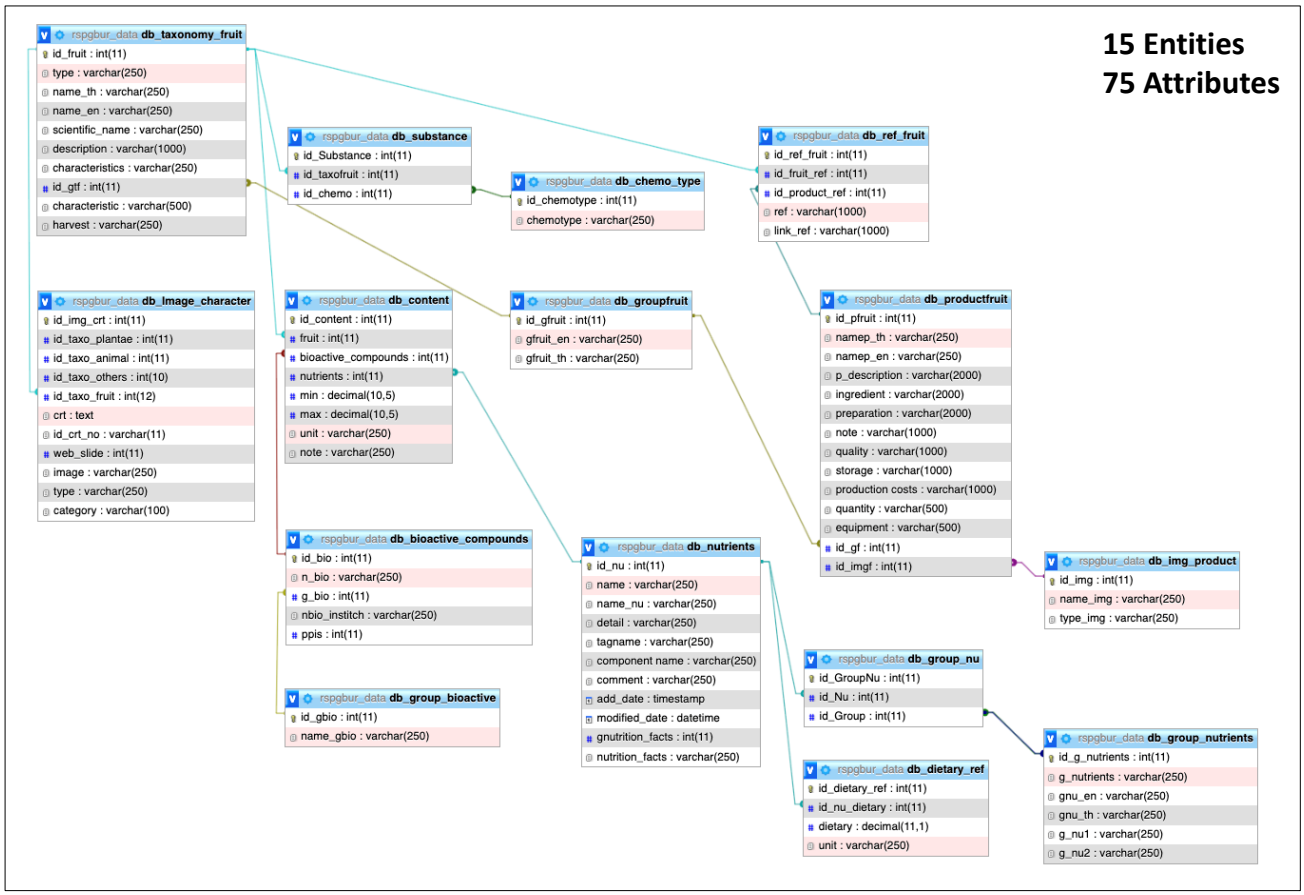

Figure 1. Entity-Relationship diagram of fruit database design in phpMyAdmin.

Limitations include incomplete phytochemical profiles for some lesser-studied varieties and variations in data collection methods across sources.

2.1.2 Fruit Samples for Illustrative Use

A comprehensive database featuring 75 Eastern Thai fruits with complete nutritional information was prepared. It showcases at least 20 readily available fruit varieties, each accompanied by multi-angle photographs and a color scale for accurate color comparison. Additionally, the database encompasses data on over 141 related products. This collected information forms the foundation for preparing fruit samples for illustrative purposes.

2.2 Methods

A relational data model using an Entity–Relationship (E–R) approach was used to organize data groups, later adapted into a MySQL database with forms and storage structures for web deployment. After developer testing on a virtual server, the system was transferred to a physical server for user testing and satisfaction evaluation across four key areas, as detailed below.

User participants (n = 476) were selected through convenience sampling among academic researchers, farmers or entrepreneurs, and general consumers who accessed the system during the evaluation phase. Demographic data were collected for subgroup analysis. Satisfaction scores were analyzed using descriptive statistics (mean and SD), and qualitative feedback was summarized to identify recurring themes.

2.2.1 Designing and Developing the Database

From the compiled information, a relational data model was designed using an Entity–Relationship (E–R) model to organize data groups such as fruit types, related species, compounds, active ingredients, and their roles and research data for product development. This model displays the interrelations among these data groups in the database. During the logical-level design phase, the E–R diagram was adapted to fit the selected database model, modifying attributes into relations and defining specifications such as primary keys and foreign keys to ensure the data were formatted normatively (Iamsiriwong, 2015). Subsequently, the storage structure, access methods, and design of data input and output forms were defined. These preparations paved the way for further development into a web application oper-

ating over the internet using the MySQL system and employing Python, HTML, CSS, and JavaScript for database management (Wongrat, 2013).

The database creation followed a structured process: data compilation and validation, E–R diagram design, normalization, MySQL implementation, web interface development, and iterative testing and refinement.

2.2.2 Database System Testing Conducted by Developers

In this phase, developers first tested the system using a database set up on a virtual server created with the AppServ program (Wongrat, 2013). They verified data import and reporting processes (input/output form design) to ensure accuracy. Any issues identified were addressed to correct defects or fix initial errors. This process was undertaken to optimize the system's efficiency and completeness before making the database available for user access.

2.2.3 Online Testing and Evaluation of Database Systems by Users

During user testing, the developers migrated the database system from a simulated to a physical server, allowing users and researchers to jointly assess the system. The evaluation, conducted online, identified two main user categories: academic and non-academic, with further subgroups—academic researchers, farmers or entrepreneurs, and general consumers. The satisfaction assessment for the database system was organized into four categories: (1) content satisfaction, (2) design satisfaction, (3) benefits and usability satisfaction, and (4) display format satisfaction. Each category contained 5–6 specific topics for evaluation, with users scoring each topic based on their level of satisfaction. The scoring system was divided into five levels: 5 for "most satisfied," 4 for "very satisfied," 3 for "moderately satisfied," 2 for "slightly satisfied," and 1 for "least satisfied" (Janekulprasoot et al., 2009).

Beyond providing feedback in the designated section, the average score ($\bar{x}$) and standard deviation (SD) were calculated for each topic and overall satisfaction. These values were used to evaluate satisfaction levels according to the following scale: Highest Satisfaction (≥ 4.50), High Satisfaction (4.00–4.49), Moderate Satisfaction (3.50–3.99), Low Satisfaction (3.00–3.49), and Needs Improvement (< 3.00), as referenced by Sootanan et al. (2022, 2023, 2024). The sample size of 476 was determined in line with the distribution of target user groups and anticipated response levels.

3. Experimental Results

Fig. 1 presents the ERD mapping of the fruit database, which comprises 15 entities, 75 attributes, and organizes 27 fruit groups into 75 varieties (e.g., ivory and Nangphaya bananas). Each variety is represented by 4 to 18 images. Fig. 2 shows the database and web application schematics hosted on RSPG-Burapha, including a home page with motion graphics, a site map, team information, and specialized pages for detailed search and categorization. Nutrient comparisons across fruits are displayed using hierarchical clustering, bar, and radar charts. Fig. 3 illustrates the graphic design and navigation linking to the home page (`https://fruit.rspgburapha.com/`).

Fig. 3 highlights the graphic and linking structure leading to the database home page, following the layout detailed in Fig. 2 and accessible via the provided URL. This database particularly emphasizes Eastern Thai fruits, showcasing detailed illustrations of at least 20 fruit varieties from multiple angles and providing information on over 141 related products. Through extensive research utilizing data from the National Institute of Nutrition database at Mahidol University and various scholarly articles, the database offers in-depth nutrition data. Its format mirrors those found in globally recognized platforms such as FoodData Central (U.S. Department of Agriculture, Agricultural Research Service, 2024) and Nutritionix (Nutritionix, 2024), providing extensive nutritional analysis.

The sample pages in Fig. 4 and Fig. 5 present nutritional information in a clear and structured format. Fig. 4 highlights total energy per serving and daily values for macronutrients and micronutrients, making key nutrition data easily interpretable at a glance (Savarino et al., 2021). It also includes both local and scientific names, seasonality, and specific characteristics, enhancing the depth and usability of the information. Fig. 5 reinforces accessibility by integrating clickable illustrations and detailed descriptions for products such as pumpkin and durian crackers. These descriptions cover essential information on fruit varieties, ingredients, production methods, and packaging, providing a comprehensive product overview.

Fig. 6 presents a radar chart comparing major nutrients, minor nutrients, and active ingredients. This format provides an intuitive way to visualize nutrient differences and similarities (Smith et al., 2015). It allows simultaneous comparison of up to five major nutrients, simplifying complex data for quick and clear insights. The chart incorporates normalization techniques to enable consistent data comparison from varied sources, ensuring accuracy and reliability (Muhammad Ali and Faraj, 2014).

Fig. 7 illustrates the use of hierarchical clustering (HCL) to categorize fruits based on their nutrient profiles. The clusters include specific durian varieties, showing nutrient-based relationships among fruits (Ardhiyanto et al., 2023). Interactive features, such as clickable clusters (e.g., the red line for Monthong durian), link directly to detailed nutritional information, improving usability (Balakrishna et al., 2022).

Fig. 8 displays comparative fruit nutrient data using bar charts, allowing direct comparisons across up to five fruits such as banana, cantaloupe, dragon fruit, durian, and guava (Kim, 2022). The charts incorporate standardized and normalized data to ensure accurate reflections of nutrient differences, enabling users to quickly assess nutrient content, such as dietary fiber, across various fruit types (Muhammad Ali and Faraj, 2014). Additional bar charts show the average fiber content across different durian varieties, highlighting specific differences between varieties such as Monthong and others.

Between July 12 and September 29, 2023, an analysis of 476 users who visited the fruit database website revealed a predominance of consumers or general users (95.80%), followed by farmers or entrepreneurs (2.31%) and academic researchers (1.89%) (Table 1). Most users (80.88%) were aged 16–20, with smaller proportions aged 21–25 (18.49%) and very few aged 26–30 or above 41 years. Regarding satisfaction with the database, the overall satisfaction levels were high across all evaluator statuses (Table 2). Academic researchers reported the highest mean satisfaction score ($\bar{x} = 4.38$, SD = 0.63), followed by farmers or entrepreneurs ($\bar{x} = 4.34$, SD = 0.66), and consumers or general users ($\bar{x} = 4.19$, SD = 0.94). The combined average satisfaction score was 4.30 (SD = 0.74), which is considered high.

Table 1. Summary of fruit database user evaluation status (476 respondents, July 12–September 29, 2023).

Status	Number (people)	Percentage
Academic researchers	9	1.89
Consumers or general users	456	95.80
Farmers or entrepreneurs	11	2.31

Table 2. Overall database satisfaction by evaluator status.

Status	$\bar{X}$	SD	Level of satisfaction
Academic researchers	4.38	0.63	High
Consumers or general users	4.19	0.94	High
Farmers or entrepreneurs	4.34	0.66	High
Average	**4.30**	**0.74**	**High**

Content satisfaction received positive feedback, with an average score of 4.29 (SD = 0.67). Users rated aspects such as clarity, volume, categorization, and presentation highly, scoring between 4.21 and 4.34, indicating that the database meets expectations for content quality and structure (Table 3). Similarly, the database design was well-received, with an average satisfaction score of 4.35 (SD = 0.65). Users appreciated specific design elements, including aesthetic appeal, modern style, and an easy-to-navigate layout, each scoring above 4.29 (Table 4).

Table 3. Database content satisfaction evaluation.

Assessment Items	$\bar{X}$	SD	Level of satisfaction
1. The content is clear, precise, and trustworthy.	4.27	0.66	High
2. The content volume adequately meets the needs.	4.21	0.64	High
3. The content is systematically categorized for ease of search and comprehension.	4.34	0.70	High
4. The content is organized sequentially and continuously.	4.30	0.68	High
5. Overall satisfaction with the content.	4.32	0.67	High
Average	**4.29**	**0.67**	**High**

Table 4. Database design satisfaction evaluation.

Assessment Items	$\bar{X}$	SD	Level of satisfaction
1. The design is aesthetically pleasing, contemporary, and engaging.	4.36	0.69	High
2. The layout is user-friendly and easy to navigate.	4.33	0.67	High
3. The color scheme of the website is well-chosen.	4.39	0.68	High
4. The typography, including size and style, is suitable.	4.29	0.68	High
5. Overall satisfaction with the design.	4.37	0.65	High
Average	**4.35**	**0.67**	**High**

Table 5. Database benefits and usability satisfaction evaluation.

Assessment Items	$\bar{X}$	SD	Level of satisfaction
1. The content is beneficial to users and offers potential for further development.	4.38	0.66	High
2. It serves as a reliable source of information that fulfills user needs.	4.34	0.69	High
3. It acts as a valuable knowledge base for interested individuals.	4.38	0.67	High
4. The information about related products is relevant and suitable.	4.34	0.68	High
5. Overall satisfaction with the benefits and usability of the content.	4.38	0.65	High
Average	**4.36**	**0.67**	**High**

The evaluation of the fruit database revealed high user satisfaction, with an overall mean rating of 4.36 (SD = 0.67). Users rated the database highly for its utility, reliability as an information source, and relevance of product-related information, with individual ratings ranging between 4.34 and 4.38 (Table 5). Additionally, features such as nutritional facts per serving and data visualization through radar and bar charts re-

ceived an average satisfaction score of 4.35 (SD = 0.65). Hierarchical clustering of fruits and detailed product information further enhanced user experience, as reflected by consistently high ratings (Table 6). Based on user feedback, key guidelines for enhancing the fruit nutrition data display include: applying normalized data for accurate comparisons, integrating interactive charts to improve usability, and ensuring consistent, clear labeling and imagery across all fruit varieties.

Table 6. Database display format satisfaction evaluation.

Assessment Items	$\bar{X}$	SD	Level of satisfaction
1. The nutrition facts of fruits are displayed per serving.	4.37	0.65	High
2. Radar charts are used to compare the composition of substances in fruits.	4.31	0.66	High
3. Bar charts facilitate the comparison of substances across different fruits.	4.33	0.65	High
4. Fruits are categorized using hierarchical clustering (HCL).	4.33	0.65	High
5. Information on products derived from each type of fruit is displayed.	4.37	0.65	High
6. Overall satisfaction with the display format is evaluated.	4.38	0.65	High
Average	**4.35**	**0.65**	**High**

The majority of feedback reflects the perspectives of general consumers (95.80%), with smaller contributions from farmers (2.31%) and academic researchers (1.89%). Feedback from all groups was positive, though detailed subgroup analysis was constrained by the unequal group sizes.

4. Discussion

Per recent works by Sootanan et al. (2022, 2023, 2024), the features illustrated in Fig. 2 of the RSPG-Burapha database demonstrate advancements in database systems and web applications. The inclusion of a motion graphic homepage, detailed search categorization, fruit-specific pages, and comparative nutrient tools aligns with current best practices in user-centered database design. These features enhance the accessibility and usability of the platform, promoting the integration of educational tools and nutrient analysis for a broader audience. The organization and visualization methods, such as hierarchical clustering and radar charts, further support effective data interpretation and decision-making for end users.

Eastern Thai fruits, known for their nutritional value and versatility, are increasingly gaining attention in health-conscious diets, as highlighted by studies such as Aekplakorn et al. (2011) and Techasuwanna et al. (2020). These fruits play a significant role in managing diabetes and metabolic risk factors in Thailand. The specialized focus of this database not only caters to the Eastern Region of Thailand but also appeals to a global audience, enhancing its utility and significance. By offering robust tools for researchers and the general public, the database facilitates informed dietary choices and enriches culinary experiences.

Comparative analysis with other databases, such as FoodData Central and Nutritionix, shows that this platform uniquely integrates comprehensive features such as multi-angle fruit illustrations and detailed product information. The inclusion of this information bridges gaps noted in prior research, such as those by Judprasong et al. (2018), Rimpeekool et al. (2017), and Pongutta et al. (2019), which emphasize the importance of accessible and detailed nutrition data for public health. Ultimately, this project contributes to promoting regional culinary heritage while advancing public health nutrition by integrating data into broader dietary and health contexts.

The structured format in Fig. 4 supports informed choices regarding fruit varieties based on nutritional content, aligning with prior research (Macdiarmid, 2013). By combining detailed nutritional data with contextual information, such as seasonality and scientific names, the platform caters to a broad audience, including health-conscious consumers and researchers.

Fig. 5 enhances user comprehension and ease of navigation by combining visuals with detailed descriptions, supporting accessibility and usability. This design approach aligns with food-based dietary guidelines and could serve as a model for broader health policies and educational initiatives (Truman, 2018). The inclusion of clickable illustrations and detailed product descriptions bridges the gap between visual engagement and practical information, making the platform a valuable tool for promoting informed dietary choices and advancing public health nutrition.

The radar chart in Fig. 6 simplifies complex nutritional data into a visual format that is both broad and detailed, supporting diverse user needs. The inclusion of normalization enhances the chart's effectiveness by enabling accurate comparisons across data sources, reflecting best practices in nutritional data visualization (Muhammad Ali and Faraj, 2014). This approach provides users with an accessible and reliable method to understand fruit nutrient profiles, supporting informed dietary decisions.

Hierarchical clustering (HCL) in Fig. 7 effectively groups fruits by similarity, aligning with established methodologies for nutritional categorization (Ardhiyanto et al., 2023). By organizing fruits into hierarchical clusters, HCL facilitates straightforward nutritional comparisons of macronutrients, micronutrients, and active compounds. The addition of interactive features, such as clickable clusters, enhances user engagement and functionality, making the database a practical tool for both researchers and general users. This design

aligns with current trends in user-centered database applications, promotes accessibility, and supports detailed exploration of nutritional data.

The use of bar charts in Fig. 8 offers a straightforward and visually intuitive method for comparing nutrient levels across multiple fruit types. By employing standardized and normalized data, the charts ensure reliable and consistent comparisons, aligning with best practices for presenting nutritional information (Muhammad Ali and Faraj, 2014). These visual tools provide users with a practical way to explore differences in key nutrients, such as dietary fiber, and support more informed dietary planning. The inclusion of specific analyses, such as average fiber content across durian varieties, further enhances the depth of insight, catering to both general users and researchers. This approach aligns with recommendations from global health organizations such as World Health Organization and United Nations Children's Fund (UNICEF) (2022), emphasizing the importance of accessible and usable nutritional data for promoting healthy diets.

The user demographic analysis indicates that the database predominantly attracts a younger audience, particularly those aged 16–20, reflecting the digital engagement trends of this age group. The low representation of older users and specialized groups, such as farmers or researchers, presents opportunities for expanding outreach and tailoring features to better serve these audiences. Despite the small proportion of academic researchers and farmers or entrepreneurs, these groups reported relatively high satisfaction levels, suggesting that the database features and content are valuable for specialized users. However, the comparatively lower satisfaction score among general users highlights a need for further refinement of the user interface, content accessibility, or additional features that cater to the preferences and expectations of this largest user segment.

The high satisfaction scores for content and design underscore the platform's success in delivering quality information in a user-friendly and visually appealing manner. Attributes such as clarity, organization, and navigability contribute to its effectiveness in meeting user expectations. Moreover, the strong alignment of the database's features with modern design and usability standards likely enhances user engagement and retention. To further improve, the database could diversify its user base by incorporating targeted content for specialized groups while maintaining its established high standards. This combination of functionality and aesthetics positions the database as a valuable tool for both general users and niche audiences.

The high user satisfaction scores demonstrate the effectiveness of the database's user-centered design in meeting diverse needs. The combination of clear information presentation and intuitive data visualization formats, such as radar and bar charts, supports user comprehension and engagement with complex nutritional data. The hierarchical clustering and detailed product information highlight the database's ability to provide both general insights and specific details, particularly appealing to young adult users. These findings reinforce the importance of designing digital resources that prioritize accessibility, clarity, and relevance to foster user satisfaction and practical utility.

While the system received high satisfaction ratings across all user groups, the findings predominantly reflect the views of young general consumers, as they formed the majority of participants. Although feedback from farmers and researchers was limited due to smaller sample sizes, their responses were positive, particularly regarding content clarity and usability. These results suggest a potential sample bias and highlight the importance of future evaluations aiming for a more balanced representation to better capture the expectations of all user categories.

User feedback emphasized satisfaction with the system's design, usability, and valuable content. Suggestions for improvement included adding more fruit types, providing additional details on cultivation and nutritional benefits, enhancing image completeness, improving mobile accessibility, and adjusting font clarity for better readability. These insights will guide future development to enhance both educational value and user experience.

Furthermore, the findings support guidelines for improving the RSPG-Burapha ecosystem, including refining interface clarity and accessibility, expanding mobile usability, enhancing interactive data visualizations such as radar and clustering charts, and strengthening testing procedures to ensure system reliability and user satisfaction. Future development should also focus on system scalability and outreach strategies to engage older users and specialized groups, ensuring broader applicability and impact.

5. Conclusion

In conclusion, the RSPG-Burapha learning ecosystem effectively combines a variety of web application features, such as motion graphics, hierarchical clustering, and advanced search tools, all designed to facilitate the analysis and categorization of Eastern Thai fruits. By merging clear nutritional data with visual tools such as radar charts for nutrient comparison and high-quality product images, the system offers users accessible, detailed insights into fruit nutrition. Additionally, hierarchical clustering and bar charts enable efficient analysis, enhancing the platform's usefulness for those exploring fruit-based nutrition. This robust database structure and in-depth nutritional content not only promote greater understanding of Eastern Thai fruits but also achieve high user satisfaction, particularly among young adults, confirming the database's role in supporting informed dietary choices. The evaluation underscores the importance of user-centered design and clear informa-

tion presentation in fostering satisfaction and utility in digital resources. Future work will focus on expanding the database to include a wider variety of fruits, enhancing mobile usability, and developing features tailored to the needs of farmers, researchers, and international users. These efforts will help scale the system and ensure its continued relevance and impact. Please visit `https://fruit.rspgburapha.com/` to access the database.

Acknowledgments

This work was financially supported by (i) Burapha University (BUU), (ii) Thailand Science Research and Innovation (TSRI), and (iii) National Science Research and Innovation Fund (NSRF) (Fundamental Fund: Grant no.3.15/2023).

CRediT authorship contribution statement

Pitak Sootanan: Conceptualization, Methodology, Validation, Resources, Database design and development, Formal analysis, Visualization, Writing – original draft, review & editing. **Chatchawin Petchlert:** Writing – review & editing.

Declaration of Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of AI Use

We declare that ChatGPT was used to assist in drafting and proofreading the English text of this manuscript under the authors' supervision. The authors are fully responsible for the entire content of the manuscript.

References

A Aziz, N. A. and Mhd Jalil, A. M. (2019). Bioactive compounds, nutritional value, and potential health benefits of indigenous durian (durio zibethinus murr.): A review. *Foods*, 8(3):96. DOI: 10.3390/foods8030096.

Aekplakorn, W., Chariyalertsak, S., Kessomboon, P., Sangthong, R., Inthawong, R., Putwatana, P., and Taneepanichskul, S. (2011). Prevalence and management of diabetes and metabolic risk factors in Thai adults. *Diabetes Care*, 34(9):1980–1985. DOI: 10.2337/dc11-0099.

Agricultural Product Processing Research and Development Group (2014). *86 Products (2nd ed.)*. Department of Agricultural Extension, Ministry of Agriculture, Thailand. Retrieved November 18, 2024, from Department of Agricultural Extension, Ministry of Agriculture, Thailand.

Ardhiyanto, O., Asyidqi, M. S., Ajif Yunizar Pratama Yusuf, S.Si, M., and Dr. Tb. Ai Munandar, S.Kom., M. (2023). Clustering of child nutrition status using hierarchical agglomerative clustering algorithm in Bekasi City. *International Journal of Information Technology and Computer Science Applications*, 1(3):122–128. DOI: 10.58776/ijitcsa.v1i3.42.

Balakrishna, Y., Manda, S., Mwambi, H., and van Graan, A. (2022). Statistical methods for the analysis of food composition databases: A review. *Nutrients*, 14(11):2193. DOI: 10.3390/nu14112193.

Iamsiriwong, O. (2015). *Data Structures for Computer Programming Design (Revised ed.)*. C.E. Education, Thailand.

Janekulprasoot, P., Thaipakdee, S., Dumrongkittikul, S., and Jiwajinda, S. (2009). Users' satisfaction on southern herb database on website. *Kasetsart Journal of Social Sciences*, 30(3):260–268.

Judprasong, K., Puwastien, P., Rojroongwasinkul, N., Nitithamyong, A., Sridonpai, P., and Somjai, A. (2018). Thai food composition database, online version 2, september 2018. `https://inmu.mahidol.ac.th/thaifcd`. Retrieved November 23, 2024, from Institute of Nutrition, Mahidol University, Thailand.

Kim, S.-H. (2022). A systematic review on visualizations for self-generated health data for daily activities. *International Journal of Environmental Research and Public Health*, 19(18):11166. DOI: 10.3390/ijerph191811166.

Klungsupya, P., Suthepakul, N., Muangman, T., Rerk-Am, U., and Thongdon-A, J. (2015). Determination of free radical scavenging, antioxidative DNA damage activities and phytochemical components of active fractions from lansium domesticum Corr. fruit. *Nutrients*, 7(8):6852–6873. DOI: 10.3390/nu7085312.

Kongkachuichai, R., Charoensiri, R., and Kettawan, A. (2019). Vitamin C, folate, and phytochemical compounds of organically versus inorganically grown fruits and vegetables commonly consumed in thailand. *Pharmaceutical Sciences Asia*, 46(4):218–230. DOI: 10.29090/psa.2019.04.018.0044.

Kongkachuichai, R., Charoensiri, R., and Sungpuag, P. (2010). Carotenoid, flavonoid profiles and dietary fiber contents of fruits commonly consumed in Thailand. *International Journal of Food Sciences and Nutrition*, 61(5):536–548. DOI: 10.3109/09637481003677308.

Macdiarmid, J. I. (2013). Seasonality and dietary requirements: Will eating seasonal food contribute to health and environmental sustainability? *Proceedings of the Nutrition Society*, 73(3):368–375. DOI: 10.1017/s0029665113003753.

Muhammad Ali, P. J. and Faraj, R. H. (2014). Data normalization and standardization: A technical report. Technical Report 1, Machine Learning Technical Reports. Retrieved October 15, 2024, from Machine Learning Technical Reports.

Nutritionix (2024). Nutritionix – Largest verified nutrition database. `https://www.nutritionix.com`. Retrieved November 23, 2024, from Nutritionix, United States.

Pettigrew, S., Coyle, D., McKenzie, B., Vu, D., Lim, S. C., Berasi, K., Poowanasatien, A., Suya, I., and Kowal, P. (2022). A review of front-of-pack nutrition labelling in Southeast Asia: Industry interference, lessons learned, and future directions. *The Lancet Regional Health - Southeast Asia*, 3:100017. DOI: 10.1016/j.lansea.2022.05.006.

Pongutta, S., Tantayapirak, P., and Paopeng, C. (2019). Packaged food consumption and understanding of front-of-pack labels in urban Thailand. *Public Health*, 172:8–14. DOI: 10.1016/j.puhe.2019.04.004.

Rimpeekool, W., Kirk, M., Yiengprugsawan, V., Banwell, C., Seubsman, S.-a., and Sleigh, A. (2017). Nutrition label experience and consumption of transitional foods among a nationwide cohort of 42,750 Thai adults. *British Food Journal*, 119(2):425–439. DOI: 10.1108/bfj-07-2016-0327.

Savarino, G., Corsello, A., and Corsello, G. (2021). Macronutrient balance and micronutrient amounts through growth and development. *Italian Journal of Pediatrics*, 47(1). DOI: 10.1186/s13052-021-01061-0.

Sirikarin, S., Lavallee, C., Visakorn, S., Sukyanandit, N., and Aranyanurak, N. (2004). *Durian Products*. Agricultural Promotion and Product Development Group, Community Agricultural Enterprise Promotion Division, Agricultural Development Office, Department of Agricultural Extension, Cooperative Printing House of Thailand. Retrieved November 20, 2024, from Agricultural Promotion and Product Development Group, Thailand.

Smith, S. B., Miller, A. C., Merchant, C. R., and Sankoh, A. F. (2015). Local site variation in stopover physiology of migrating songbirds near the south shore of Lake Ontario is linked to fruit availability and quality. *Conservation Physiology*, 3(1):cov036. DOI: 10.1093/conphys/cov036.

Sootanan, P., Dumrangrojwattana, P., Chewpreecha, B., Khachonpisitsak, S., Sukparangsi, W., Tangkrock-olan, N., Rattanaseth, R., Mungkung, P., and Leelathakul, N. (2022). RSPG-Burapha: Database and web application of eastern local resources. *Burapha Science Journal*, 27(3):1490–1516.

Sootanan, P., Dumrangrojwattana, P., Chewpreecha, B., Khachonpisitsak, S., Sukparangsi, W., Tangkrock-olan, N., Rattanaseth, R., Mungkung, P., Panithanarak, T., Suriyaphan, J., Teeramaethee, J., and Leelathakul, N. (2023). RSPG-Burapha: Additions and improvements of database and web application of eastern local resources. *Burapha Science Journal*, 28(3):1723–1748.

Sootanan, P., Dumrangrojwattana, P., Chiwapreecha, B., Khachonpisitsak, S., Sukparangsi, W., Tangkrock-olan, N., Rattanaseth, R., on Sakwilaisakul, S., Panithanarak, T., Suriyaphan, J., Teeramaethee, J., and Leelathakul, N. (2024). RSPG-Burapha: Enhancing the database of local resources to support a learning ecosystem in the eastern region. *Burapha Science Journal*, 29(3):925–951.

Srimanee, S., Chatwirun, L., Sookyanudit, W., and Aranyanurak, N. (2004). Banana products. `https://ebook.lib.ku.ac.th/ebook27/ebook/2011-005-0096/#p=1/`. Retrieved October 21, 2024, from Kasetsart University Library, Thailand.

Techasuwanna, R., Chottanapund, S., Chamroonsawasdi, K., Sornpaisarn, B., and Tunyasitthisundhorn, P. (2020). Risk factors for type 2 diabetes mellitus in Thai population. *Disease Control Journal*, 46(3):268–279. DOI: 10.14456/dcj.2020.26.

Truman, E. (2018). Exploring the visual appeal of food guide graphics: A compositional analysis of dinner plate models. *British Food Journal*, 120(8):1682–1695. DOI: 10.1108/bfj-02-2018-0112.

U.S. Department of Agriculture, Agricultural Research Service (2024). Fooddata central. `https://fdc.nal.usda.gov/index.html`. Retrieved November 22, 2024, from U.S. Department of Agriculture, Agricultural Research Service.

Wongrat, T. (2013). *Guide to Developing Web Applications with PHP & AJAX + jQuery*. C.E. Education, Bangkok, Thailand.

World Health Organization and United Nations Children's Fund (UNICEF) (2022). *National Nutrition Information Systems: Technical Note: Designing Effective Data Visualizations*. World Health Organization and UNICEF, Geneva, Switzerland. Retrieved October 18, 2024, from World Health Organization and UNICEF.

Zarena, A. and Sankar, K. U. (2011). Phenolic acids, flavonoid profile and antioxidant activity in mangosteen (garcinia mangostanal.) pericarp: Analysis of phenolic acid by HPLC-ESI-MS. *Journal of Food Biochemistry*, 36(5):627–633. DOI: 10.1111/j.1745-4514.2011.00575.x.

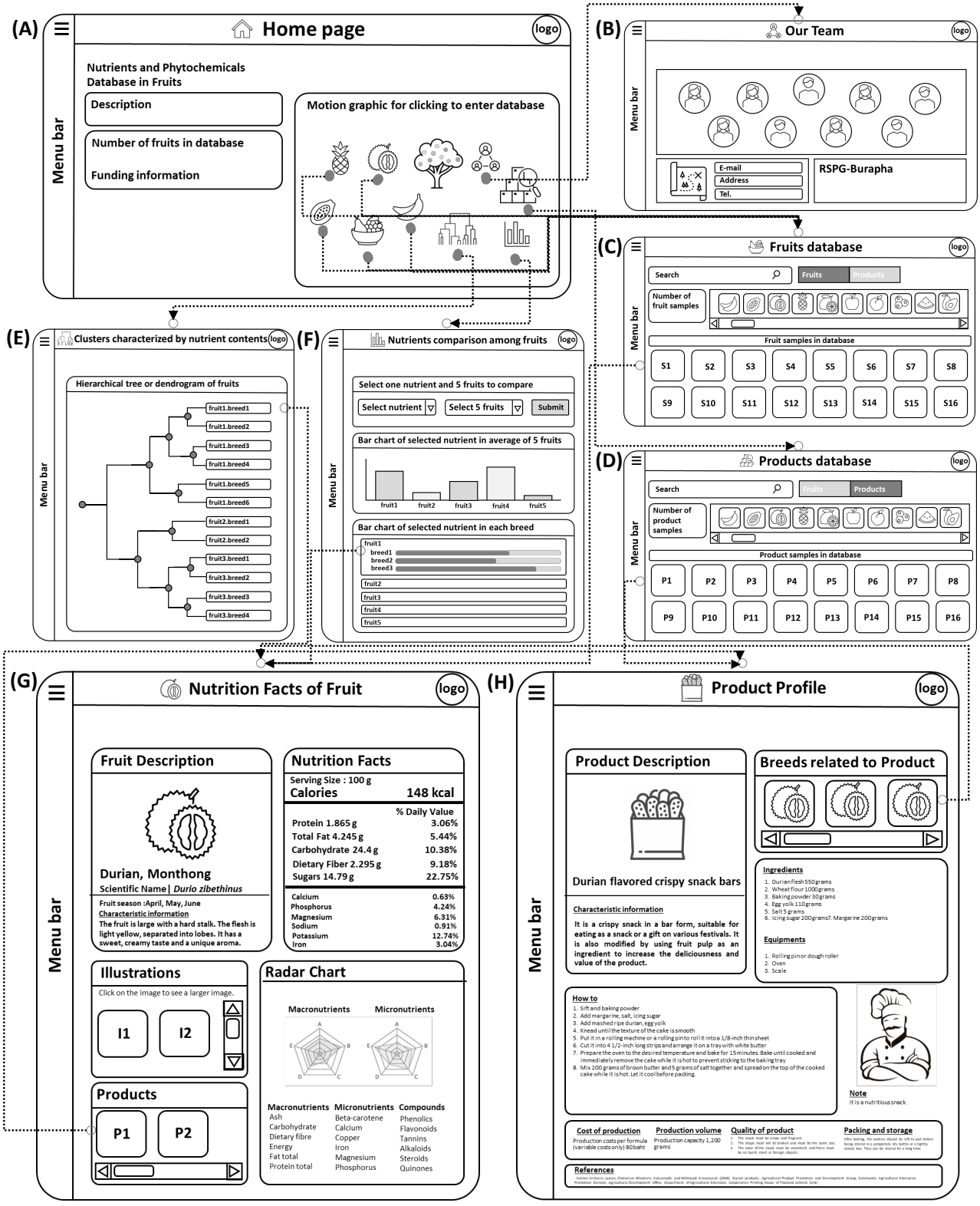

Figure 2. Schematic diagrams of database systems and web applications of fruit database on RSPG-Burapha. (A) The fruit database home page shows a motion graphic for entering the database. (B) Site map and team of creators. (C) A comprehensive page for searching fruit and product databases organized into categories. (D) The page includes fruit products that are categorized ac-cording to fruit groups. (E) Hierarchical clustering (HCL) of fruits' nutrients. (F) Comparison of nutrients between fruits by bar chart. and (G) Presentation of nutrition facts of fruits per serving and comparison of nutrients in fruits by radar chart.

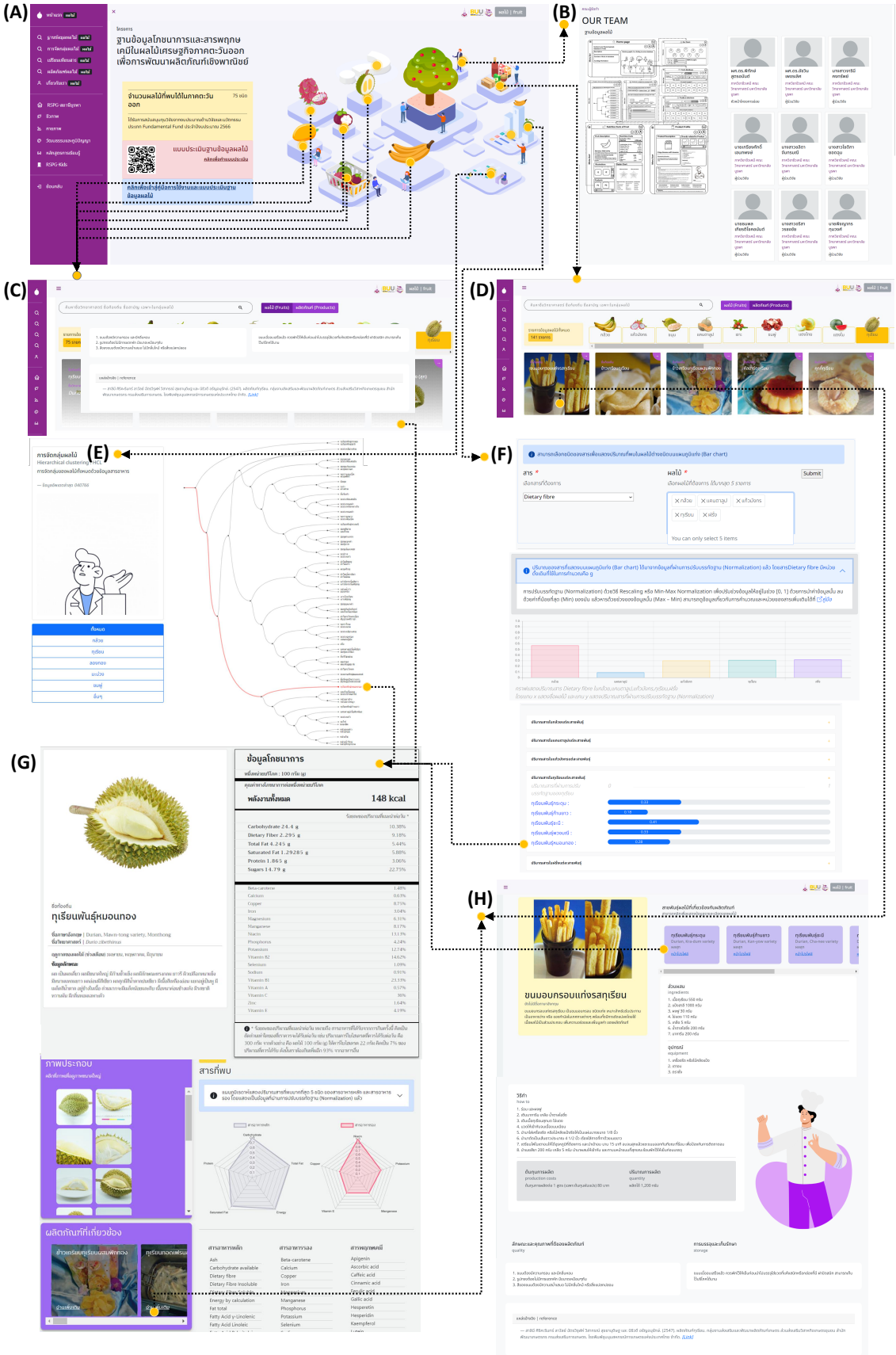

Figure 3. Graphic design and linking structure to the fruit database home page according to the structure diagram in Fig. 2 (`https://fruit.rspgburapha.com/`).

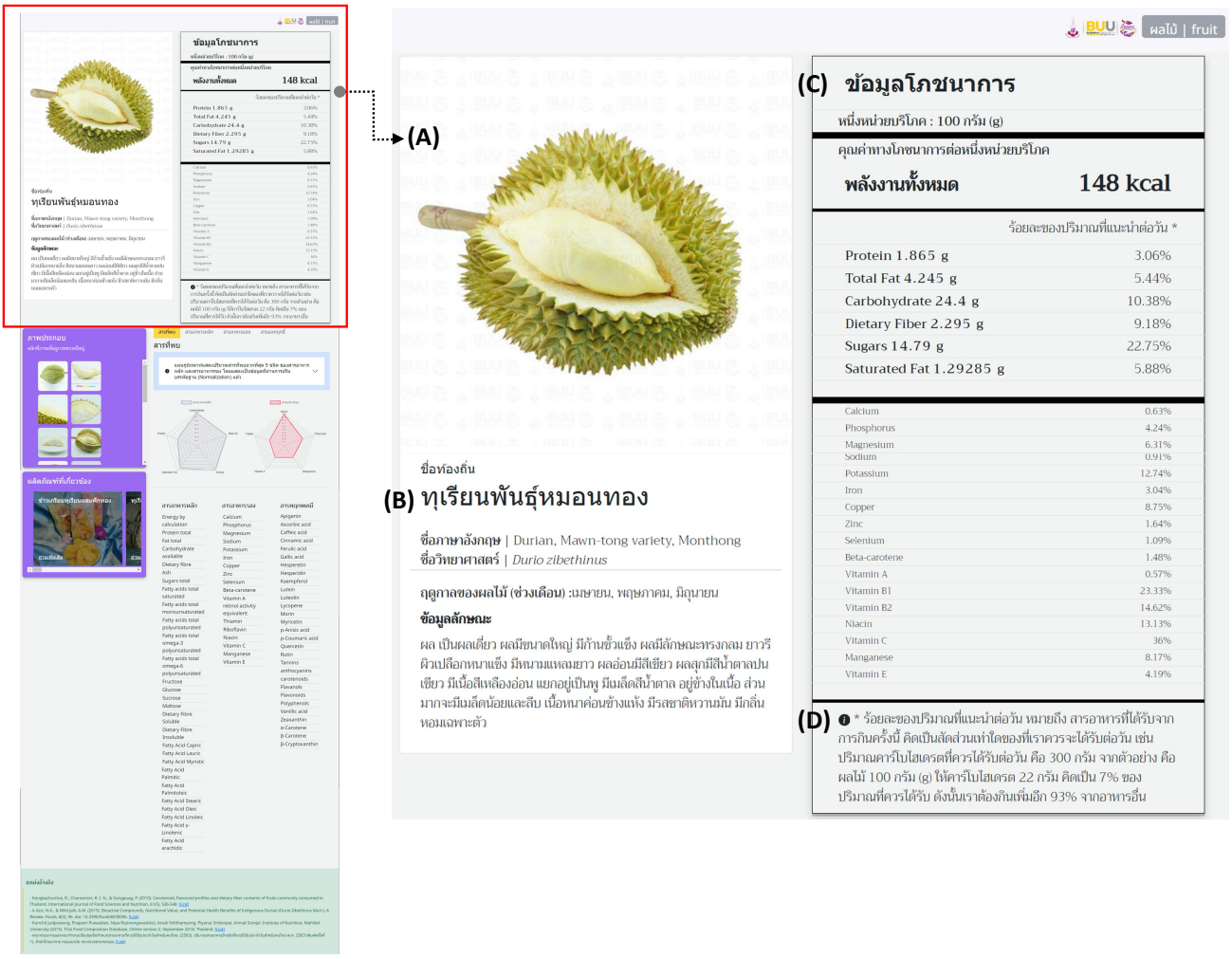

Figure 4. Sample page includes the following details: (A) Cover image of the fruit, (B) Local name, English name, scientific name, season-ality, and specific characteristics, (C) Nutrition facts: total energy per serving, and the percentage of daily values for macronu-trients and micronutrients, and (D) Explanation and example of calculating the percentage of daily values.

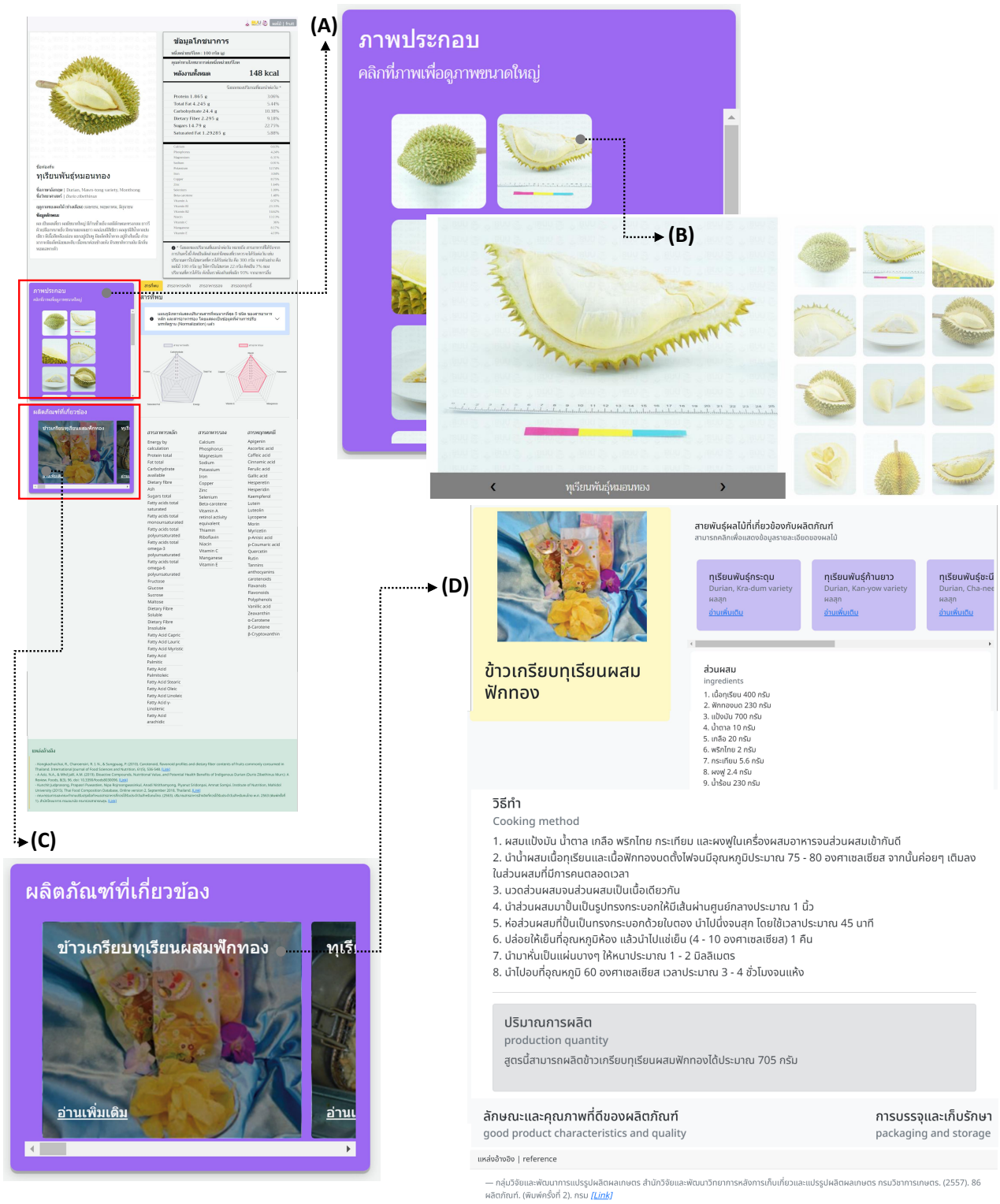

Figure 5. Sample page includes the following details: (A) Clickable illustrations to view larger images, (B) Images of the product from multiple angles, featuring three color strips, (C) Related product recommendations, and (D) Example of a pumpkin mixed with duri-an cracker product, showcasing information on fruit varieties used, ingredients, production methods, production volume, product characteristics and quality, as well as packaging and storage details.

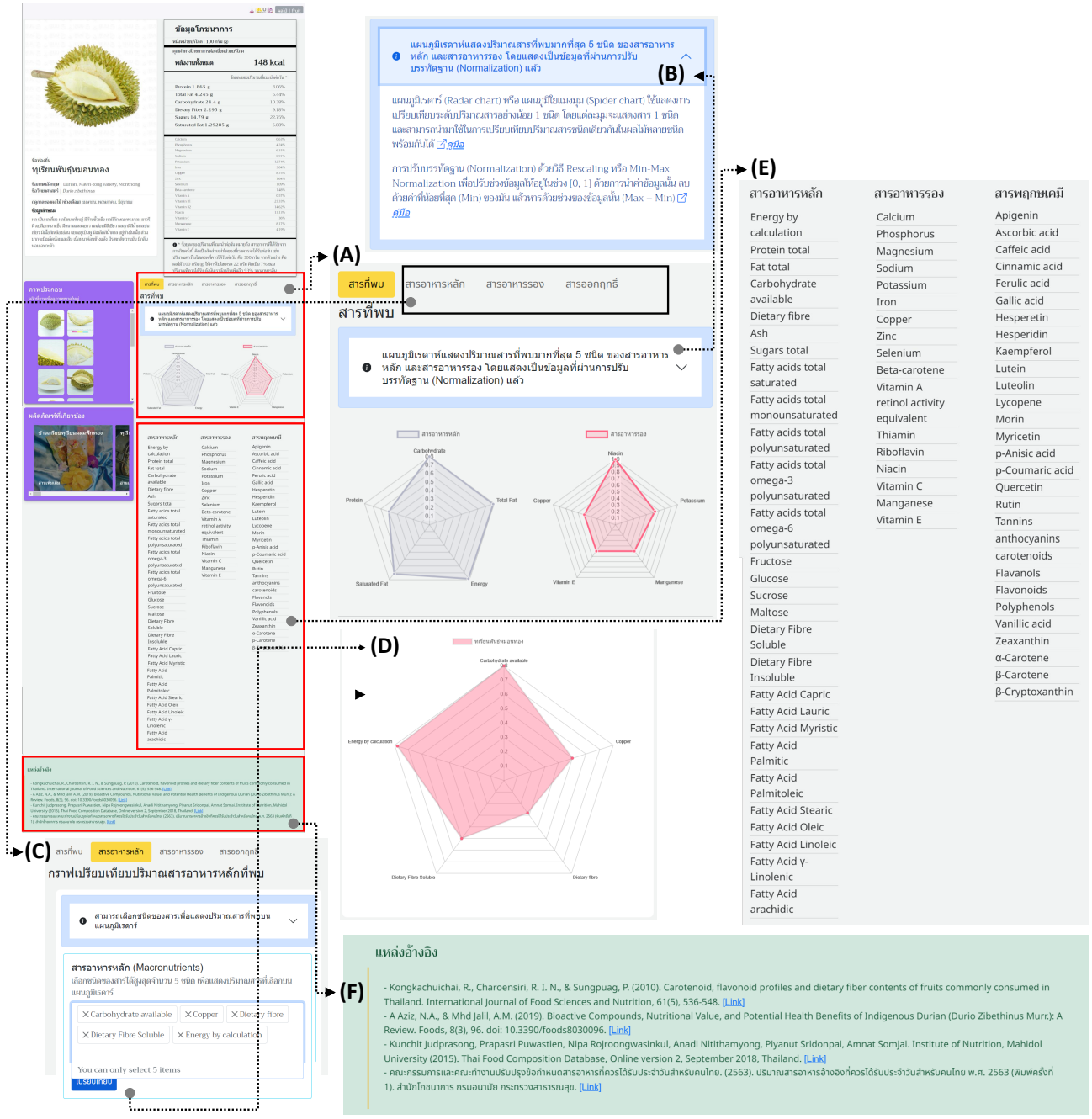

Figure 6. Sample page includes the following details: (A) Display of comparative data for major nutrients, minor nutrients, and active ingredients using a radar chart, (B) Explanation of the radar chart and normalization process, (C) Example comparing the amounts of up to five selected major nutrients, (D) Radar chart illustrating the comparison of all five selected major nutrients, (E) List of major nutrients, minor nutrients, and active ingredients, and (F) References indicating the sources of information.

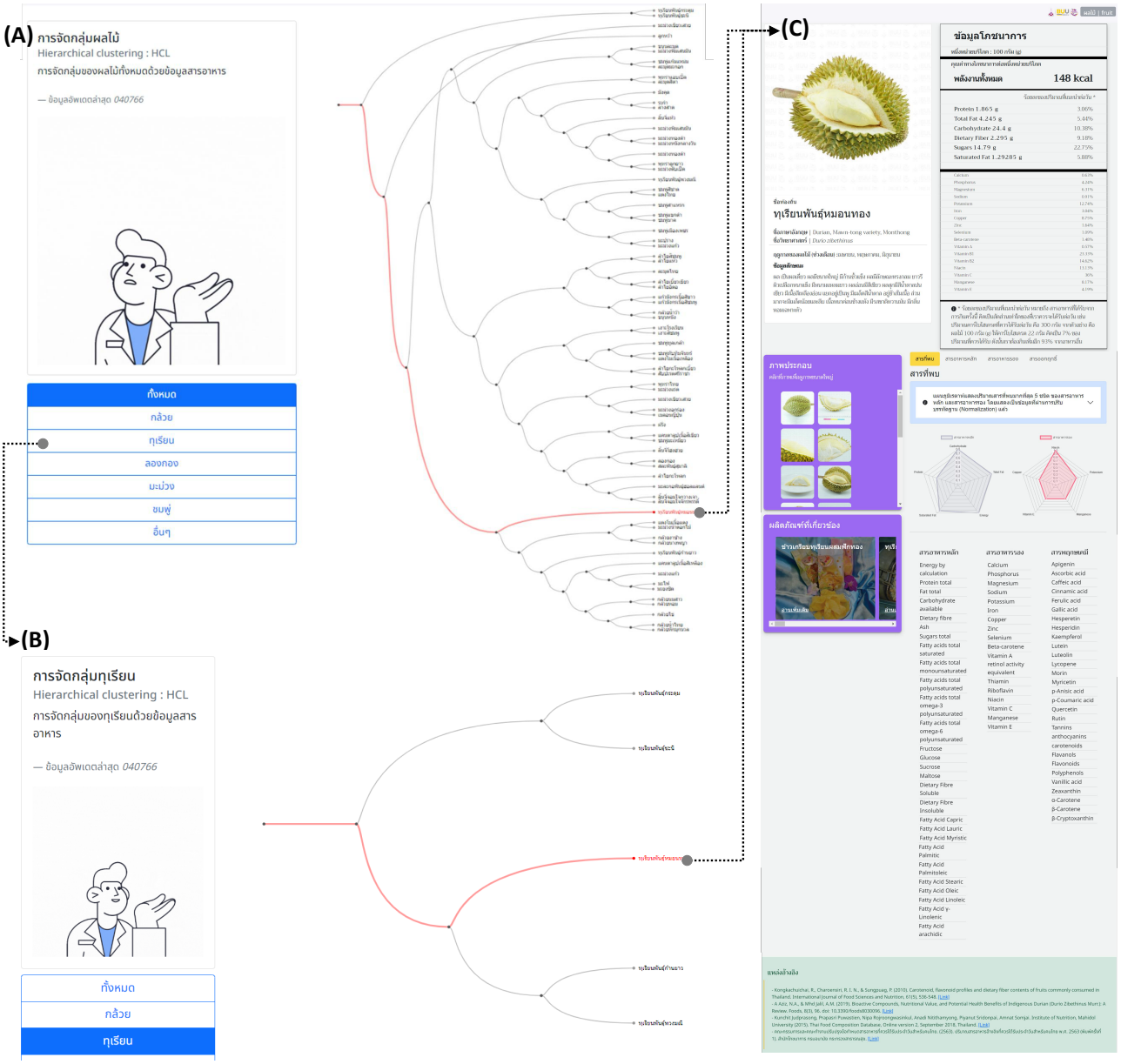

Figure 7. Grouping of all fruits based on nutritional information using the Hierarchical Clustering (HCL) technique. (A) Clustering of all fruits in the database, (B) Clustering of durian varieties. Clicking on the red line directs to (C) the nutritional information page of the selected fruit, here shown for Monthong durian.

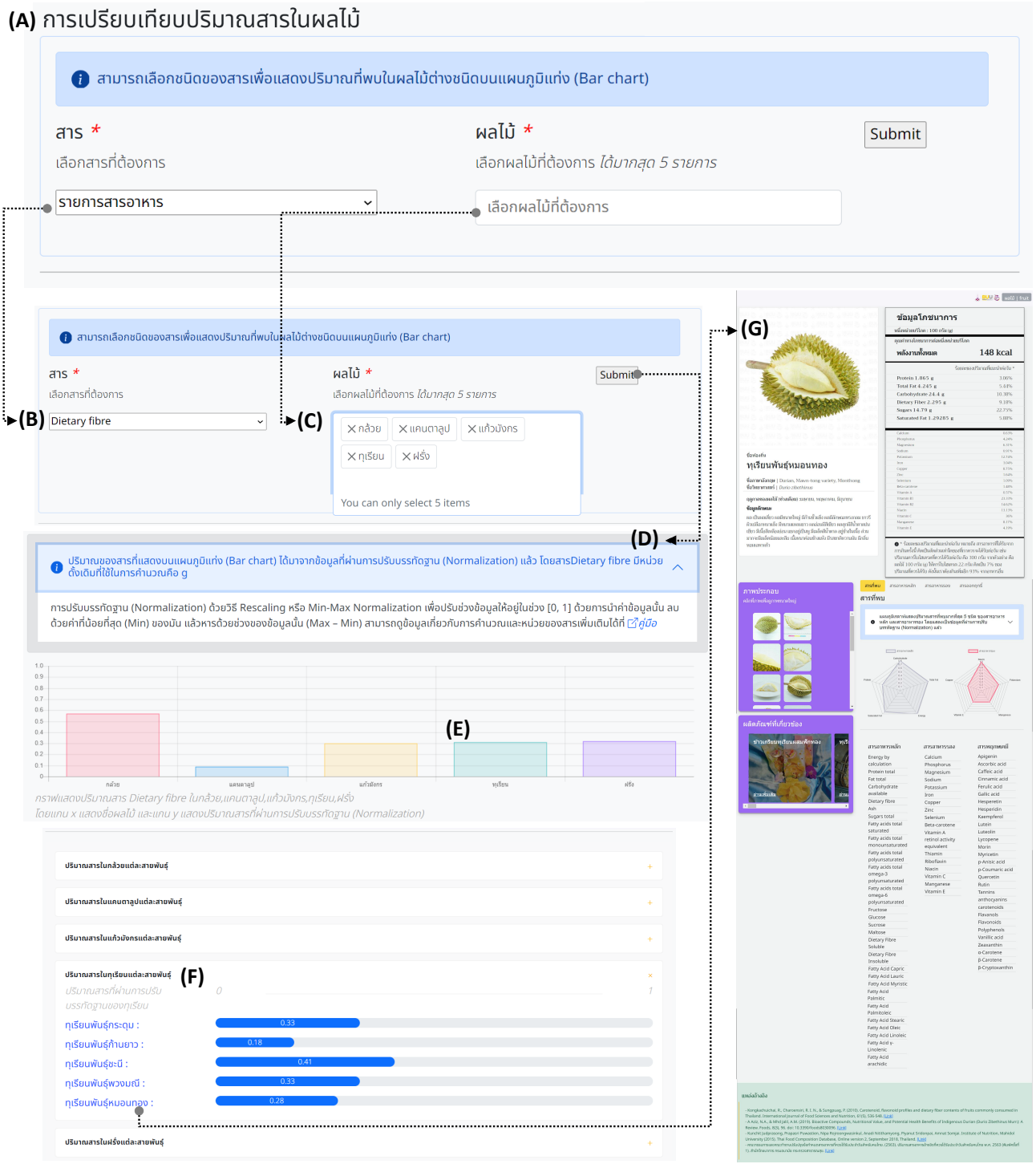

Figure 8. (A) Comparison of nutrient content in fruits, allowing selection of up to five fruits to display on a bar chart. (B) Example se-lection: 'Dietary Fiber'. (C) Five fruits: banana, cantaloupe, dragon fruit, durian, and guava. After submission, it displays (D) A bar chart with normalized data and description, (E) Bar chart of average dietary fiber across all durian varieties, (F) Bar chart of dietary fiber for each durian variety, with links to specific fruit pages, such as (G) Monthong durian.