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Research Article

A GCC Artificial Food Additives Management based Mobile Application Development

Ehab Adwan*, Jana Adwan, Entesar Alwedaei, and Maryam Mohsen

Department of IS, College of IT, University of Bahrain, Sakhir, Bahrain;
e-mail : eadwan@uob.edu.bh, janadwan@gmail.com, intesarwed@gmail.com, maryam201@gmail.com
* Corresponding Author : Ehab Adwan

Abstract: Artificial food additives pose significant health risks to Gulf Cooperation Council (GCC) citizens despite regional authorities' extensive medical, legislative, and technological efforts. Literature highlights the detrimental impacts of these additives, including malnutrition, digestive disorders, respiratory problems, skin issues, hives, nausea, diarrhea, shortness of breath, allergic reactions, high blood pressure, and tumors. The research project at hand aims at becoming the first official and comprehensive mobile application of its own in the GCC region that manages the calculation and demonstration of an up-to-date health and legal knowledge base of the impacts of artificial additives, enhances the awareness, automatically recognizes the artificial additives, and provides alternative solutions, for both android and IOS mobile platforms. This research project introduces "Weqaya," a pioneering mobile application designed to manage, educate, and raise awareness about the effects of artificial additives. Weqaya provides real-time health and legal information, identifies additives, and suggests alternative solutions for Android and iOS platforms. The project employs an Agile-based SDLC model to explore, develop, and evaluate the food additive phenomena in Weqaya. The application's usability evaluation scores a promising 95.21%, indicating its potential utility for GCC health ministries, dietitians, academics, researchers, and food producers in enhancing knowledge and promoting non-artificial food options.

Keywords: Artificial food additives management; Agile SDLC; Mobile application; OutSystems; GCC.

1. Introduction

With the huge expansion in the food market, consumers consume unlimited artificial food additives-based food products daily, ignoring the short and long-term impact of these additives on their health. Reference [1] defines artificial food additives as synthetic substances that are added intentionally to food products during food production, processing, packaging, and storage until the consumer consumes the food product [1], [2] list several food additives such as preservatives, nutritional, coloring agents, flavoring agents/enhancers, texturing agents, antioxidants, emulsifiers and stabilizers, colors, sweeteners, Flavorings, and other/miscellaneous additives.

According to [3]–[5], artificial food additives positively contribute to decreasing food deterioration, enhancing food appearance, and preserving meals throughout the year. Other studies, particularly in the GCC region, however, advocate that artificial additives negatively impacted GCC citizens by causing malnutrition and digestive disorders[6], [7], respiratory problems, skin problems, hives, nauseousness, diarrhea, shortness of breath, allergic reactions, high blood pressure[8], or tumors [4], [9]. Several medical, legislative, and technological efforts towards the phenomena of artificial food additives have been proposed by the governments in Europe [9], the USA [2], Japan [10], and the GCC region[10]–[14]. The EU legislation followed the European Commission with three safely accepted groups of directives preceded by " E number," including 15 accepted Sweeteners, 42 accepted Colors, and 80 accepted miscellaneous additives. However, the Federal Food, Drug, and Cosmetic Act (FFDCA) established the legal foundation for food safety in the USA at which food is divided

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into three categories: food additives (i.e., Saccharin), previously approved food ingredients (i.e., Sodium nitrate), and safe substances (i.e., Sorbitol). Alternatively, Japan approves two lists of food additives, each grouped into four main categories: designated food additives, existing food additives, food additive ingredients, and natural flavorings[8]. Alternatively, the Gulf Standards [7], [10]–[14] are adopted by the Council of the GCC countries (GSO 995/1998) according to the following food additives regulations, at which the internationally permitted additives in the GCC countries are denoted by "INS" while the maximum permitted food additives daily intake in mg/kg for various food categories "ADI".

Moreover, with respect to the software application developments, several initiatives have been proposed, as demonstrated in Table 2 in Section 2.5. European mobile apps have been proposed, including E Food additives, Food additives checker, E numbers, etc., while several mobile apps have been proposed in the USA, including Scan Halal food additive Haram, Food additives database, Food Additives, and MyFitnessPal. Alternatively, several Asian mobile apps have been proposed , including Ingredio. However, in the GCC region, there appears to be no unified mobile application that provides a calculation mechanism of artificial food additives to accept daily intake, an accurate and trustworthy knowledge base of identified natural and artificial food additives and health impacts, and an up-to-date base of information newly established legislations about artificial food additives.

To the best of our knowledge, the literature surveying reveals the absence of previous GCC-based mobile applications that collectively calculate additives, provide up-to-date information about additives, show the impact of additives, recognize artificial additives, and provide alternatives in one comprehensive and interactive management mobile application for both android and IOS platforms. The importance of Weqaya lies in its capability of firstly, expanding the level of awareness of the GCC citizens and residents regarding their food additives nutritional daily consumption, aiming to avoid any potential human health risks such as overconsumption toxicity, secondly, serving the ministries of health (MOH) and dietitians in providing a plan according to the calculations carried out, enriching the academic knowledge base, and persuading the organic food producers/factories to provide healthy food for their customers without any additives that will negatively impact them.

Derived from the research aim, the research project at hand achieved two research objectives: explore the artificial food additives phenomena and develop and evaluate the Weqaya mobile-based application that helps manage this problem by following a two-staged agile-SDLC model[15], entailing the exploration of the artificial food additives phenomena and the development and evaluation of a GCC mobile-based management application. The 1st stage was employed based on an interview with the MOH, a systematic literature review technique (SLR) for collecting best-reviewing articles [16]–[18], a content analysis technique (CA) to analyze worldwide mobile apps and their distinct features in multiple geographical locations [19], and a 1st questionnaire [20] to collect user requirements [21], [22]. The 2nd stage utilized several design techniques including data flow diagrams (DFD) [21], [22], entity relationship diagrams (ERD) [23], Process specification, DB schema, and Dialogue diagram [15], [21], [24]–[26], a requirement technique such as a 2nd questionnaire to collect the functional and non-functional requirements [21], [22] of Weqaya, an implementation technique by employing the Outsystems, HTML 5, CSS 3, JavaScript to develop user interfaces (UI)[27], unit testing [28], [29], and an evaluation technique including a 3rd questionnaire to evaluate the usability level score of Weqaya based on eight criteria and 22 sub-criteria of Nielsen heuristics[30].

Throughout the development efforts of Weqaya, the research work contributed to exploring the worldwide and GCC artificial food additives phenomena, designing the architectural specification of the GCC mobile application, constructing and testing Weqaya to support iOS and Android platforms, and evaluating the usability level of it based on Nielsen heuristics.

The research project at hand is composed of six sections. The literature review is introduced in Section 2, where Section 3 is dedicated to the research design method, while Section 4 aims to explore the application development's foundational analysis elements. Alternatively, Section 5 covers the application implementation, testing, and evaluation, while Section 6 debates the conclusion and future work.

2. Literature Review

Several techniques were utilized to investigate the relevant literature of food additives state of the art and associated global web and mobile applications managing them.

2.1. Literature review techniques

The SLR is a state-of-the-art collection technique and strategy that addresses the eligible pre-formulated research questions and adequate answers at which it describes, chooses, and develops a fine protocol and strategy for performing a comprehensive review of the articles and papers[16]–[18], [31] as illustrated in Table 1, advocates that the SLR is composed of five phases including selection of data source, applying searching formula, refining the document type items, manual reviewing, and exclusion and selection of the most cited work. Consequently, Google Scholar was chosen as an academically accessible off-campus search engine that covers several scholarly publications free of charge and provides citations and matrices. The use of Boolean operators and parentheses of four mainstream keywords and synonyms (Phase 1-Phase 3) revealed an initial list of 140 articles and papers, while the selection and reviewing (Phase 5) of the findings based on relevancy and with a minimum citation =1 revealed a final list of 53 articles, which were selected and used to enrich the theoretical and the empirical sides of the study. On the other hand, [19] advocates that CA/online textual analysis is a combination of a set of testing methods used by structured coding and analysis to define and draw inferences about online content, such as website content. Consequently, web content analysis (CA) was employed in this research project to analyze the web for similar applications, at which 12 mobile relevant applications were analyzed for common and special features of mobile food additives management apps, based on Nielsen criterians as suggested by [30], [31].

Table 1. The Systematic Literature Review (SLR) technique and findings

Keywords / Phases	Thematic subject	Articles
Keyword 1	Food additive; Mobile app; Artificial; Calculation	12
Keyword 2	Additives; Calories; Mobile app; Calculation	33
Keyword 3	Additive; Food Impact; Health	68
Keyword 4	Food additive; Mobile app; Development; Alternative	27
Phase1: Selection of data sources data	Google Scholar (Journal articles, Conference papers, Website reports)	140
Phase2: Applying searching formula data	AND/OR/NOT	101
Phase3: Refining the document items	AND/OR/NOT	73
Phase4: Manual reviewing and exclusion	AND/OR/NOT	62
Phase5: Selection and review of articles	Direct and Indirect Articles	51

2.2. Food additives

Artificial Food Additives are artificial substances or a mixture of artificial substances that are added intentionally to food products during food production, processing, packaging, and storage until the consumers consume the food product [1], [2] at which production refers to the preparation of raw materials of food into finalized products for human use while processing aids to characterize food additives as substances or additions of natural or synthetic origin used in the manufacturing of foods to increase and improve the product quality and consistency. Alternatively, packaging is a method of protecting processed food from alterations.

Advocated by [1], [2], [32]–[34], food additives are classified into eight categories: Preservatives, Antioxidants, Emulsifiers and stabilizers, Colors/Coloring foodstuffs, Sweeteners, Flavor enhancers, Flavorings, and other additives at which preservatives according to [32], [35], [36] are utilized to keep some items safe over a period of time while extending their shelf life by preventing bacterial breakdown, which can result in toxin formation and food poisoning. Antioxidants, however, are antioxidants that delay oxidative degradation and increase the shelf life of food.

Concerning Emulsifiers and Stabilizers, [2], [37] believe they are used to make it easier for substances like fat and water to mix that otherwise wouldn't, while Colors according to [32], [35], [36] are used to improve Foods' visualization. However, Coloring foodstuffs are ingredients on the label without specifying their purpose. At the same time, Sweeteners are categorized into bulk and intense and are allowed in foods that either contain less energy or

no added sugar[2]. Flavor enhancers, on the other hand, are food flavor enhancers as ingredients. At the same time, Flavorings take the form of a combination of different flavoring preparations and specific chemical components. In contrast, other additives refer to other categories such as thickeners, acids, acidity regulators, anti-caking agents, anti-foaming agents, bulking agents, carriers, glazing agents, humectants, raising agents and sequestrates[2], [32].

2.3. Health impacts of food additives

Regarding the impacts of additives, [3] believe that some food additions preserve or increase the meal's nutritional value. This includes flour, bread, biscuits, breakfast cereals, and pasta because they contain added vitamins a, c, d, thiamine, niacin, and riboflavin, while according to [4]–[6], several additives cause bad medical reactions including such as Digestive disorders such as diarrhea and colicky pains, Nervous disorders such as hyperactivity, insomnia, and irritability, Respiratory problems such as asthma, rhinitis and sinusitis, and Skin problems such as hives, itching, rashes and swelling, allergic reactions including dizziness, headaches, heart palpitations, nausea and chest pain, cancer, asthma, digestive problems, and other unclassified problems.

2.4. Legislations of food additives

There are regional legislation variations of specific food additives from Europe, USA, Japan, and the GCC regions[2]. For example, the EU legislation was developed following the European Commission in 1985. According to[7], there exist three adopted directives such as Directive 2008/60/EC "Sweeteners Directive," Directive 2008/128/EC "Colors Directive," and 2008/84/EC "Miscellaneous Additives Directive," which permit and list additions of 15 sweeteners, 42 colors, and over 280 further additives), as well as both general and specific food categories in which each additive is legal and necessary maximum levels of use. For example, the "E" number indicates that food additives are accepted as safe for use in food by the European Commission's Scientific Committee on Food (SCF). Research [7] lists a group of food additives, including Sweeteners, Colours, Preservatives, Antioxidants, Carriers, Acids, Acidity regulators, Anticaking agents, Antifoaming agents, Bulking agents, Emulsifiers, Emulsifying salts, Firming agents, Flavour enhancers, Foaming agents, Gelling agents, Glazing agents, Stabilizers, Thickeners, and Flour treatment agents. The EU Labelling Rules on Food Additives Directive 2000/13/EC enforces food ingredient lists by category name, followed by E number.

Alternatively, according to [2] and [8], the USA's food legislation has evolved in its own ways. The Federal Food, Drug, and Cosmetic Act (FFDCA) establishes the legal foundation for food safety in the USA at which food is divided into three categories: food additives (i.e., Saccharin), previously approved food ingredients (i.e., Sodium nitrate), and safe substances (i.e., Sorbitol). In addition, [2], [8], believe that food additives are direct, secondary, or indirect, depending on their use. The direct type is divided into eight categories [32], [35], [36]: Firstly, Food preservatives, coatings, and films. Secondly, Related substances, special dietary. Thirdly, Nutritional additives; Fourth, anticaking agents; flavoring agents. Fifth, related substances: gums and chewing-gum bases. Sixth, Related substances; Seventh, other specific usage additives; and Eighth, multipurpose additives. The secondary direct is divided into four categories: polymer substances and polymer adjuvants for food treatment; enzyme preparations and micro-organisms; solvents, lubricants, release agents, and related substances; and specific usage additives.

Japan approves two lists of food additives, each of which is grouped into four main categories: Firstly, designated food additives; Secondly, existing food additives; Thirdly, food additive ingredients; and Fourth, natural flavorings [8]. For the designated food additives, there exist several guidelines such that food additives must be effective and present no hazard to human health, food use must be of benefit to consumers, the safety of food additives must be proven or confirmed in the intended use methods and must conform to certain specifications.

On the other side, according to [7], [10]–[14] the Gulf Standards are adopted by the Council of the GCC countries (GSO 995/1998) according to the following food additives regulations, at which the permitted additives in the GCC countries are denoted by "INS" that

refers to the international food additives numbering system, while "ADI" refers to the maximum acceptable food additives daily intake in mg/kg for various food categories including meat, poultry and game (feathered and furred birds).

2.5. Food Additives Mob/Web Applications

As an analysis of CA collected data, Table 2 illustrates the comparison of relevant mobile and web applications in the market based on several types, geographical location, purpose, and general, and specifically dedicated features. Concerning the general features collected by the CA technique[19], the Registration and subscription fee (login) was present in [38]–[42] of Table 2, having registration and subscription fees feature. Besides, some applications provided the registration feature with extra fees (subscription fees). A registration system is vital to Weqaya because it will save time for both sides and allow easy administration of participants by following the participant status (i.e., canceled, registered, etc.). Information can be easily collected to carry out useful statistics and make relevant decisions based on it. Moreover, having this feature in Weqaya will also improve customer service by collecting information from the user and using it to benefit the customer. They will be updated directly of any new updates. Most of the applications have no registration system except the previously mentioned applications. There may be some users who prefer applications without a registration feature. However, this feature is vital to benefit the user better and support their needs by knowing their credentials.

Either way, users will have both choices. Consequently, the Weqaya application is intended to do a registration so the user can choose what they prefer. Accessing (Offline Access) was found in 3 applications [38], [39], [43]of Table 2, which have offline access features, while others require a reliable internet connection. Offline access is a feature that allows the user to access mobile apps without being connected to the internet. Weqaya is intended to provide an offline access database so users can navigate it without an internet connection.

However, navigation was present in 11 applications [38], [39], [43]–[45] and [40]–[42], [46]–[48] of Table 2 and has navigation tools that are essential for the users to find what they intend quickly. All related data is connected to access it easily. However, most applications use only one way to navigate: the tab, navigation, or menu bar. Consequently, in Weqaya, the Tab Bar, a navigational element, is immediately noticeable when the application is accessed. All the pages and features offered can be easily and simply navigated with this Tab Bar. The Navigation Bar enables the user to return to the previous page and provides info, is another key navigation component. Furthermore, Weqaya is intended to propose a menu bar for more efficient navigation.

Finally, Searching Food Additive Information was found in 11 applications [38], [39], [48], [40]–[47] Table 2, having a searching feature, and all of them used a visible search bar at the top of the app, at which E-Food additives application has a search bar that allows the users to search by the additives name, and Search by hazard where the user can filter search results for hazard information and products using the Advanced Hazard Search so to demonstrate that your additives does not have these characteristics you can search the list of additives with low hazards for categorization. Food Additives Checker Application and Food Additives database website allows users to search by additives name or E-number quickly and easily. The e-number application has a dynamic search feature that begins scanning the dictionary for the words as you input, a simple method for sharing with your pals. Consequently, Weqaya intends to create a search feature that allows users to search by the additive's name and E-number.

With respect to specific features, Bookmark (Offline storage) food additives info was present in 3 applications [38], [39], [41] of Table 2, which all used a visible search bar at the top of the app, at which E Food additives application has a bottom that allows the users bookmark. Bookmark enables users to save and share links. This is a good solution for storing and organizing important links for users. However, the Scan Halal food additive Haram application has search history storage so that the user can control their browsing history and other information, including stored form data. In E-Numbers, users can save their search history in a bookmark list, where they can go back to it whenever they need. Consequently, Weqaya is intended to make a bookmark list to save your search history and easily access your favorites. Color-coded danger levels and diseases were present in six applications [38-40], [43-44], [49] of Table 2, which have color-coded danger levels and diseases, E-food additives provide levels of danger, health warnings (if any), the various color grades identify clearly

between safe, hazardous, and neutral additives: (Red denotes danger, orange risk, yellow denotes uncertainty, green denotes safety and no adverse effects, and gray is unknown).

Table 2. Comparative Analysis of Previous Technologies

					General features						Specific features		
Apps Name	**Ref**	**Apps Type**	**Loc**	**Purpose of Application**	Registration and subscription fee (login)	Accessing (Offline Access)	Navigation tools	Searching Food Additive Information	Bookmark (Offline storage) food additives info	Color coded danger level and diseases	Scanning food bar/QR code	Halal, Haram, Mushbooh Classification and Checker	Calculator (Additives rate)
E Food additives	[38]	Mob	EU	Food add DB	X	X	X	X	X	X			
E numbers	[39]	Mob	EU	Food add DB	X	X	X	X	X				
Info Cons	[40]	Mob	EU	Food add DB, Calc	X		X	X		X	X		X
Scan Halal food add	[41]	Mob	EU, US	Food add DB, Halal Check	X		X	X	X		X	X	
Food additives DB	[42]	Web	EU, US	Food add DB	X		X	X					
Food additives checker	[43]	Mob	EU	Food add DB		X	X	X		X			
Yuka Food & cosmetic	[44]	Mob	EU	Food add DB, Halal, AlertSys			X	X		X	X		
Lifesum	[45]	Mob	EU	Food add DB, Calc			X	X					X
Ingredio	[46]	Mob	ASIA	Food add DB			X	X			X		
MyFitnessPal	[47]	Mob	US	Food add DB, Calc			X	X			X		X
Food Additives	[48]	Mob	US	Food add DB			X	X		X	X	X	
E- inspect Food add	[49]	Mob	EU	Food add DB				X		X			
Weqaya		**Mob**	**GCC**	**Food add DB, Calc, Halal Chk, AlertSys**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

Food additive checkers provide a description of side effects and a color-coded list of danger levels (green = safe, orange = be careful, red = dangerous). In contrast, food additives provide the customer with a wealth of information on each ingredient and a list of components with allergies highlighted in bold. Yuka provides a color-coded system for the additives where each color represents the level of danger of the additive. For E- inspect food additives, each additive's safety assessment for this app is shown as either "considered safe," "suspicious," "avoid," "dangerous," or "risk unknown.". Weqaya is intended to make a color-coded

danger level and diseases system where each additive will have a color based on the level of danger (Green = "safe", Yellow= "neutral", red = "dangerous").

However, Scanning food bar/QR code was found in six applications [40], [41], [43], [44], [46], [47] of Table 2, which have a scanning feature. In Scan Halal, a mobile app can scan the food additive Haram product's contents to determine whether they include preservatives, colors, or other food chemical additions. The food additives app offers a product scan option and a list of food additives for each scanned product. In Yuka, you can quickly determine how certain foods and personal care items may affect your health by scanning their barcodes. InfoCons provides a scanning feature where you can scan the bar code with your camera to display the additives in the product. Ingredio will allow you to capture product ingredients, upload a photograph, or scan the ingredients to check their information. While MyFitnessPal will provide the customer with the option for a bar code and meal scanning. The other six applications don't have a scanning feature. Consequently, Weqaya is intended to provide a scanning feature where the customer can scan the bar code to display the product additives and their information.

Halal, Haram, Mushbooh Classification, and Checker were available in Scan Halal food additive Haram food additives apps. Having a Halal, Haram, Mushbooh classification. Scan Halal food additive Haram will determine whether they include preservatives, colors, or other food chemical additions that are Halal, Haram, or Mushbooh. The food additive application provides a status that informs you of the additive's vegetarian, vegan, Halal, or kosher status. While the remaining ten applications don't have this feature. Consequently, Weqaya intends to do a classification system for the additives where each additive will be classified into Halal, Haram, or Mushbooh. Alternatively, the Calculator (Additive rate) was found in three applications (i.e., lifesum, InfoCons, MyFitnessPal) with an additive rate calculator. Lifesum app will provide a digital self-care tool that assists you in achieving your health through better eating. This app will calculate everything for the user. Additionally, the rating system is intended to assist in forming new routines and daily healthy decisions. InfoCons provides a calculator system to calculate food additives within the product. With MyFitnessPal, you will see users' daily progress. While the nine applications don't have a calculator system. Consequently, Weqaya intends to develop a calculator system for additives rate.

3. Proposed Method

3.1. The research design model

As per the insights of [21], the Agile-SDLC approach was selected as the most suitable research study because of its capability to plan, develop, and monitor the mobile application and is divided into exploratory and mobile development stages as depicted in Fig. 1. Obviously, this approach is comprised of two stages; Artificial food additives Exploration and Mobile Application Development and Evaluation. Those stages comprise seven integrative phases: identify the problem, opportunities, and objectives. Determine human information requirements, analyze system needs, design the recommended system, develop and document the software, test and maintain the system, and implement and evaluate the system. The 1st stage was executed following the SLR, CA literature surveying methods, an interview, 1st and 2nd questionnaires to collect and analyze the user and system requirements. While the 2nd stage was initiated by employing a 3rd questionnaire to evaluate the performance of Weqaya.

Moreover, the 1st phase affects the completion of the project [15], [31], while the 2nd phase identifies human needs by using electronic questionaries, and interviewing can help when the need is reported and concluded at the end of this phase [15], [31]. The 3rd phase involves using tools, such as data flow diagrams or use case diagrams, to show how the events are processed and describe the system's structure and how it will look at the end. A proposal will be necessary to be prepared in this phase for the system , which includes data about the applicant that have been found during data retrieval, ease of use and convenience of the framework, giving a cost analysis /benefit of other options, and making suggestions on what to do [15], [31]. The collected information will utilize the logical information system design in the 4th phase [15], [31]. During the 5th phase, the application will be developed [43], while the 6th phase enforces the test method. The implementation and evaluation based on certain criteria of the developed information system begin during the 7th phase [15], [31].

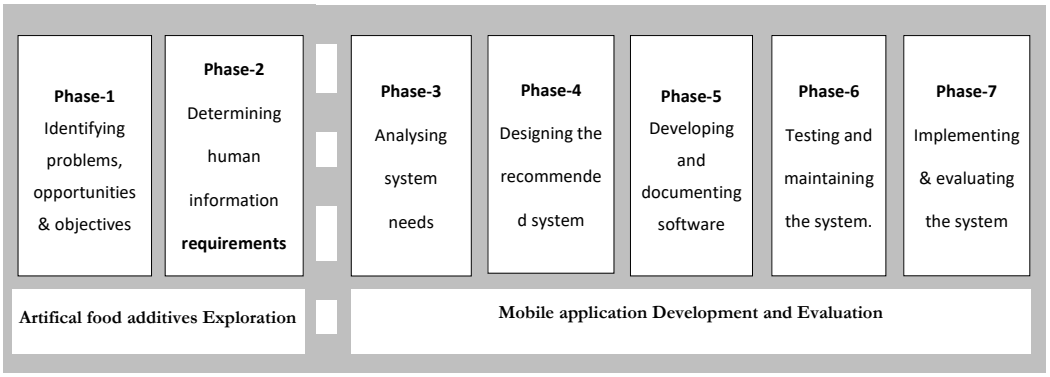

Figure 1. The Research Design Model

3.2 Requirements collection techniques:

An interview was initiated at the beginning of March 2023 with the Bahraini Ministry of Health (MOH) to collect insights about Bahrain and the GCC's food additive phenomena and requirements. In addition, the following 1st and 2nd questionnaires were designed to collect information that aligns both the user and system requirements of Weqaya with the business and system requirements [20]–[22]. During May 2023, the 1st and 2nd questionnaires were conducted to collect respective data. The sample size for each was measured as in Equation (1) to be 130 with a population size of Bahrain [50], [51], a margin of error of 5.6%, and an 80% confidence level. Thus, N = population size, e = Margin of error, p = percentage of the population, and z = z-score (the number of standard deviations a given proportion is away from the mean).

$$\text{sample size} = \left(\frac{\frac{\left(z^2 \times p(1-p)\right)}{e^2}}{\left(1 + \left(\frac{\left(z^2 \times p(1-p)\right)}{(e^2 N)}\right)\right)} \right) \quad (1)$$

The 130 responses of 1st questionnaire were analyzed and used to design and build the system based on client needs, at which the questionnaire was divided into three parts. The first part consisted of basic questions to understand the individuals' preferences based on age, nationality, and other generic parameters. The second part consisted of questions related to artificial food additives, awareness of the phenomena, and generic information about artificial food additives. The 2nd questionnaire was dedicated to the proposed Weqaya mobile-based application with a sample size of 130 [50- 51] and with 130 respondents. The questions focused on the Functional (FR) and Non-Functional Requirements (NFR) [20- 22].

3.3. Application development techniques

This section explores the system techniques employed to describe the models of Weqaya that acknowledge all the requirements collected in previous stages. Additionally, Weqaya development aims to create and design the intended application. This includes System models (level-0, Level-1 DFD), Process specification, and System design (ERD, Data dictionary, and Dialogue diagram).

The DFD is a SAD tool that helps in planning, developing, visualizing, and explaining a system and is a representation of graphical diagrams where it outlines systems' specifications in a graphical view ranging from a brief representation (level 0) to a detailed and specific representation (level 2) [21- 22]. Any system consists of three core components to achieve its objective: input, process, and output, where the data flows into the system as an input. The system processes the data and provides the end user's output , which is the service. DFD levels include those components to achieve such a goal by representing the entities, data stores, data flow through a system, and its processes [21- 22].

A context diagram is a level 0 of the DFD that provides a fundamental abstract of the entire system. It provides a high-level overview of the main functions in the system and the interaction between the external agents in the system through those functions. Level 1 and 2 decompose the originally designed level 0 [21- 22].

The Process specification is described by [15], [21], [24- 26] as a method of assessment, summarization, and documentation of the formulas and reasoning behind decisions made to produce high-quality, consistent, and clear o/p results from processed input data that aims to outline and convey the procedures and requirements of the regulations. The Entity relationship diagram (ERD) is defined by [23] as a graphical format of a data FW that outlines the links between people and surrounding entities. The database schema, as insight by [15], [21], [24]–[26]outlines the relationship between different tables and how they are connected, like the concept of a blueprint of the building created by an architect consisting of schema objects such as tables, views , relationships at which it includes the table records, attributes, and their connections, and the name of the attribute and its keys (primary and foreign keys) which are all used in managing the stored data and knowing the database's shape. Alternatively, a dialog diagram is defined by [15], [21], [24- 26] as a methodological mapping approach that shows navigability between the user and the system and how to navigate between pages in the system, which acts as the system map.

3.4 Application implementation and testing techniques

The implementation phase aims to program the application w.r.t the previously collected Functional and Non-Functional requirements, at which the system's development, testing, and installation are explicitly performed. According to [27], OutSystems released a mobile building service (MABS), a fast, reliable, and secure service for building mobile applications at which it produces a ready-to-install application. OutSystems applications are built using Apache Cordova (i.e., an open-source mobile framework) that allows the use of HTML5, CSS3, and JavaScript for cross-platform mobile application development. Using the plugin source code and applicational configurations, OutSystems generates mobile packages to be installed on mobile devices based on Android Build Tools, iOS Xcode, and SDK. However, the server code is secured while the client-side code and plugins are sent to the service [27]. The Apache Cordova is an open-source mobile development framework. It allows you to use standard web technologies - HTML5, CSS3, and JavaScript for cross-platform development. Applications execute within wrappers targeted to each platform and rely on standards-compliant API bindings to access each device's capabilities, such as sensors, data, network status, etc. [27]. Moreover, for the database implementation, the OutSystems platform integrates with large database systems, supported by various integration builders such as SQL Azure, Oracle, MySQL, SQL Server, DB2 iSeries, PostgreSQL, Aurora PostgreSQL, and Azure PostgreSQL for RDBS, as well as MongoDB for non-RDBS [27].

The Validation and Unit testing techniques were recommended by [28]–[30] to guarantee the correctly entered I/P data types and ensure that each application's unit works as expected. [28]–[30] define Unit testing as software testing where software units are tested to validate that every unit performs as planned. This is done during the application's development stage by isolating a part of the program code and verifying its performance.

3.5 Application evaluation technique

The usability of the Weqaya mobile-based application was measured based on a 3rd questionnaire based on 25 of 5 Likert scale-based questions by following Nielsen's heuristics[30], which are composed of 8 major criteria and 22 sub-criterions. The questionnaire was designed online and carried out during December 2023, with a sample size of 30 [50- 51], with 30 respondents, with an error margin of 6% and 90% confidence level, to Bahrain's mobile application users [50]. The sample size was calculated using Eq. 1, where N is the population size of Bahrain, e is the error margin, p = percentage of the population, and z is the no. of standard deviations from the mean [51]. Nielsen heuristics include visibility, which indicates how conspicuous the system is to the users from different service viewpoints. While the model accuracy shows three main sub criteria that were used to build the model accuracy: user control, which indicates the evaluation based on navigation and menus as well as simplicity. Consistency refers to the users using such mobile applications and the elegant design UI alongside other media being used within privacy and security. The usability is measured according to Equation (2), at which each criterion (%)= the average of the summation of sub_criterians (%). Thus, the overall usability (%) = the average of the summation of criterians (%).

$$\text{Usability (\%)} = \left[\sum \text{Satisfaction} \left(\sum \frac{\text{subcriteria}}{\text{No. of subcriteria}}\right) 100\%\right] / 8 \quad (2)$$

4. Results and Discussion

4.1 Requirements analysis

As for the users and FRs of Weqaya, the 1st questionnaire revealed that 84.6% of participants identified themselves as clients, with 84.6%. In comparison, Medical institution representatives like Dietitians and researchers constituted 4.8% of the participants. Furthermore, Food producers made up 1.4%, implying that most features should have been dedicated to clients. Of the participants' residents, 98.1% were GCC residents, which was higher at 98.1%, implying that GCC people were more interested in exploring and managing the daily intake of artificial food additives. 46.2% and 37.5% of the majority of the participants were 18-30 years old and 30-50 years old, respectively, implying that the application must have a modern appearance and design to satisfy the youth and Ease of use and navigate to satisfy the older people. That's why we have selected the mobile-based application type for Weqaya. A response of 82.7% was for females , while males represented 17.3%, implying that females are more interested in artificial food additive management.

Also, 82.7% of the respondents heard about artificial food additives, while 17.3% didn't. This implies that the problem of artificial food additives is known in society and considered a crucial issue that must be managed; 75.6% of the respondents are aware of the purpose of Artificial food additives, while 24.4% are not, implicating the importance of this project to help to manage artificial food additives. Furthermore, this can help increase awareness in people unaware of it. In addition, 82.7% of the participants were interested in exploring artificial food additives in Bahrain and GCC. Meanwhile, only 17.3% weren't, indicating that people in GCC and Bahrain are interested in knowing about artificial food additives and learning more about their purposes, advantages, and risks. Furthermore, it also shows that people are willing to manage the accurate daily intake of food additives. In addition, Table 3 demonstrates the Functional requirements.

As per the reasons of the participant's interest in knowing about artificial food additives, 76.7% wanted to be aware of artificial food additives' side effects, 68.6% of respondents were interested to be aware of Halal, Haram, Mushbooh artificial food additives, 57% of respondents wanted to manage and not to exceed the safety limits of artificial food additives, and 44.2% of respondents showed an interest in being aware of chemical names on food products labels. This implies the importance of showing artificial food additives' side effects must be provided in the application, and the other reasons must be considered due to its high percentages. Alternatively, 44.2% of participants agree about the positive impact of technology 40.7% strongly agree that it will enhance, while 14% feel neutral and 1.2% disagree. This indicates that the majority of people believe in the role of technology to enhance the management of artificial food additives and respond positively to the technology related to this issue. Moreover, for participants % preference for the technology tool used for the artificial food additives application, according to the responses, 61.6% preferred the mobile app, while 24.4% preferred to use the website. 14% think it doesn't matter if it's a mobile app or website, implying that Weqaya was better for a mobile-based application.

Moreover, 4.7% of participants preferred to navigate between interfaces by menu bar, 37.2% preferred tab bar, and 15.1% preferred bar. This implies that users are much more comfortable with the menu bar. For the most convenient way to browse the list of all additives, 40.7% preferred a content list, 33.2% preferred tiles, and 29.1% preferred details. For searching functionality, 69.8% preferred to search by text, 40.7% by using pictures, and 39.5% by barcode scanning. Meanwhile, only 14% were by voice, implying that users were more convinced to search by text method for artificial food additives and other methods could be considered in the Weqaya application. For the service delivery by internet, 60.7% of the participants often didn't experience a disconnected internet service, while 39.3% didn't. This indicates the application could provide the service by connecting to the internet. However, some features may not require the internet to provide. As per the feature of inserting the additive in the application, 60.5% preferred scanning the food bar/QR code, while 27.9%

preferred uploading a photo and 11.6% manual insertion, implying that users were more comfortable with inserting additives in the application by using scanning bar/QR code.

Table 3. The functional requirements of the Weqaya Application.

Function No.	Function features
F01	**User Registration**
Description	Feature that allows users to register into the application using their credentials.
Activities	1. A user registers personal info to create an act. 2. System verifies and validates user email of user credentials. 3. The system stores user credentials and info.
F02	**User Login**
Description	Feature that allows users to register into the application using their credentials.
Activities	1. The system checks the validity of the email. 2. System sends email confirmation to the user 3. The user responds to the email 4. System validates the user 5. User enters login credentials (username and password)
F03	**Product Scanning**
Description	The feature that allows users to scan product barcodes.
Activities	1. System requests camera authorization from a user 2. User accepts authorization 3. User scans product label 4. System retrieves stored additive info 5. System displays additive info.
F04	**Food Additive Searching**
Description	Feature that allows users to search for information about food additives.
Activities	1. The user looks up the food additive in the search engine. 2. System retrieves info. 3. The system displays relevant info to the user.
F05	**Danger level Classification**
Description	Feature that provides users with three danger levels and possible diseases.
Activities	1. User enters the additive name. 2. System retrieves info 3. The system displays color-coded danger level of each additive. 4. The system displays possible diseases caused by each additive.
F06	**Halal, Haram, or Mushbooh Classification**
Description	Feature that allows users to detect Halal, Haram, or Mushbooh.
Activities	1. User enters the additive name. 2. System retrieves info. 3. The system displays the additive status of Halal, Haram, or Mushbooh.
F07	**Calculation of maximum additive daily intake**
Description	The feature allows users to remember the maximum daily intake of food.
Activities	1. The user enters product info by either searching or scanning. 2. System retrieves info. 3. System calculates additive allowed daily intake consumption (ADI).
F08	**Bookmark Food Additive**
Description	Feature that allows users to bookmark previously performed findings.
Activities	1. User bookmarks info of searched additive. 2. User bookmark info of searched products. 3. The system saves info on searched additives and products.

In addition, 54.7% preferred warnings and restrictions of food additives to be displayed in the application, 32.6% preferred to receive SMS, and 12.6% preferred to be displayed and

received from email. This indicates that people find it easier to have the warnings and restrictions displayed in the application. However, 75.6% of the participants preferred additives level of danger to be shown in a color-coded system, 15.1% additives' level of danger to be shown in percentage, and 19.3% in text. Also, 60.5% of the participants could not determine whether the product was Halal, Haram, or Mushbooh, indicating that Weqaya must support solving this issue for the people in GCC and Bahrain. 76.9% of the participants were strongly concerned about the Halal, Haram, or Mushbooh classification for the additives, and 13.5% agreed, while 5.8% felt neutral about it and only 3.8% were not concerned.

Moreover, as for the most efficient way to calculate the acceptable daily intake of artificial food additives, 48.8% preferred an automated calculator, 33.7% excel file, and 17.4% voted for manual calculation, implying that an automated calculator was the easiest way for users. For the reception of the daily intake statistical report preference, 81.4% preferred a displayed report, and 18.6% preferred a report received by email. 79.1% preferred to download the report as a PDF document, 20.9% preferred not to download the report. For daily usage of Weqaya, 47.7% preferred once a day, and 46.5% 2-5 times/day. For the OS compatibility, 97.7% preferred compatibility with iOS and Android. Alternatively, as per the design considerations, 64% preferred ease of navigation, 46.5% preferred design simplicity, 43% wanted data consistency, and 34.9% preferred interactive design. Finally, for how users view privacy, 68.6% looked at privacy as their data are not shared with third parties, 19.8% Anonymous identity, and 10.5% chose data not used for decision-making purposes.

4.2 Application development analysis

Appearing in Figure 2, the context diagram DFD (Level 0) of Weqaya showcases the system's structure and relationship with external agents, while Level 1 and Level 2 are depicted respectively in Figures 3 and 4 to represent a decomposed level of details into multiple subprocesses. Regarding the ERD, Figure 5 represents 13 entities and four tables for the Weqaya mobile application to articulate information architecture clearly to support the entire process's technological logic. This includes the user, additives, profile, and bookmark. In addition, the process specifications, as illustrated in Table 4, demonstrate seven processes named registration/login, Scanning product labels, Searching for food additives, Classifying danger level, Classify Halal, Haram, Mushbooh, Calculate additive daily intake, and Bookmark additives. Regarding the database schema, Table 5, Table 6, and Table 7, respectively, represent the application form data dictionary, the additives table data dictionary, the bookmark table data dictionary examples, and an excerpt of Weqaya application database records. Alternatively, the dialogue diagram of the Weqaya application is depicted in Fig. 5 to illustrate the eight window interfaces of the mobile application.

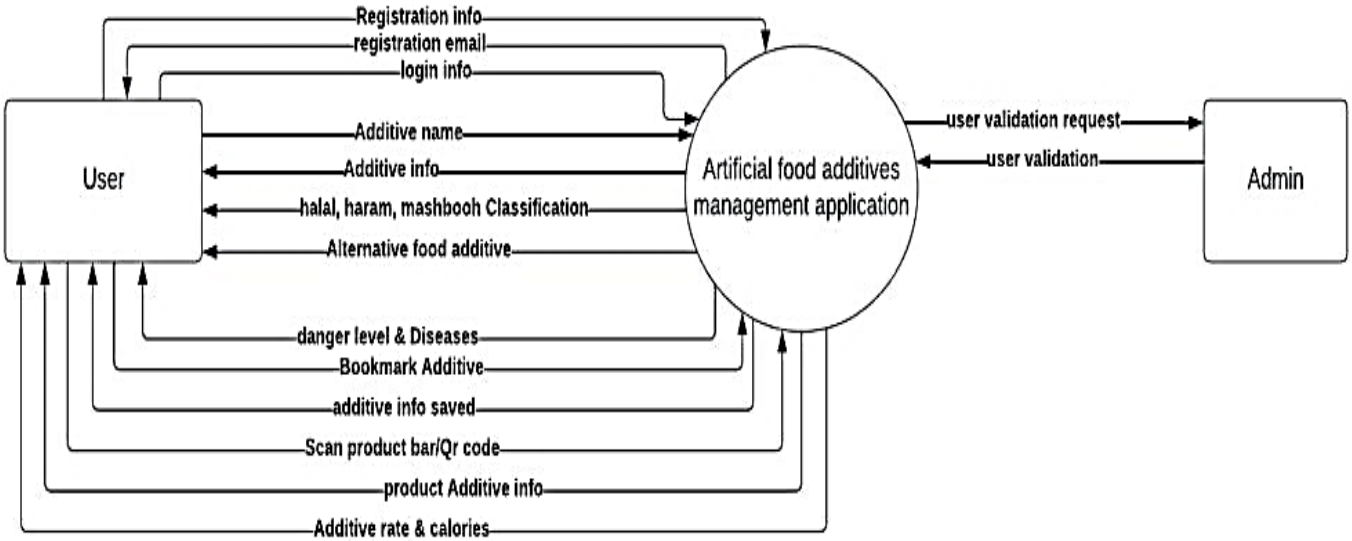

Figure 2. The Context Diagram of Weqaya

Table 4. The process Specification of Weqaya application

Process Name	**Registration /Login**
Description	The user signs up/registers by entering personal info and receiving an email confirmation.
Input	User Personal info, including name, username, contact details, email, and password.
Output	User registration and login (access)
Process Name	**Scan product label**
Description	The user accepts camera authorization and then provides a product label to receive additive product info.
Input	Product label
Output	Display the product additives and their information.
Process Name	**Search for food additives.**
Description	Users search for additives by entering the additives' names and receiving relevant info.
Input	Additive name or product details
Output	Additive information and bookmarked additive information
Process Name	**Classify Danger level**
Description	The user enters the additive name and receives color-coded danger levels and diseases caused by additives.
Input	Additive name
Output	Color-coded danger levels and diseases (if any)
Process Name	**Classify Halal, Haram, Mushbooh**
Description	The user inputs an additive name and gets Halal, Haram, or Mushbooh status.
Input	Additive name
Output	Message displaying whether the additive consumption is Halal, Haram, or Mushbooh
Process Name	**Bookmark additives**
Description	The user bookmarks the searched additive and product.
Input	Bookmark additive and product info
Output	Product Additive info
Output	Product Additive info

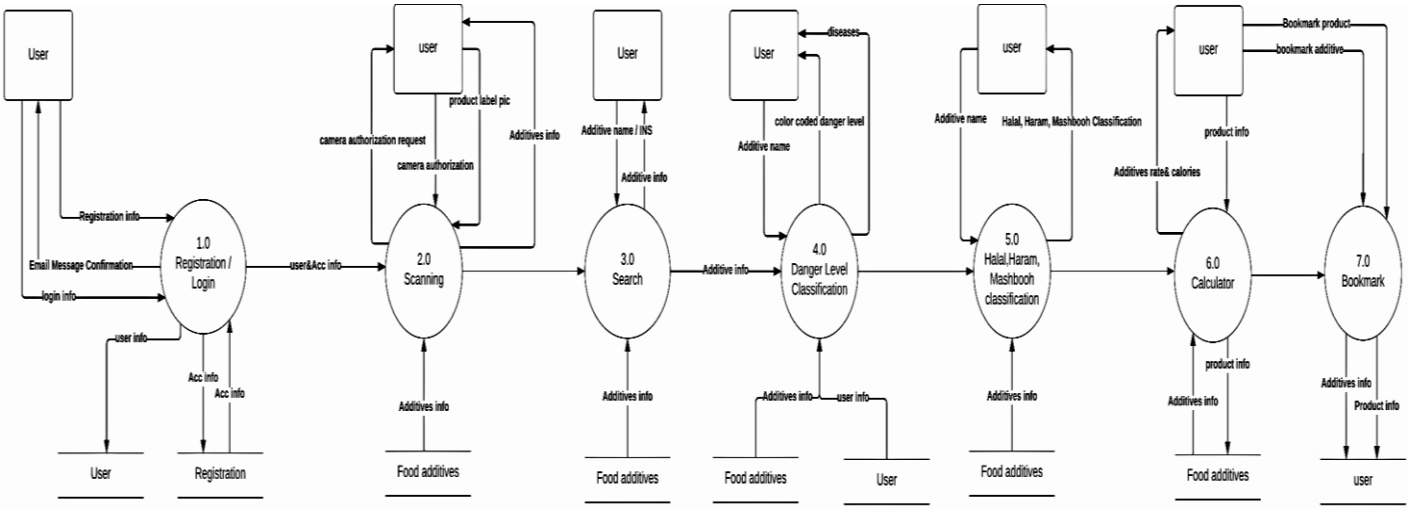

Figure 3. The Level-1 DFD of Weqaya

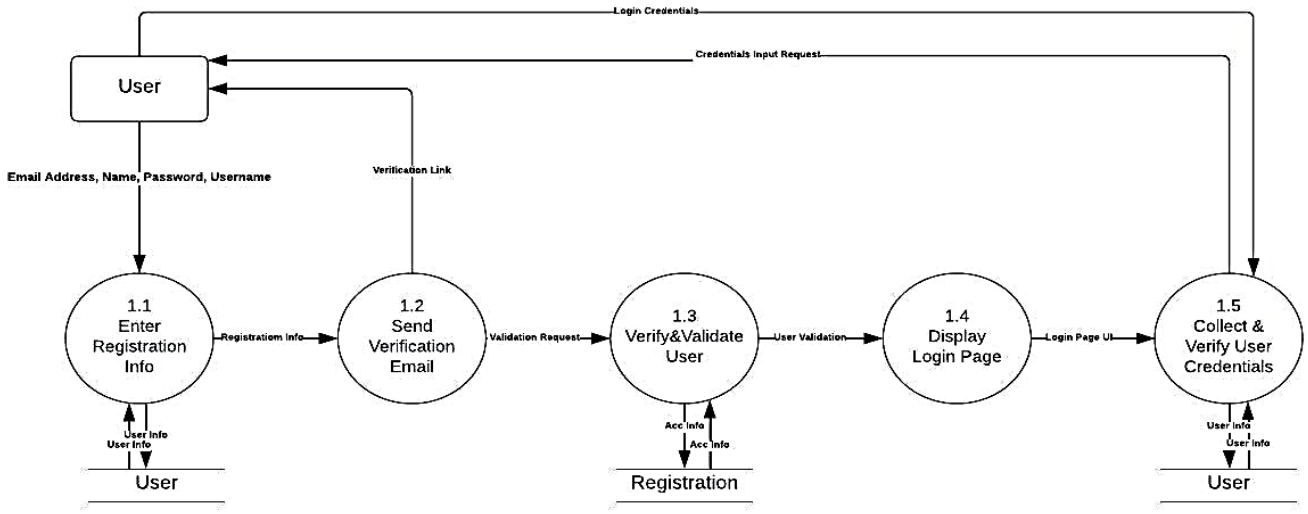

Figure 4. The Level-2 DFD of Weqaya

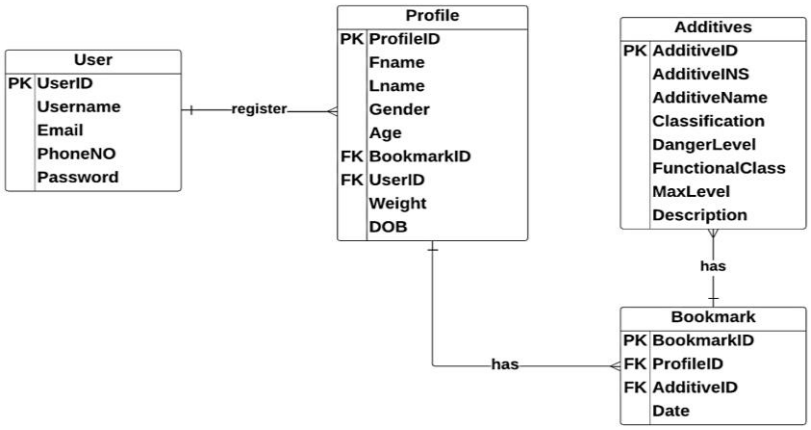

Figure 5. The ERD of Weqaya

Table 5. The Additives table data dictionary

Attribute name	Data type	Field	Format	PK	FK	Null	Unique	Other constraints
AdditiveID	Number	4	9999	Yes	No	No	Yes	RANGE>0
AdditiveINS	Varchar2	10	-		No	No	No	Yes
AdditiveName	Varchar2	10	-		No	No	No	Yes
Classification	Varchar2	8	-		No	No	No	No
DangerLevel	Varchar2	10	-		No	No	No	No
FunctionalClass	Varchar2	15	-		No	No	No	No
MaxLevel	Number	7	9999999	No	No	No	No	RANGE >0
Description	Varchar2	4000	-		No	No	No	No

Table 6. The Bookmark table data dictionary

Attribute name	Data type	Field	Format	PK	FK	Null	Unique	Other constraints
BookmarkID	Number	4	9999	Yes	No	No	Yes	RANGE>0
ProfileID	Number	4	9999	No	Yes	No	Yes	RANGE>0
AdditiveID	Number	4	9999	No	Yes	No	Yes	RANGE>0
Date	Date	-	DMY	No	No	No	No	Sysdate generated

Table 7. An Excerpt of the Weqaya application database records

Food Category	14 Subcategory	24 Additive Functional Class	Additive Name	INS No.	Max level mg/kg
Meat and meat products, including poultry and game	المصنعة غير المعاملة بالحرارة	Antioxidant, Colour, Emulsifier, Stabilizer, Acidity regulator, Preservative, Sequestrant, Humectant, Thickener, Raising agent, Firming agent, Flour treatment, Anticaking agent	Trisodium	339	2200
	المدخنة (تشمل المملحة)	Preservative	Sorbic acid	200	200
	المدخنة (تشمل المملحة)	Preservative	Sod	201	200
	المخمرة المصنعة غير المعاملة	Preservative	Potass	202	200
	المخمرة المصنعة غير المعاملة	Preservative	Calc	203	200
	المصنعة المعاملة بالحرارة الكاملة	Colour, Preservative, Emulsifying salt	Potass	452	1320
	المصنعة المعاملة بالحرارة الكاملة	Colour, Preservative, Emulsifying salt	Calcium	452	1320
	المصنعة المجمدة الكاملة والمجزأة	Glazing agent, Antifoaming	Mineral	905	950
	المصنعة المجمدة الكاملة والمجزأة	Antioxidant, Colour, Preservative	Phosphori	338	2200
	المفرومة المصنعة	Colour, Preservative, Sequestrant, Humectant, Thickener, Emulsifying salt	Sodi	339	2200
	المفرومة المصنعة	Colour, Preservative, Sequestrant, Humectant, Thickener, Emulsifying salt	Disodium	339	2200
	المفرومة المصنعة	Colour, Preservative, Sequestrant, Humectant, Thickener	Trisodium	339	2200
	المفرومة المصنعة غير المعاملة	Antioxidant, Colour, Preservative, Sequestrant, Flavour enhancer	Tartaric	334	500
	المفرومة المصنعة والمدخنة غير	Antioxidant, Colour	Sunset	110	300
	المفرومة المصنعة والمدخنة غير	Preservative	Benzoic	201	1000
	المفرومة المصنعة والمدخنة غير	Preservative	Sodium	211	1000

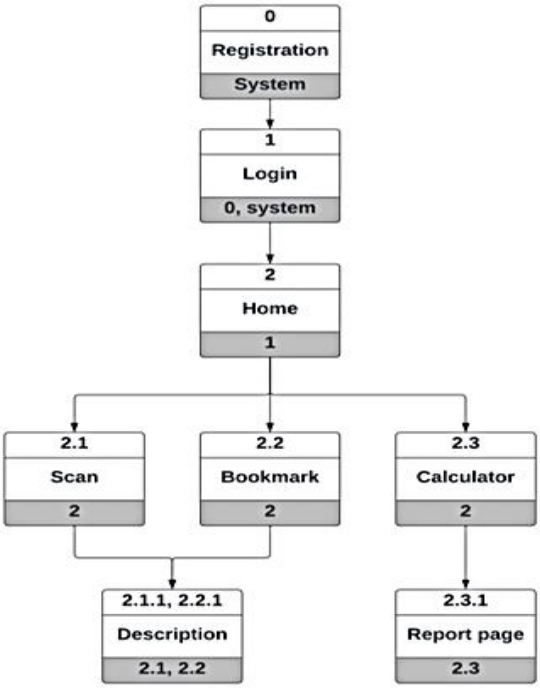

Figure 6. The dialogue diagram of Weqaya

4.3 Application implementation and testing analysis

The Client I/O interfaces are designed w.r.t user's requirements collected and should satisfy the functionality, ease of use, and interaction. Fig. 7 and Fig. 8 depict examples of I/O interfaces designed for the Weqaya application according to the basic UI guidelines. The Welcome UI displays the application name, the wordmark, and the loading icon during the application processing. The Login UI Display permits users to enter the registered username and password. Suppose the user failed to satisfy these requirements. In that case, an error message will be displayed to notify the user about the error and then instruct the user to refill the invalid/missing information to continue with the login process to the desired services.

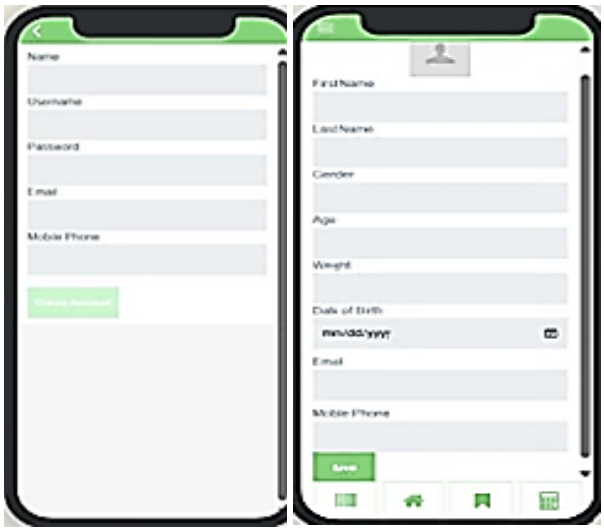

Figure 7. Registration and Profile I/P interfaces

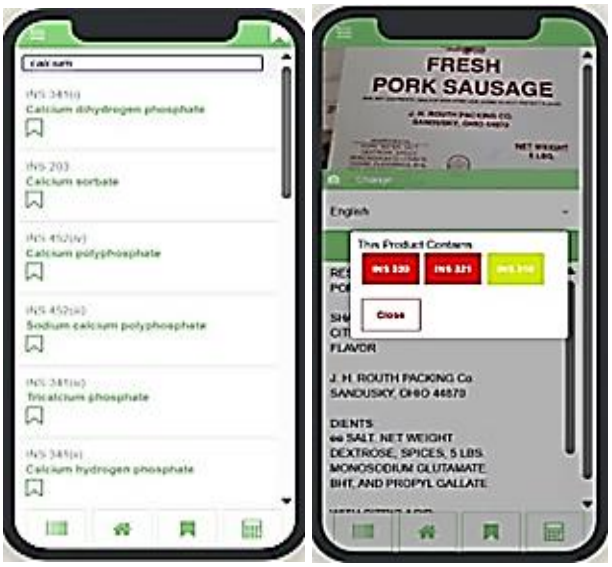

Figure 8. Search and Scan I/P interfaces

In addition, the Registration UI Display allows users to enter their personal information, such as a unique username, email, phone number, and password. The user is directed to this page from the login when the "register to login" option is selected. Suppose the user failed to meet the validity and uniqueness criteria to the username, email, or phone number. In that case, an error message will be displayed to notify the user regarding the error and then instruct the user to refill the invalid/missing information to continue the login process. Moreover, the Menu UI Display is a hidden affordance added to the application as an icon of three lines on top of each other. The menu bar is revealed only when the user decides to click on the icon

and is added in the top left section in all application headers to display the pages of the application to be selected by the user to navigate easily from one page to another, to show the username registered and, to provide an option to logout. Alternatively, The Search UI Display allows users to search for additives from the additive list. A search engine is provided to search for additives by entering either additive name or additive INS number in the search bar. The input text is then compared to the records in the database and displays results. However, nothing will be displayed if the search criteria are invalid, and the user will be notified.

Furthermore, the Scan UI Display allows users to search for additives by scanning the product, which is read using ML entity recognition. However, nothing will be displayed if the scanned product was invisible/invalid, and the user will be notified. Otherwise, the scanned product's artificial food additive details will be displayed. However, the Bookmark UI Display allows users to view the saved additive. After the user searches for any additive by text, additives can be bookmarked and added for later view on this page by displaying a list of all the preferred additives to be viewed. In addition, the Calculator UI Display calculates the additive maximum allowed daily intake. According to the selected profile on the login page, the user will provide weight in kg as input. Based on this weight, the calculator will retrieve the maximum allowed intake amount, multiply it with the given weight, and then display the accepted daily intake accordingly.

As per the application's testing, a section of code was written to test specific functions in the Weqaya application at which the functions were isolated to reveal unnecessary dependencies between functions being tested and other units and, therefore, verify their performance. Therefore, Table 8 illustrates an example of a unit test log for "search additive".

Table 8. The Unit Testing of Search Page I/O Interface.

Objective	Steps	Expected Result
Search additive	User selects from additives list.	App displays additives based on the search criteria.
Reset filter od additive list	User erase text from the search engine.	App resets search criteria and displays all additives.
Search additive	User selects from additives list.	App displays additives based on the search criteria.

4.4 Application Evaluation Analysis

Based on the method of usability calculation in Section 3.5, Table 9 demonstrates the usability scores of Weqaya, the overall usability score of which was 95.21%. As per the subsections, the visibility scored an average of 96.67%, while the model accuracy scored an average of 96.67%. The user control scored an average of 95.56% , while consistency scored 94.44%. As per the aesthetic and minimalist design error recognition and error prevention, Weqaya scored 92.22% and 93.33%, respectively, while in terms of privacy and security, it scored 95.00% and 97.78%, respectively.

Table -9 The Usability of Weqaya based on Nielsen's Heuristics

Heuristics/ Criterians	H. Satisfied	Satisfied	Neutral	Unsatisfied	H. Unsatisfied
Visibility of The Application					
Location of information	53.33%	36.67%	0%	0%	0%
Response time	63.33%	30%	6.67%	0%	0%
Selection input of data	56.67%	40%	3.33%	0%	0%
Model Accuracy					
Navigation structure	43.33%	53.33%	3.33%	0%	0%
Menus	50%	46.67%	3.33%	0%	0%
Simplicity	46.67%	50%	3.33%	0%	0%
User Control					

Explorable interface	53.33%	40%	3.33%	3.33%	0%
Menus control	70%	26.67%	3.33%	0%	0%
Process confirmation	43.33%	53.33%	3.33%	0%	0%
Consistency					
Design consistency	73.33%	23.33%	3.33%	0%	0%
Naming convention	60%	36.67%	3.33%	0%	0%
Application response	56.67%	33.33%	6.67%	3.33%	0%
Aesthetic & minimalist design					
Multimedia content	53.33%	40%	6.67%	0%	0%
Icons	53.33%	33.33%	13.33%	0%	0%
Menus	63.33%	33.33%	3.33%	0%	0%
Errors					
Error recognition	56.67%	43.33%	0%	0%	0%
Error prevention	43.33%	43.33%	13.33%	0%	0%
Privacy					
Clear warnings	60%	33.33%	6.67%	0%	0%
Privacy protection	46.67%	50%	3.33%	0%	0%
Security					
Timely information display	56.67%	36.67%	6.67%	0%	0%
Simple interface	66.67%	33.33%	0%	0%	0%
Problem assistive platform	66.67%	33.33%	0%	0%	0%
Average	**56.25%**	**38.96%**	**4.51%**	**0.28%**	**0%**

6. Conclusions

This paper introduced a comprehensive analysis of the development of a GCC-based Artificial Mobile Food Additive Management System aiming at becoming the first comprehensive mobile application of artificial food additives by achieving two objectives: Exploring the food additives phenomena in food products and developing and evaluating a mobile based application (Weqaya) that helps to manage this problem. Weqaya provided several functionalities: calculating additives, providing awareness of food additives, showing the impact of additives, recognizing the natural and artificial additives, and providing alternatives in one comprehensive and interactive management mobile application for both Android and IOS platforms. The research outcomes recognized the shortcomings of the currently used mobile food additives management system. They informed the requirements of the Weqaya mobile application revealing 95.21% of acceptance of the overall usability, 96.67% w.r.t. visibility, 96.67% w.r.t. model accuracy, 95.56% w.r.t. user control, 94.44% w.r.t. consistency, 92.22% w.r.t. Aesthetic and minimalist design, 93.33% w.r.t. error recognition and error prevention, 95.00% w.r.t. privacy, and 97.78% w.r.t. security. Weqaya was useful to the GCC ministries of health and dietitians in providing a plan according to the calculations carried out, to the academics and researchers in enriching the knowledge base, and to the food producers/factories to provide non-artificial food. However, several functionalities will be added in the near future, including Chatbot, extended DB of food products, donation, other language interfaces, youth features, and extra danger levels.

Author Contributions: Conceptualization: All; Methodology: E.A.; Software: All; validation: All; Formal analysis: All; Investigation: All; Resources: All; Data curation: All; Writing—original draft preparation: All; Writing—review and editing: All; Visualization: E.A.; Supervision: E.A.; Project administration: E.A.; Funding acquisition: this research isn't funded.

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Data Availability Statement: The authors declare that all supporting research data is available.

Conflicts of Interest: The authors declare no conflict of interest.

References

[1] A. L. Branen, P. M. Davidson, S. Salminen, and J. Thorngate, *Food Additives*, 2nd ed. CRC Press, 2001.
[2] V. Emerton and E. Choi, *Essential Guide to Food Additives*. Leatherhead Publishing, Royal Society of Chemistry, 2008. doi: 10.1039/9781847559234.
[3] K. Curinga, "Advantages & Disadvantages of Food Additives," *Livestrong.com*, 2011. https://www.livestrong.com/article/395959-advantages-disadvantages-of-food-additives/ (accessed Aug. 02, 2022).
[4] Better Health Channel, "Food additives," *State Government of Victoria*, 2012. https://www.betterhealth.vic.gov.au/health/conditionsandtreatments/food-additives (accessed Aug. 26, 2022).
[5] National Research Council (US) Committee on Diet, Nutrition, and Cancer, "The Carcinogenicity of Food Additives and Contaminants," in *Diet, Nutrition, and Cancer*, Washington, D.C., DC: National Academies Press, 1982, p. 492.
[6] S. Al-Thawadi, "Public perception of algal consumption as an alternative food in the Kingdom of Bahrain," *Arab J. Basic Appl. Sci.*, vol. 25, no. 1, pp. 1–12, Jan. 2018, doi: 10.1080/25765299.2018.1449344.
[7] A. O. Musaiger, A. S. Hassan, and O. Obeid, "The Paradox of Nutrition-Related Diseases in the Arab Countries: The Need for Action," *Int. J. Environ. Res. Public Health*, vol. 8, no. 9, pp. 3637–3671, Sep. 2011, doi: 10.3390/ijerph8093637.
[8] A. B. Khalil *et al.*, "Diabesity in the Arabian Gulf: Challenges and Opportunities," *Oman Med. J.*, vol. 33, no. 4, pp. 273–282, Jul. 2018, doi: 10.5001/omj.2018.53.
[9] OriGym, "Food Additives: Benefits and Risks," *origympersonaltrainercourses.co.uk*. https://origympersonaltrainercourses.co.uk/blog/food-additives (accessed Aug. 27, 2022).
[10] M. Saltmarsh, *Essential Guide to Food Additives*. The Royal Society of Chemistry, 2013. doi: 10.1039/9781849734981.
[11] Ministry of Health Kingdom of Bahrain, "Food Safety Guidelines Food Control Section Public Health Directorate." [Online]. Available: https://www.moh.gov.bh/Content/Upload/File/638242460024477544-Food-Safety-Guidelines_EN.pdf
[12] M. Hensley, "Food Additives: Regulations and Repercussions," *J. Undergrad. Res. XVII*, 2014, [Online]. Available: https://www.uwlax.edu/globalassets/offices-services/urc/jur-online/pdf/2014/hensley.mariah.politicalscience.pdf
[13] T. M. Osaili *et al.*, "Consumers' knowledge and attitudes about food additives in the UAE," *PLoS One*, vol. 18, no. 3, p. e0282495, Mar. 2023, doi: 10.1371/journal.pone.0282495.
[14] V. Komolprasert and P. Turowski, *Food Additives and Packaging*, vol. 1162. Washington, DC: American Chemical Society, 2014. doi: 10.1021/bk-2014-1162.
[15] E. J. Adwan, M. Y. AlSada, J. A. Alnfaiai, J. E. Adwan, and M. S. Alkhayat, "Centralized Web portal for organ, tissue and blood donation in GCC," in *2022 International Conference on Data Analytics for Business and Industry (ICDABI)*, Oct. 2022, pp. 472–478. doi: 10.1109/ICDABI56818.2022.10041461.
[16] K. Davies, "Content Analysis of Research Articles in Information Systems (LIS) Journals," *Libr. Inf. Res.*, vol. 36, no. 112, pp. 16–28, Sep. 2012, doi: 10.29173/lirg495.
[17] M. Templier and G. Paré, "A Framework for Guiding and Evaluating Literature Reviews," *Commun. Assoc. Inf. Syst.*, vol. 37, 2015, doi: 10.17705/1CAIS.03706.
[18] M. Tate, E. Furtmueller, J. Evermann, and W. Bandara, "Introduction to the Special Issue: The Literature Review in Information Systems," *Commun. Assoc. Inf. Syst.*, vol. 37, 2015, doi: 10.17705/1CAIS.03705.
[19] A. Yoon and T. Schultz, "Research Data Management Services in Academic Libraries in the US: A Content Analysis of Libraries' Websites," *Coll. Res. Libr.*, vol. 78, no. 7, Nov. 2017, doi: 10.5860/crl.78.7.920.
[20] B. Lund, "The questionnaire method in systems research: an overview of sample sizes, response rates and statistical approaches utilized in studies," *VINE J. Inf. Knowl. Manag. Syst.*, vol. 53, no. 1, pp. 1–10, Jan. 2023, doi: 10.1108/VJIKMS-08-2020-0156.
[21] N. Juristo, A. M. Moreno, and M.-I. Sanchez-Segura, "Analysing the impact of usability on software design," *J. Syst. Softw.*, vol. 80, no. 9, pp. 1506–1516, Sep. 2007, doi: 10.1016/j.jss.2007.01.006.
[22] L. Chung, B. A. Nixon, E. Yu, and J. Mylopoulos, *Non-Functional Requirements in Software Engineering*. Boston, MA: Springer US, 2000. doi: 10.1007/978-1-4615-5269-7.
[23] N. E. Cagiltay, G. Tokdemir, O. Kilic, and D. Topalli, "Performing and analyzing non-formal inspections of entity relationship diagram (ERD)," *J. Syst. Softw.*, vol. 86, no. 8, pp. 2184–2195, Aug. 2013, doi: 10.1016/j.jss.2013.03.106.
[24] Q. Li and Y.-L. Chen, "Entity-Relationship Diagram," in *Modeling and Analysis of Enterprise and Information Systems*, Berlin, Heidelberg: Springer Berlin Heidelberg, 2009, pp. 125–139. doi: 10.1007/978-3-540-89556-5_6.
[25] S. P. Guest, "The use of software tools for dialogue design," *Int. J. Man. Mach. Stud.*, vol. 16, no. 3, pp. 263–285, Apr. 1982, doi: 10.1016/S0020-7373(82)80062-X.
[26] M. Fisher and D. E. Baird, "Online learning design that fosters student support, self-regulation, and retention," *Campus-Wide Inf. Syst.*, vol. 22, no. 2, pp. 88–107, Apr. 2005, doi: 10.1108/10650740510587100.

[27] B. Grácio, "I'm a Magic MABS: How the Mobile Apps Build Service Works," *OutSystem Blog*, 2018. https://www.outsystems.com/blog/posts/how-mobile-apps-build-service-works/ (accessed Mar. 07, 2023).
[28] N. Juristo, A. M. Moreno, and W. Strigel, "Guest Editors' Introduction: Software Testing Practices in Industry," *IEEE Softw.*, vol. 23, no. 4, pp. 19–21, Jul. 2006, doi: 10.1109/MS.2006.104.
[29] T. Hamilton, "What is Unit Testing?," *Guru99*, 2023. https://www.guru99.com/unit-testing-guide.html (accessed Apr. 06, 2023).
[30] J. Nielsen, "Enhancing the explanatory power of usability heuristics," in *Proceedings of the SIGCHI conference on Human factors in computing systems celebrating interdependence - CHI '94*, 1994, pp. 152–158. doi: 10.1145/191666.191729.
[31] E. J. Adwan, Y. Al-Aradi, M. Essa, and H. Malabari, "A Comprehensive Study and Development of Unified Mobile-Based Admission System for GCC Universities," *J. Comput. Theor. Appl.*, vol. 1, no. 2, pp. 212–230, Dec. 2023, doi: 10.62411/jcta.9793.
[32] L. Wu, C. Zhang, Y. Long, Q. Chen, W. Zhang, and G. Liu, "Food additives: From functions to analytical methods," *Crit. Rev. Food Sci. Nutr.*, vol. 62, no. 30, pp. 8497–8517, Oct. 2022, doi: 10.1080/10408398.2021.1929823.
[33] M. Carocho, P. Morales, and I. C. F. R. Ferreira, "Antioxidants: Reviewing the chemistry, food applications, legislation and role as preservatives," *Trends Food Sci. Technol.*, vol. 71, pp. 107–120, Jan. 2018, doi: 10.1016/j.tifs.2017.11.008.
[34] A. O. Bankole, E. A. Irondi, W. Awoyale, and E. O. Ajani, "Application of natural and modified additives in yogurt formulation: types, production, and rheological and nutraceutical benefits," *Front. Nutr.*, vol. 10, Oct. 2023, doi: 10.3389/fnut.2023.1257439.
[35] I. Benucci, C. Lombardelli, C. Mazzocchi, and M. Esti, "Natural colorants from vegetable food waste: Recovery, regulatory aspects, and stability—A review," *Compr. Rev. Food Sci. Food Saf.*, vol. 21, no. 3, pp. 2715–2737, May 2022, doi: 10.1111/1541-4337.12951.
[36] C. Novais *et al.*, "Natural Food Colorants and Preservatives: A Review, a Demand, and a Challenge," *J. Agric. Food Chem.*, vol. 70, no. 9, pp. 2789–2805, Mar. 2022, doi: 10.1021/acs.jafc.1c07533.
[37] I.-A. Potărniche, C. Saroşi, R. M. Terebeş, L. Szolga, and R. Gălătuş, "Classification of Food Additives Using UV Spectroscopy and One-Dimensional Convolutional Neural Network," *Sensors*, vol. 23, no. 17, p. 7517, Aug. 2023, doi: 10.3390/s23177517.
[38] Melon AD, "E Food Additives," 2009. https://apps.apple.com/us/app/e-food-additives/id326134581?platform=iphone (accessed Feb. 23, 2023).
[39] E Numbers app, "E Numbers - Food additives," *Google Play*, 2023. https://play.google.com/store/apps/details?id=com.ashomok.eNumbers&hl=en_US (accessed Feb. 17, 2023).
[40] InfoCons, "InfoCons," *infocons.org*, 2023. https://infocons.org/the-infocons-app/ (accessed Feb. 23, 2023).
[41] MyOnlyIslam, "Scan Halal food-Additive haram," *Google Play*, 2023. https://play.google.com/store/apps/details?id=softbrigh.muslim.halal.haram.mushbooh&hl=en_US (accessed Feb. 23, 2023).
[42] FAO-WHO, "Codex general standard for food additives (GSFA) online database," *Food Additives DB (GSFA Online) | Codexalimentarius*, 2023. https://www.fao.org/fao-who-codexalimentarius/codex-texts/dbs/gsfa/en/ (accessed Feb. 23, 2023).
[43] enumbersapp, "Food Additives Checker (E Numbers)," 2024. https://enumbersapp.com/en/1 (accessed Feb. 17, 2023).
[44] Yuka, "Yuka - Food & Cosmetic Scanner," 2023. https://yuka.io/en/app/ (accessed Feb. 17, 2023).
[45] Lifesum, "Lifesum Food Tracker & Fasting," *App Store Preview*, 2023. https://apps.apple.com/us/app/lifesum-food-tracker-fasting/id286906691?mt=8 (accessed Feb. 17, 2023).
[46] Raúl Vadillo, "Ingred - cosmetics and food," *Google Play*, 2023. https://play.google.com/store/apps/details?id=com.zorrosoft.android.ingred&hl=en_US (accessed Feb. 23, 2023).
[47] MyFitnessPal, "Calorie Tracker & BMR Calculator to reach your goals," 2023. https://www.myfitnesspal.com/ (accessed Feb. 23, 2023).
[48] insanyya Apps, "Food additives," *Google Play*, 2023. https://play.google.com/store/apps/details?id=com.app.mrschak.tab&hl=en_US (accessed Feb. 23, 2023).
[49] Fueneco, "E-Inspect Food additives," *Google Play*, 2003. https://play.google.com/store/apps/details?id=com.fueneco.additives.slo&hl=en_US (accessed Feb. 23, 2013).
[50] Worldometers.Info, "Population by Country 2023," 2023. https://www.worldometers.info/world-population/population-by-country/ (accessed Feb. 23, 2023).
[51] Survey Monkey, "Sample size calculator," 2023. https://www.surveymonkey.com/mp/sample-size-calculator/ (accessed Feb. 23, 2023).