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JITK (JURNAL ILMU PENGETAHUAN DAN TEKNOLOGI KOMPUTER)

DEVELOPMENT A DAILY NUTRITIONAL ADEQUACY BALANCE IDENTIFICATION SYSTEM AS AN EFFORT TO PREVENT MALNUTRITION

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Abstract— *Malnutrition is a deficiency, excess or imbalance in a person's energy and nutritional intake. Malnutrition can occur when a person has too much or too little food and important nutrients in their body. The Ministry of Health, Indonesia, has campaigned for food consumption that complies with balanced nutrition guidelines under the slogan "Isi Piringku". However, the guidelines regarding this matter are still not properly understood by the public. Even if implemented, the nutritional levels contained in one portion of food consumed cannot yet be measured. Thus, to identify the fulfillment of balanced nutritional, a device is needed to easily detect how much calories is consumed. Therefore, this research aims to develop a system which can identify whether the portion of food consumed meets balanced nutrition or not. It is developed in Django framework, Python programming language, and MySQL database. It has been evaluated using black box testing, white box testing, and system usability scales. The result shows that all system requirements have been run well. Meanwhile, system usability testing result shows that the identification system has been tested with a score of 82 and categorized in Excellent.*

Keywords: *identification, nutritional adequacy, nutritional balance, software development*

Intisari— *Malnutrisi merupakan kondisi tubuh yang mengalami kekurangan atau ketidakseimbangan energi dan asupan gizi. Malnutrisi dapat terjadi ketika seseorang memiliki terlalu banyak atau terlalu sedikit nutrisi penting dalam tubuhnya. Kementerian Kesehatan Indonesia telah mengkampanyekan konsumsi pangan yang sesuai dengan pedoman gizi seimbang dengan slogan "Isi Piringku". Namun pedoman tersebut masih belum dipahami dengan baik oleh masyarakat. Selain itu, jika komposisi tersebut diterapkan, kandungan gizi yang terkandung dalam satu porsi makanan pun belum bisa diukur. Sehingga, untuk mengidentifikasi pemenuhan kebutuhan gizi seimbang, diperlukan suatu alat untuk mendeteksi dengan mudah berapa banyak kalori yang dikonsumsi. Oleh karena itu, penelitian ini bertujuan untuk mengembangkan sistem yang dapat mengidentifikasi apakah porsi makanan yang dikonsumsi memenuhi gizi seimbang atau tidak. Sistem ini dikembangkan dengan menggunakan framework Django, bahasa pemrograman Python, dan database MySQL. Kemudian sistem ini dievaluasi menggunakan metode black box, white box, dan system usability scales. Hasil pengujian menunjukkan bahwa semua kebutuhan sistem telah berjalan dengan baik. Sedangkan hasil pengujian kegunaan sistem menunjukkan bahwa sistem identifikasi telah diuji dengan skor 82 dan berkategori Sangat Baik.*

Kata Kunci: *identifikasi, kecukupan gizi, keseimbangan gizi, pengembangan perangkat lunak.*

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INTRODUCTION

Malnutrition is a deficiency, excess or imbalance in a person's energy and nutritional intake. Malnutrition can occur when a person has too much or too little food and important nutrients in their body [1], [2]. Malnutrition often attacks children, which is known as stunting. Many factors cause stuttering in toddlers, but because they are very dependent on the mother, family, and environmental conditions that influence the family will have an impact on their nutritional status. Indonesia has quite a serious nutritional problem, which is characterized by many cases of stunting in children under five[3], [4]. Households with good Nutritional Awareness behavior have the opportunity to decrease the risk of stunting in children under five 2.435 smaller than households with poor Nutritional Awareness behavior[5]. In fact, malnutrition is still common in Eastern Indonesia. Statistics show that in 2022, Sulawesi is the area with the most cases, followed by Papua [6]. This condition is generally caused by inadequate nutritional intake, low birth weight, sanitation and access to clean water[7]. Therefore, efforts to determine the adequacy and balance of nutritional intake are very important.

On the other hand, balanced nutrition is a daily food composition that contains nutrients in types and quantities that suit the body's needs, taking into account the principles of food diversity, physical activity, clean living behavior and maintaining a normal body weight on a regular basis [8], [9]. The energy-producing nutrients needed to fulfill balanced nutrition include carbohydrates, fats and proteins. Meanwhile, cell-building nutrients are protein, and regulatory nutrients are vitamins, minerals and water[10]. To facilitate understanding of balanced nutrition, the Government through the Ministry of Health has campaigned for food consumption that complies with balanced nutrition guidelines in the slogan "*Isi Piringku*". The slogan describes the portion of food consumed on one plate consisting of 50 percent fruit and vegetables, and the remaining 50 percent consisting of carbohydrates and protein. The "*Isi Piringku*" campaign also emphasizes limiting sugar, salt and fat in daily consumption [11].

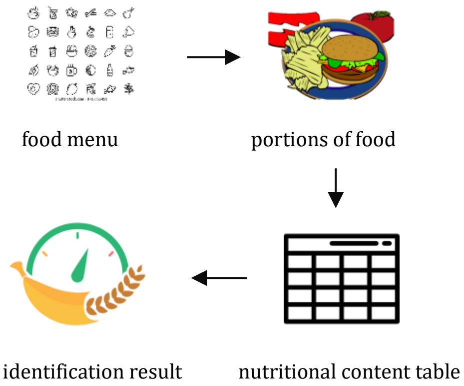
However, the guidelines for fulfilling balanced nutrition through the "*Isi Piringku*" campaign are still not properly understood by the public. Besides that, the nutritional levels contained in the contents of my plate cannot yet be measured. Therefore, we need a tool that can be used to identify the fulfillment of balanced nutritional needs that is easy to use and understand. This is an alternative solution because by understanding the fulfillment of balanced nutrition from the family, society can avoid cases of stunting in infants and toddlers.

Research on food identification has been widely carried out and is still ongoing research today. For example, in research [12] a system was developed that can determine the amount of food calories according to a calorie database. In this research, 50 food image data were used to test each food category, and the test obtained an average accuracy of 86%. Other research on food identification has also been carried out in [13] using machine learning algorithms. The resulting output is in the form of identification of food objects contained in the refrigerator. The food objects tested were bananas, cucumbers, broccoli and oranges. From the test results, it can be seen that the program identifies objects with the highest confidence level of 78.61%. This shows that software development using machine learning algorithms to identify food has been carried out well. However, machine learning requires large data to create a model. Therefore, the problem of identifying nutritional adequacy and balance that already has clear rules from health experts can be used as a valid basis. This is the advantage of a rule-based system.

Until now, the research that has been carried out is about identifying food objects and the identification methods used[14]-[17]. In fact, researches has reached nutritional scanning, but it has not been to achieving balanced nutrition. Therefore, this research aims to develop a system which can automatically identify whether the portion of food consumed meets balanced nutrition or not. We hope that this system will be able to help provide information on nutritional adequacy and balance an as an effort to prevent malnutrition.

MATERIALS AND METHODS

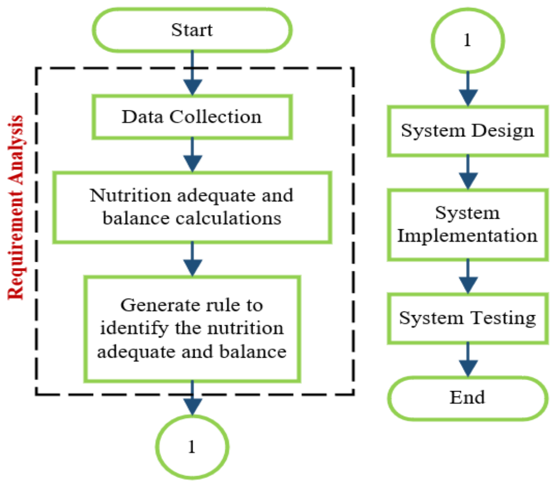
The system developed aims to identify whether the portion of food consumed meets balanced nutrition or not. So that, it can receive food menu data consumed firstly and also portion sizes. Then, food consumed will be converted to calorie values based on nutritional table reference data. Finally, the system will provide results of nutritional adequacy and balance. The system flow can be seen in Figure 1 below:



Source : (Research Results, 2024)

Figure 1. System flow

Furthermore, we will develop a system using a simple and reliable software development method, namely waterfall. This method consists of four main stages, namely requirement analysis, system design, implementation, and testing[18], [19]. To start developing the system, we start by collecting a dataset of food menus and their nutritional values. Further, determining each person's nutrition depends on their physical condition, so the input data is in the form of food menu data and weight. This food data will then be converted based on the nutritional content table. After describing the content, it is necessary to create rules to calculate the amount of nutritional content. To achieve this goal, the following are the research steps that will be carried out:



Source: (Research Results, 2024)

Figure. 2. Research Stages

A. Data Collection

The data used in this research comes from the 2019 Indonesian Food Sufficiency Table or *Table Komposisi Pangan Indonesia* (TKPI) which is collected from the Ministry of Health of the Republic of Indonesia[20]. The Indonesian food composition table has been published since 2009. The current TKPI condition contains around 1,300 types of food ingredients which have 19 nutrients, ash content and water content. From this data, the nutritional content is obtained, including Water, Energy, Protein, Fat, Carbohydrates, Fiber, Ash, Calcium (Ca), Phosphorus (P), Iron (Fe), Sodium (Na), Potassium (Ka), Copper (Cu).), Zinc (Zn), Retinol (vit. A), β-carotene, Carotentotal, Thiamin (vit. B1), Riboflavin (vit. B2), Niacin, and Vitamin C. Based, the values will be used is the macro content, namely carbohydrates, protein and fat. The following is a snippet of the data used:

Table 1. Dataset from Indonesian Food Sufficiency Table

ID	Name	Energy	Protein	Fat	Carbo
AP001	Rice	180	3	0.3	39.8
AP002	Tim Rice	120	2.4	0.4	26
AP003	Red rice	149	2.8	0.4	32.5
...	...	...	...	...	...

Source: (Indonesia[20], 2020)

B. Nutrition Adequency and Balanced Calculation

The method used adopts in identification system is forward chaining learning method which uses rules with a forward flow [21]. However, the rules created are directly from expert knowledge. Because the value that is the calculation parameter is an integer, the rule in the form of a condition does not require a certainty factor. The concept of calculating nutritional adequacy in the Basal metabolic rate (BMR) and Total Daily Energy Expenditure (TDEE) has been implemented in system. BMR is the calories your body needs to carry out basic body activities[22] and TDEE is the total calories a person needs to carry out daily activities[23]. If *w* is body weight, *h* is height, *a* is age, the following is how to calculate BMR[22]:

$$BMR_{Male} = 66.5 + 13.7 * \mathrm{w} + 5 * \mathrm{h} - 6.8 * \mathrm{a} \quad (1)$$

$$BMR_{Female} = 655 + 9.6 * \mathrm{w} + 1.8 * \mathrm{h} - 4.7 * \mathrm{a} \quad (2)$$

Next, it will all be multiplied by a multiplier to found the TDEE. Here they are, minimum movement or office work, TDEE multiplier = 1.2; light activity (exercise 1-2 times/week), TDEE multiplier = 1.375; moderate activity (exercise 3-5 times/week), TDEE multiplier = 1,550; heavy activity (exercise 6-7 times/week), TDEE multiplier = 1.725; and extreme activities (exercise 2 times a day or more), TDEE multiplier = 1.9[23].

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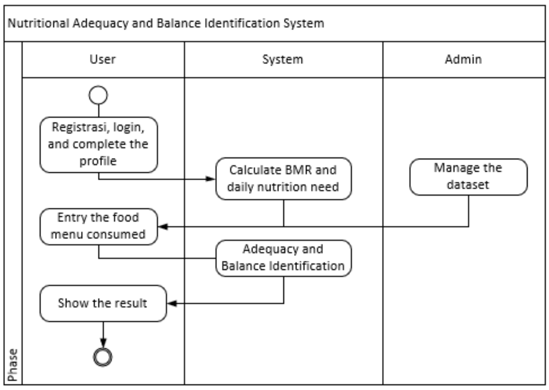
C. Generate Rule

However, the rules created are directly from expert knowledge. The knowledge will be embedded in the system is as follows:

1. Calculate the BMR value as a representation of physical condition
2. Calculate TDEE which is divided into carbohydrates, protein and fat
3. Identify the number of calories consumed based on the morning, afternoon and evening food menu
4. Calculate nutritional adequacy and balance

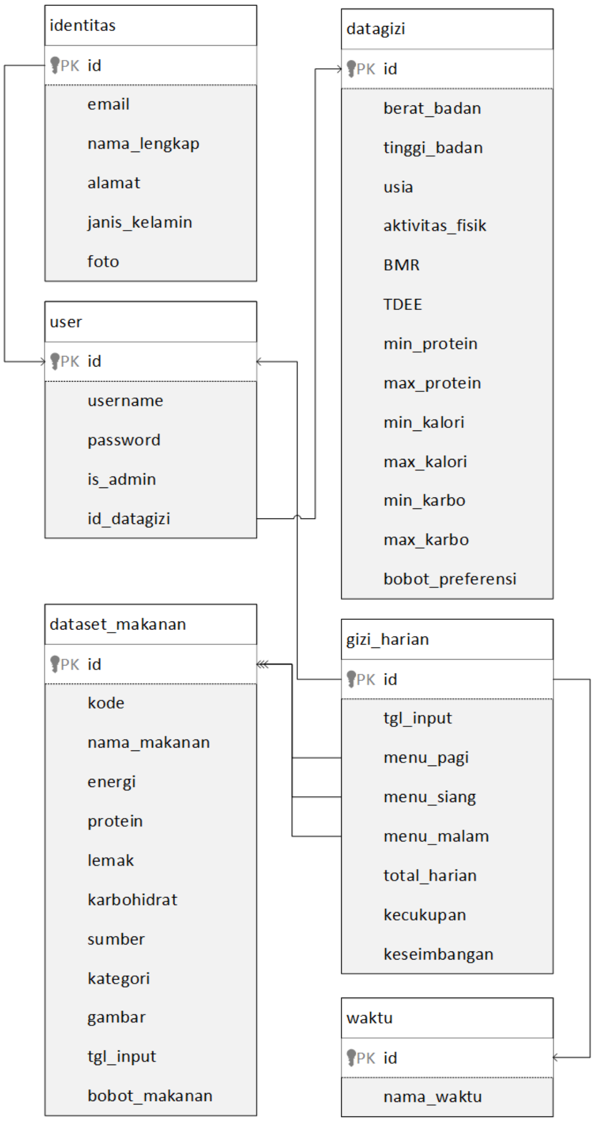
D. System Design

If the requirement analysis which includes data sources and identification calculation concepts is clear, then system design is carried out. The following is a user requirement functional analysis as a basis for developing a system are the system has two user access, namely administrator and member. Administrators have access to manage user data (administrators and members) as well as food data sourced from TKPI. Members can register by entering personal data and data required as a basis for information on calorie needs including weight, height, age and type of activity. Members can see information on BMR values and daily calorie needs consisting of carbohydrates, protein and fat. Members can calculate nutrition adequate and balance intake consumed in a day. After the system requirements are written, the system business flow will be designed in unified modeling language (UML), namely activity diagrams. Firstly, the system begins with user registration. After logging in and completing the data, the system can automatically calculate BMR. Based on the dataset entered by the admin and BMR, the user can enter the menus that will be consumed. From the user data entered and matched in the rule system, the user can see the results of identifying adequate or balanced nutrition. The design can be shown in Figure 3:



Source: (Research Results, 2024)
Figure. 3. Activity Diagram

To store the TKPI food dataset and user personal data, a database with 6 related tables is needed according to the following design in Figure 4.



Source: (Research Results, 2024)
Figure. 4. Database Design

E. Testing Scenario

At the end of the stage, the system will be tested using black box, white box and system usability scale methods. In the usability scale methods, we will involve 10 respondents. They consisted of 2 nutritionists at Bhayangkara Kediri Hospital, 3 lecturers at Malang State Polytechnic, and 5 users who were chosen randomly without representing any institution. This number of respondents was deemed sufficient because the nutritionist represented a health expert, while the lecturer represented a software developer expert, and the rest represented potential users in general.

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RESULTS AND DISCUSSION

A. System Implementation

Previously, it has been explained that the firstly in developing an identification system is to determine the user's BMR and TDEE based on the profile that has been stored. So that, calculating daily calorie consumption requirements is shown in a script code in Figure 5.

```
if jk == 'Female':
    bmr = (jk_pr + (bb_pr * float(bb)) + (tb_pr * float(tb)) -
(usia_pr * float(usia)))
else:
    bmr = (jk_lk + (bb_lk * float(bb)) + (tb_lk * float(tb)) -
(usia_lk * float(usia)))
 if af == 'Not Active':
     kalori = bmr * not_active
 elif af == 'Little Active':
     kalori = bmr * little_active
 elif af == 'Middle Active:
     kalori = bmr * middle_active
 elif af == 'Very Active':
     kalori = bmr * very_active
 else:
     kalori = bmr * extra_active
```

Source: (Research Results, 2024)

Figure 5. Algorithm to calculate BMR and TDEE

After we know the total calorie requirements, then we have to calculate the lower and upper limits for consumption of protein, carbohydrates and fat. This proportion follows the proportion of 10-15% protein, 10-25% fat, and 60-75% carbohydrates. The following is the implementation in a script code in Figure 6.

```
min_pro_fat = calories * 0.1
max_pro = calories * 0.15
max_fat = calories * 0.25
min_carbo = calories * 0.6
max carbo = calories * 0.75
```

Source: (Research Results, 2024)

Figure 6. Algorithm to calculate calorie limit

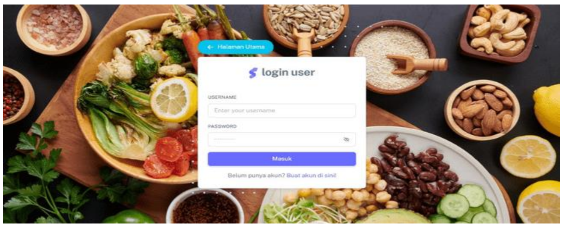
Finally, after all the required data has been saved, the results of the system which are identification of nutritional adequacy and balance will be displayed. For this reason, rules are needed as written in the script code in Figure 7.

```
If(calories_need <= tdee){
      $('#kecukupanGizi').text(CUKUP);
   }else{
      $('#kecukupanGizi').text(KURANG);
   }
 If(ketProtein == 'SEIMBANG' && ketFat == 'SEIMBANG' &&
ketCarbo == 'SEIMBANG'){
      $('#keseimbanganGizi').text(SEIMBANG);
   }else{
      $('#keseimbanganGizi').text(TIDAK SEIMBANG);
        }
```

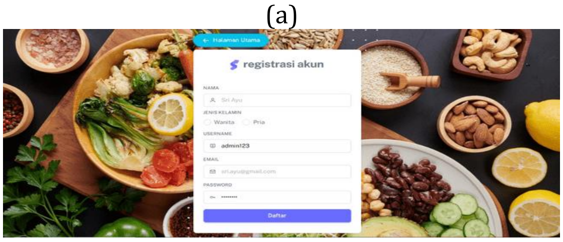
Source: (Research Results, 2024)

Figure 7. Algorithm to nutrition identification

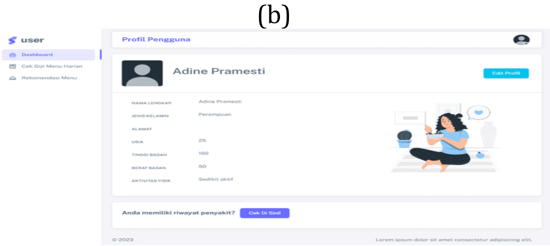
After the design is implemented, the following is an explanation of the results of the identification system that has been built. The first page that can be accessed by the user is the login page. The login page displays a username and password form. The admin login page can be seen in the Figure 8(a). If the user does not have a username, he will be directed to the registration page. On the registration page there is a form to fill in the user's personal data which will be managed to calculate BMR. The admin login page can be seen in the Figure 8(b). Next, the user profile page which is contain a personal information (name, username) and nutritional needs (gender, weight, height, age and physical activity). The user profile page can be seen in the Figure 8(c). After complete the identity, user can see dashboard page that displays the BMR value and daily Calorie Requirements which include protein, fat and carbohydrates). The user dashboard page can be seen in the Figure 8(d). And finally, the identification results page displays the results of calculating adequacy and balanced nutrition consumed. The identification results page can be seen in the Figure 8(e).



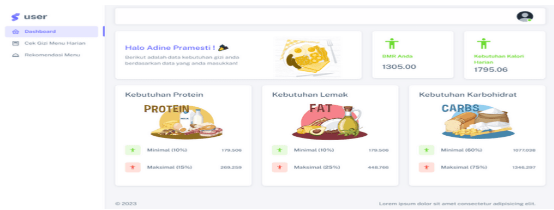
(a)



(b)



(c)



(d)

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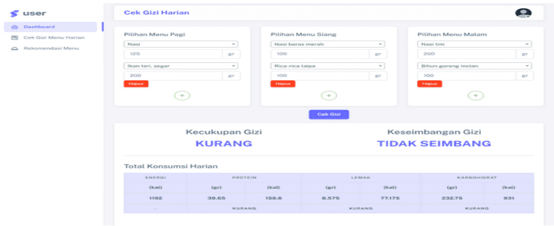


(e)

Source: (Research Results, 2024)

Figure. 8. Daily Nutritional Adequacy and Balance Identification System (a) Register Page (b) Login Page (c) Profile Manage Page (d) Dashboard Page (e) Identification Page

B. System Testing

System testing is carried out with the aim of ensuring that the system built is in accordance with the results of analysis and design so that final conclusions can be drawn. System testing is carried out to find out how good and appropriate the system created is, in accordance with the needs that have been determined in the analysis phase of the procedures above[24]. Testing is carried out by entering data, the calculation process for both payroll and transactions, and also the desired report output. The system will be evaluated using black box testing, white box testing, and system usability scales. Black box testing aims to find incorrect functions, interface errors, data structure errors, performance errors, initialization and termination errors [25], [26]. Table 2 are the results of black box system testing carried out in the laboratory.

Table 2. Black Box Testing Result

No	Testing	Test Case	Expected Results	Status
1	Registration	User completes the registration form	Account has been created	Success
		User fill out the registration form incompletely	A notification appears to complete the data	Success
2	Login	User enters username and password are correct	Go to the dashboard page	Success
		The username and password are incorrect	Stay on the login page	Success
3	Logout	Admin presses the logout button	Back to log in page	Success
4	Profile User	User fills in profile data regarding weight, height, age, gender and activity category	Show form to add data profile, then Basal Metabolic Rate (BMR) value appears	Success
		User edits profile data regarding weight, height, age, gender and activity category	Show form to edit data profile, then BMR value changed	Success
		User sees the total calories needed	The number of Total Daily Energy Expenditure (TDEE) appears on the dashboard	Success
5	Nutritional identification	User presses the nutrition identification menu button	A page appears containing dropdown menus for morning, afternoon and evening food	Success
		User enters the food consumed in the morning, afternoon and evening	A dropdown displays food menu list. Users can select one of the menus and then add another menu	Success
		User edits the food consumed in the morning, afternoon and evening	A dropdown will appear again to change the data that has been entered	Success
		User deletes the food consumed in the morning, afternoon and evening	Selected data deleted	Success
		User presses a button to start calculating nutritional identification	System will add up the daily calories consumed	Success
		User sees the total calories consumed	The number of total calories consumed appears on the page	Success
		User sees the results of identifying nutritional adequacy	The results of the nutritional adequacy classification appear on the page. The result is a yes or no decision	Success
		User sees the results of identifying nutritional balance	The results of the nutritional balance classification appear on the page. The result is a yes or no decision	Success

Source: (Research Results, 2024)

The next test is to use white box testing. It is necessary to see that the system algorithm sequence is appropriate. Testing begins by creating a system flowchart and numbering each path and then calculate the number of paths that must be tested using cyclomatic complexity value[27]. If the flowchart is displayed in Figure 9, with the number of edges E is 14 and number of nodes N is 12, then the following is the calculation of the number of cyclomatic complexity values:

$$M = E - N + 2 = 14 - 12 + 2 = 4 \quad (3)$$

So, these are the paths that must be tested based on the system flowchart:

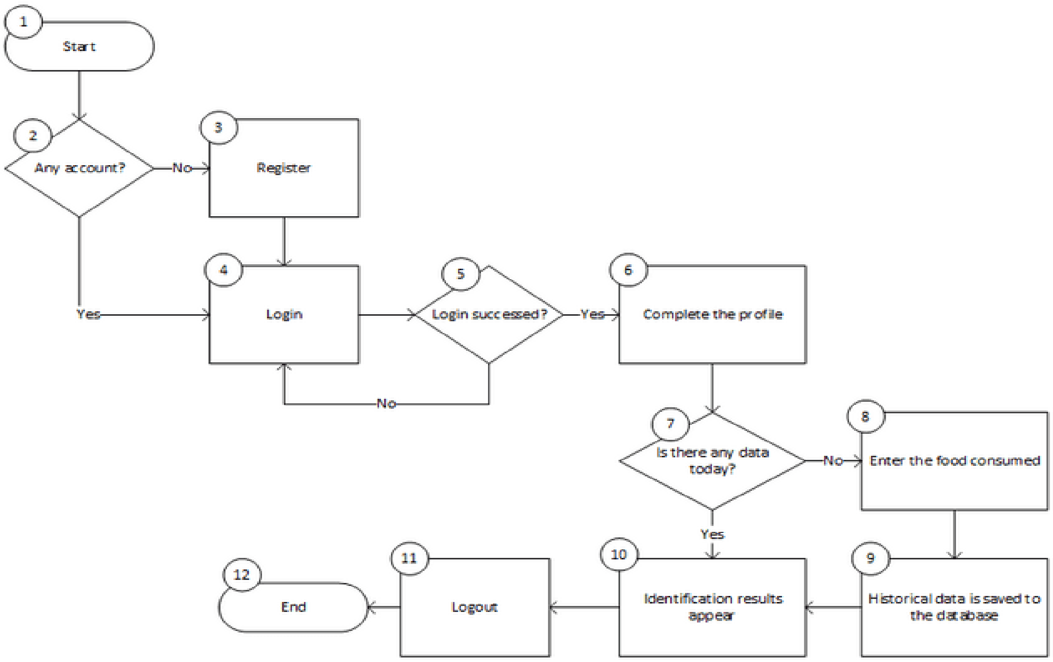
Path 1 : 1 – 2 – 3 – 4 – 5 – 4 – 5 – 6 – 7 – 8 – 9 – 10 – 11 – 12

Path 2 : 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 – 11 – 12

Path 3 : 1 – 2 – 4 – 5 – 6 – 7 – 8 – 9 – 10 – 11 – 12

Path 4 : 1 – 2 – 4 – 5 – 6 – 7 – 10 – 11 – 12

Furthermore, Table 3 shows the white box testing result which explains every condition path, expected result, and status.



Source: (Research Results, 2024)

Figure. 9. System Flow

Table 3. White Box Testing Result

Path	Condition	Expected Result	Status
1	The user registers then logs in but with the wrong username and password	The system will refuse to enter and give a warning to the user to recheck the username and password	Valid
2	The user registers an account and then logs in with the correct username and password and then it is successful. The flow continues by completing the data and checking nutritional adequacy and balance	The system will allow the user to enter, then displays the profile form so that the BMR and TDEE values appear. Then the user enters his daily consumption and the system can decide whether it is adequacy and balanced	Valid
3	Users who already have an account enter the system. then if on the same day there is no nutritional identification data, the system can do it	Users can enter the system with previously saved account. Next, the user will complete the profile and can fill in data about the food they have consumed that day. Finally the system will display the identification results	Valid
4	Users who already have an account enter the system. However, on the same day the previous nutritional identification data was saved. then the system will immediately display the identification results.	Users can enter the system with previously saved account. However, the system will not display a food selection dropdown. The system will immediately display the results of the identification that was previously carried out	Valid

Source: (Research Results, 2024)

The final test is using the system usability scale method. This method is carried out by distributing a questionnaire consisting of 10 questions. There are already standard questions as shown in Table 4. Next, respondents will run the identification system and give a score on a scale of 1-5[28]. Respondents rated it with numbers 1 to 1. 5. A score of 1 means strongly disagree, 2 means disagree, 3 means neutral, 4 means agree, and 5 means strongly agree.

Table 5 shows the testing score results by 10 respondents consisting of the general public and nutrition experts as explained before. Testing begins by reducing the results of the questionnaire answers with a value of 1 if the question number is odd and adding a value of -5 for an even number of

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questions. After that, the scores for each respondent are added up and the average is calculated. Finally, Table 5 shows that the identification system has been tested with a score of 82. Thus, because this value can be interpreted in the Excellent category because the value is >80.3.

Table 4. System Usability Scale Questionnaire

No	Question
1	I think that I would like to use this system frequentl y.
2	I found the system unnecessarily complex.
3	I thought the system was easy to use.
4	I think that I would need the support of a technical person to be able to use this system.
5	I found the various functions in this system were w ell integrated.
6	I thought there was too much inconsistency in this s ystem.
7	I would imagine that most people would learn to us e this system very quickly.
8	I found the system very cumbersome to use.
9	I felt very confident using the system.
10	I needed to learn a lot of things before I could get g oing with this system.

Source: (Research Results, 2024)

Table 5. System Usability Scale Score Result

Respondent	System Usability Scale Score Result										Total	Final Score
	1	2	3	4	5	6	7	8	9	10		
1	1	4	3	4	3	3	3	4	3	4	32	80
2	3	4	4	3	4	4	3	4	3	4	36	90
3	4	4	4	4	3	4	3	4	3	4	37	93
4	0	4	3	4	3	4	2	4	3	4	31	78
5	1	3	2	3	3	4	2	4	3	4	29	73
6	3	4	3	4	4	3	2	4	3	3	33	83
7	3	4	3	4	2	4	4	4	4	4	36	90
8	1	4	4	4	2	4	2	4	4	4	33	83
9	2	4	4	3	2	4	2	3	3	4	31	78
10	2	3	0	4	3	4	3	4	3	4	30	75
Total												820
Final Score												82

Source: (Research Results, 2024)

CONCLUSION

This research aims to develop an expert system which can identify whether the portion of food consumed meets balanced nutrition or not. Thus, the novelty of this research is to develop a system for identifying nutritional adequacy and balance based on expert knowledge rules. This system has the ability to calculate the calories needed and the calories consumed daily while comparing them so it can provide a decision whether daily consumption meets adequate and balanced nutrition. This is the advantage and difference from previous similar research. It works by receive menus data input with portion sizes consumed, then based on nutritional table reference data, the system will provide results of nutritional adequacy and balance. This method consists of four main stages, namely requirement analysis, system design, implementation, and testing. To start developing the system, we start by collecting a dataset of food menus and their nutritional values. Furthermore, determining each person's nutrition depends on their physical condition, so the input data is in the form of food menu data and weight. This food data will then be converted based on the nutritional content table. After describing the content, it is necessary to create rules to calculate the amount of nutritional content. After the design is implemented, the following is an explanation of the results of the identification system that has been built. Meanwhile, system usability testing result shows that the identification system has been tested with a score of 82 and categorized in Excellent.

We hope that this system will be able to help provide information on nutritional adequacy and balance an as an effort to prevent malnutrition. For further development, system features can be added with a food menu recommendation feature for users. These recommendations can help determine what food to consume so that it meets the requirements for adequate and balanced nutrition. This system will have a beneficial impact if the government which is responsible for public health can socialize the use of this system to the public from the top level to the bottom level, such as community health centers, integrated service posts, and the community can even do it independently. In this way, the hope of comprehensive prevention of malnutrition will be achieved.

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