# The application of an analytic network process to select vegetarian food for chronic disease patients

*Wilaitip* Punyota [1,*], *Athakorn* Kengpol [2], *and Preecha* Rungsaksangmanee [3]

[1]Industrial Engineering, Faculty of Engineering, King Mongkut's University of Technology North Bangkok, Bangkok, Thailand

[2]Industrial Engineering, Faculty of Engineering, King Mongkut's University of Technology North Bangkok, Bangkok, Thailand
[3]Infirmary of Kasetsart University, Bangkok, Thailand

**Abstract.** Food is important for patients with chronic diseases. Food choice is a multiple-criteria decision problem because there are so many options and factors to consider. The number of chronic disease patients continues to increase. People with chronic diseases eat a lot of healthy food groups, such as vegetarian foods, because it can help prevent, treat, and lower the risk of chronic diseases. People with chronic diseases should eat vegetarian food. From previous research studies, no research has been done to prioritize the appropriate vegetarian food menus for people with chronic diseases. Therefore, the objective of this research is to prioritize the appropriate vegetarian food menu for patients with three chronic diseases as appropriate for each disease by using the analytic network process. The results show that the model for prioritizing food menus in patients with chronic disease is appropriate and nutritionally correct. The benefits of this research can help support food decisions for consumers with chronic diseases. This model encourages people who suffer from chronic diseases to eat nutritious foods that are appropriate for their condition. Vegetarian food that is appropriate for an individual is referred to as being a part of a sustainable food system.

**Keyword.** Vegetarian food, Analytic network process, Sustainable food system

## 1 Introduction

The change in the modern world has resulted in many people living with risky behaviors. Consumers eat foods that are very sweet, salty, and high in fat, lacking in fruits and vegetables, being less physically active, and living in the midst of pollution. Also, the selection of favorite food leads to the production of food waste, which contributed a major portion of greenhouse gas worldwide. Chronic diseases, such as diabetes, high cholesterol, high blood pressure, osteoporosis, cancer, and others are caused by these factors. These conditions can lead to more serious conditions, such as coronary artery disease, chronic kidney disease, and dementia. It also lowers the quality of life, makes people sick, and is a leading cause of death.

The most common noncommunicable diseases (NCDs) in Thai people are diabetes, obesity, high blood pressure, high cholesterol, chronic respiratory disease, and cancer. The population with noncommunicable diseases has been rising, and the average age of these patients is getting younger. The first obvious risk factor is the increase in body weight among the overweight, which increases the risk of developing NCD [1]. Additionally, the spread of coronavirus 2019 (COVID-19) has heightened the impact of NCDs. According to the World Health Organization (WHO), people with

underlying diseases are more likely to develop a severe illness or die from COVID-19 than healthy people [2]. These long-term illnesses are caused by poor eating habits, not getting enough sleep, and overworking. These factors have a long-term negative effect on health. A healthy diet is the most important factor in preventing NCDs.

In Thailand, healthy food is becoming more popular, and consumption is increasing. Health-conscious consumers are looking for food that balances the body and lowers the risk of getting many different diseases. Entrepreneurs are competing to develop better products for the body to meet the needs of these people. Numerous healthy food groups, such as clean food, vegetarian food, or food made with organic ingredients, as well as vitamins and dietary supplements, are extremely popular [3]. As a result, eating healthy foods is a good way to care for the body. Vegetarian food is one of the healthiest and most popular foods. It is mainly composed of fruits and vegetables, with no meat. According to the World Health Organization, eating more than 400 g of fruits and vegetables per day can reduce the risk of contracting non-communicable diseases [4]. Therefore, vegetarian foods are suitable for reducing the risk of chronic diseases.

In the past, numerous factors influenced the desire to make healthy food choices. Consumers believe that

---

eating healthier foods can improve their overall health. These factors are essential for the selection of healthy foods that consumers can accept. There have been numerous types of restaurants that have expanded rapidly to meet consumer demand. As the number of restaurants increases, consumers have more food options to choose from. Consumers have to make dietary decisions on a regular basis but often lack the knowledge to use them. Most consumers choose food based on their own experiences, friends' advice, advertising, or their favorite food tastes. Therefore, if consumers lack experience or knowledge, they can make decisions with only a general understanding. Consumers are unable to select the most appropriate food for their individual needs, resulting in these limitations on their food choices. Food production is a resource-intensive effort with a significant environmental impact. Access to nutritious and healthy food remains a problem for many. Chronic diseases are related to consuming unhealthy foods and participating in unhealthy daily activities. This is a major public health issue that has a negative impact on the economy and society.

The majority of previous vegetarian food research studies have focused on consumer food consumption behaviors, factors that influence vegetarian food choices, and vegetarian diet satisfaction. Consumers are unaware of the nutritional value of their food [5]. If a patient with chronic disease is informed and consumes appropriate healthy foods, they can reduce their disease occurrences and medical costs. However, no research supports or helps solve the problem of proper menu provision for chronic disease patients. Therefore, the objective of this research is to determine the appropriate vegetarian food menu for patients with three chronic diseases by using the analytic network process (ANP). Appropriate food means food that is safe for the body and helps prevent, alleviate, or treat chronic diseases. The analytic network process framework represents network relationships to represent complex interrelationships between decision levels or clusters [6]. It is able to manage the relationship between the decision criteria and their impact on choice. The analytic network process uses a comparative ratio scale as a super matrix to reduce analytic hierarchy process (AHP) errors [7]. The analytic network process method is used in this study to prioritize appropriate food menus for people with chronic diseases. The benefits of this research encourage consumers with chronic diseases to consume appropriate vegetarian foods for their condition. Consumer-appropriate vegetarian food is considered to be part of a sustainable food system (SFS) [8]. Sustainable food systems need to be made into long-term food systems so that they are more productive and can provide food that is healthy and nutritious. Vegetarian food has health, environmental, global food security, and animal welfare benefits. As a result, vegetarian food is a logical means of promoting sustainable food development [9].

# 2 Literature review

## 2.1 Vegetarian food

Vegetarian food involves abstaining from eating meat, fish, and poultry. It contains various levels of fruits, vegetables, grains, pulses, nuts, and seeds, but no meat. Plant-based vegetarian food is becoming more popular, and consumers may find it to be a cost-effective and low-risk treatment for a variety of chronic diseases. According to a number of studies, vegetarian foods reduce the risk of diabetes, hypertension, and heart disease [9]. Vegetarianism is becoming more popular all over the world, in part because it is healthier. Vegetarian foods can prevent and treat heart disease, hypertension, diabetes, cancer, osteoporosis, renal disease, and dementia. The lower prevalence of chronic diseases among vegetarians may be partially attributable to dietary choices other than the absence of meat. According to Glenn *et al.*, vegetarianism is associated with a 22% reduction in cardiovascular mortality and a 28% reduction in cardiovascular disease [10]. For example, bitter lemon is a part of the Cucurbitaceae, which has long been used in traditional medicine to treat diseases such as cancer and diabetes. A lectin found in bitter melon lowers blood glucose levels by acting on peripheral tissues and suppressing appetite, similar to how insulin works in the brain [11]. Ginger decreases blood pressure by dilating blood vessels and blocking calcium channels [12]. Based on previous research studies, Mehta (2017) proposes that proper vegetarian diet planning can be beneficial to health. The most significant effect is a 25% reduction in the risk of death and morbidity from coronary heart disease [13]. Agnoli et al. (2017) study important nutrients in vegetarian diets (proteins, vitamin B12, iron, zinc, calcium, vitamin D, and n-3 fatty acids). Regular consumption of plant-based foods can provide health benefits and help prevent chronic diseases [14]. In summary, vegetarian food is healthy because it reduces risks, alleviates diseases, and prevents chronic diseases. Additionally, it reduces the cost of medical care and increases agricultural production [15].

## 2.2 The Analytic Network Process (ANP)

One of the multi-criteria decision-making solutions is the AHP and ANP methods. This method has the advantage of being applicable to both quantitative and qualitative decision-making criteria. AHP is used for advanced decision analysis. It can eliminate weight-related issues. AHP compares each pair of elements using a hierarchical structure. Occasionally, the structure involves non-hierarchical decision-making elements. This is a limitation of the AHP. Thus, the ANP can manipulate the relationship between decision criteria and non-hierarchical selections. ANP uses a comparative ratio scale and processes it as a super matrix, which reduces AHP errors [16]. The ANP creates a network of relationships between criteria and sub-criteria that indicate dependencies between the criteria and sub-criteria. Inner dependencies are between criterion

components (nodes). External dependencies are between-sub-criteria dependencies [17]. From previous research studies, Xia and Cheng (2019) use an analytic network process (ANP) to organize multiple-criteria decision-making (MCDM) to determine sustainable rural built-up landscapes in rural planning. The results show that weights and relative importance have been appropriately assigned to each criterion [18]. Hu et al. (2019) use a multi-criteria ANP to make maintenance networks for clusters of agricultural machinery. The ANP can solve the problem of evaluating competing alternatives and implementing decision-making criteria. This decision-making process involves a limited number of options, each of which is given a priority or preference [19]. In this research, the ANP method is used to determine appropriate foods for consumers with chronic diseases.

## 3 Material and Method

This section describes five steps for prioritizing a vegetarian diet for patients with chronic disease. The beginning step is to study appropriate foods for chronic diseases. Step 2 defines the structure of the problem. Step 3 is paired comparison. Step 4 is to determine the importance. Finally, step 5 finds a consistency ratio.

### 3.1 Study information on foods suitable for chronic diseases

This study is a pilot study to prioritize vegetarian food in patients with chronic disease. This study focused on high blood pressure, diabetes, and dyslipidemia, which are three of the most common long-term diseases. Then select a total of 5 dishes, namely, menu1: spicy mixed vegetable soup, menu2: stir-fried tofu with ginger, menu3: bitter melon with mixed Chinese herbs soup, menu4: fried eggplant and basil with textured vegetable protein (TVP), menu5: sour soup with mixed vegetables. These foods are readily available for purchase and consumption on the market. Fig. 1 shows examples of appropriate foods for chronic diseases.



**Figure 1.** Examples of appropriate foods for chronic diseases.

### 3.2 Define the structure of the problem

The objective of defining the structure of the problem is to describe the relationship between the problem's goals and the different criteria. The section explains the structure of the food evaluation problem in chronic disease patients. The structure consists of two parts: 1) Goal: The objective of the decision is to select the appropriate food for patients with chronic diseases. 2) Criteria: A criterion is a factor that influences a decision. It is defined as a food menu with five options.

### 3.3 Paired Comparison

A paired comparison is used to determine the significance of each relationship using data from the Bureau of Nutrition, the Department of Health, and the Ministry of Public Health [20]. The raw ingredients of each dish are considered when determining the relationship between diet and chronic diseases. The right nutritional value for each chronic disease determines which foods are most important for that disease. The considered factor and the reference factor are compared using an equal-numbers comparison. As shown in Table 1, the Saaty rating scale is used for pair comparison, which has a value between 1 and 9 [21]. The pair comparison evaluation is represented in Table 1 by the pair comparison matrix. The objective comparison scores $i$ and $j$ is represented by $a_{ij}$ as shown in Fig. 2.

**Table 1.** Priority for comparing decision criteria.

| Importance Level | Numerical Value |
|---|---|
| Equally | 1 |
| Equally to Moderately | 2 |
| Moderately | 3 |
| Moderately to Strongly | 4 |
| Strongly | 5 |
| Strongly to Very Strongly | 6 |
| Very Strongly | 7 |
| Very Strongly to Extremely | 8 |
| Extremely | 9 |



**Figure 2.** Matrix of pair comparisons.

### 3.4 Prioritization

From the paired comparison in Step 3.3, the following step is to calculate the significance of the criteria from the $A_{norm}$ matrix using equation 1. The priority weights for each goal are averaged in each row of the $A_{norm}$ matrix.

$$A_{norm} = \begin{bmatrix} \dfrac{a_{11}}{\sum_{j=1}^{n} a_{1j}} & \cdots & \dfrac{a_{i1}}{\sum_{j=1}^{n} a_{ij}} \\ \vdots & \ddots & \vdots \\ \dfrac{a_{1j}}{\sum_{j=1}^{n} a_{1j}} & \cdots & \dfrac{a_{ij}}{\sum_{j=1}^{n} a_{ij}} \end{bmatrix} \quad (1)$$

*3.5 Consider the Consistency Ratio (CR)*

The consistency ratio from pair comparisons is used to determine whether or not pair comparison assessments are consistent with one another. The eigen vector value is used to determine the priority of the consistency check. It can be used to calculate the consistency ratio (CR), which is the ratio of the consistency index (CI) to the random consistency index (RI) as shown in equation 2. The consistency index value is determined by the variance of $\lambda_{max}$ and the number of decision criteria. Table 2 shows the random index used to calculate the random consistency index [15].

$$CR = \frac{CI}{RI} = \frac{\dfrac{\lambda_{max} - n}{n-1}}{RI} \quad (2)$$

where $n$ is the number of decision criteria.

$\lambda_{max}$ is the sum of the product between the sum of the elements in each digit of the matrix and the significant weight.

**Table 2.** Random Index.

| Order | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|-------|---|---|------|------|------|------|------|------|------|------|
| R.I. | 0 | 0 | 0.52 | 0.89 | 1.11 | 1.25 | 1.35 | 1.40 | 1.45 | 1.49 |

If the consistency ratio (CR) is less than 0.1, then the comparative evaluations of the pairs are consistent. It can bring weight values and comparative evaluation results in pairs for decision making in the next step. If the consistency ratio (CR) is greater than 0.1, it means that the pairs are not consistent with each other. The weights and results of the paired comparison cannot be used to consider making any more decisions.

# 4 Results and discussion

This ANP method is used to determine the priority of foods for patients with chronic diseases. The results and discussion are as follows:

## 4.1 The result of determining the structure of the problem

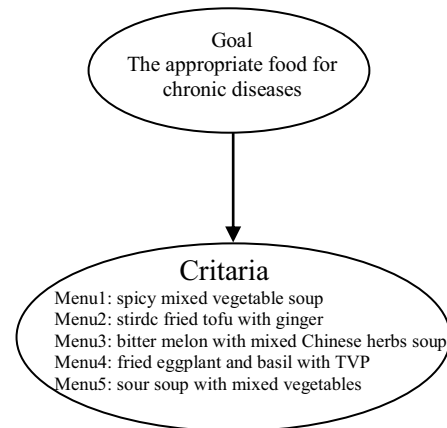This step shows a diagram of the relationship between goals and decision criteria.



**Figure 3.** Relationship between goals and criteria

*4.2 The results of the paired comparison assessment*

A paired comparison of the importance of each food menu relationship is assessed by a group of nutrition experts. The decision criterion and each criterion are compared proportionally in a paired comparison. Table 3 presents an example of a paired comparison of a pair of foods for diabetes.

**Table 3.** Paired comparison with decision goals for diabetes.

| Criteria | Menu 1 | Menu 2 | Menu 3 | Menu 4 | Menu 5 |
|----------|--------|--------|--------|--------|--------|
| Menu 1 | 1 | 2 | 1/5 | 1/4 | 1/3 |
| Menu 2 | 1/2 | 1 | 1/6 | 1/5 | 1/4 |
| Menu 3 | 5 | 6 | 1 | 2 | 3 |
| Menu 4 | 4 | 5 | 1/2 | 1 | 2 |
| Menu 5 | 3 | 4 | 1/3 | 1/2 | 1 |

Table 3 shows an example of a comparison of the criteria used to make a decision for diabetic patients. The evaluation results can be explained by comparing the impact or importance of criteria on decision-making goals, as shown below: A score of 2 between criterion 1 and criterion 2 indicates that criterion 1 is twice as important as criterion 2 to the decision goal. The raw ingredients of each dish are considered when determining the relationship between food and chronic diseases. The right nutritional value for each chronic disease determines which foods are most important for that disease. On the other hand, if the significance comparison score is proportional, the score for criterion 2 versus criterion 5 is 1/4. This means that criterion 2 is four times less important to the goal of making a decision than criterion 5. From the paired comparison, the example evaluation results can be shown in the form of a metric $A$ as follows:

$$A = \begin{pmatrix} 1 & 2 & 1/5 & 1/4 & 1/3 \\ 1/2 & 1 & 1/6 & 1/5 & 1/4 \\ 5 & 6 & 1 & 2 & 3 \\ 4 & 5 & 1/2 & 1 & 2 \\ 3 & 4 & 1/3 & 1/2 & 1 \end{pmatrix}$$

The $A_{norm}$ matrix is obtained by performing the operation with equation 1 as follows:

$$A_{norm} = \begin{pmatrix} 0.07 & 0.11 & 0.09 & 0.06 & 0.05 \\ 0.04 & 0.06 & 0.08 & 0.05 & 0.04 \\ 0.37 & 0.33 & 0.45 & 0.51 & 0.46 \\ 0.30 & 0.28 & 0.23 & 0.25 & 0.30 \\ 0.22 & 0.22 & 0.15 & 0.13 & 0.15 \end{pmatrix}$$

The significance of each criterion is determined by averaging each row of the matrix $A$ as shown in Table 4. An example of evaluating the significance of the criteria for diabetes is (0.07+0.11+0.09+0.06+0.05)/5 = 0.07.

**Table 4.** The weight of comparing pairs for diabetes.

| Criteria | Menu | Weight |
|---|---|---|
| 1 | Spicy mixed vegetable soup | 0.07 |
| 2 | Stir-fried tofu with ginger | 0.05 |
| 3 | Bitter melon with mixed Chinese herbs soup | 0.42 |
| 4 | Fried eggplant and basil with TVP | 0.27 |
| 5 | Sour soup with mixed vegetables | 0.17 |

### 4.3 Weight of the importance of decision-making criteria

The nutritional value of each menu item for a chronic disease is calculated by using nutrition data from the Bureau of Nutrition. The ANP method is used to analyze the results of food priorities in chronic disease patients using a Python programming language with a quick and easy library. Figure 4 shows ANP analysis by Python.

```
priority.pri_eigen(Diabetes, return_eigenval=True)

Xmax = priority.pri_eigen(Diabetes, return_eigenval=True)

priority.pri_eigen(Diabetes)

Priority = priority.pri_eigen(Diabetes)

priority.incon_std(Diabetes)

CR = priority.incon_std(Diabetes)

Paired Comparison Diabate =
 [[1.         2.         0.2        0.25       0.33333333]
 [0.5        1.         0.16666667 0.2        0.25       ]
 [5.         6.         1.         2.         3.         ]
 [4.         5.         0.5        1.         2.         ]
 [3.         4.         0.33333333 0.5        1.         ]]
Priority =
 [0.0762662  0.05056501 0.4271063  0.2728264  0.17323609]
SumXmax = 5.097532883557998
Consistency Ratio(CR) = 0.021770732937053037
```

**Figure 4.** ANP analysis by Python.

The results of food prioritization for high blood pressure are shown in Table 5, diabetes is shown in Table 6, and dyslipidemia is shown in Table 7, respectively.

**Table 5.** The priority of the criterion for high blood pressure.

| No. | Criteria | Weight |
|---|---|---|
| 1 | Spicy mixed vegetable soup | 0.31 |
| 2 | Stir fried tofu with ginger | 0.31 |
| 3 | Bitter melon with mix Chinese herbs soup | 0.18 |
| 4 | Fried eggplant and basil with TVP | 0.11 |
| 5 | Sour soup with mixed vegetables | 0.06 |

**Table 6.** The priority of the criterion for diabetes.

| No. | Criteria | Weight |
|---|---|---|
| 1 | Bitter melon with mix Chinese herbs soup | 0.42 |
| 2 | Fried eggplant and basil with TVP | 0.27 |
| 3 | Sour soup with mixed vegetables | 0.17 |
| 4 | Spicy mixed vegetable soup | 0.07 |
| 5 | Stir fried tofu with ginger | 0.05 |

**Table 7.** The priority of the criterion for dyslipidemia.

| No. | Criteria | Weight |
|---|---|---|
| 1 | Sour soup with mixed vegetables | 0.39 |
| 2 | Spicy mixed vegetable soup | 0.27 |
| 3 | Bitter melon with mix Chinese herbs soup | 0.19 |
| 4 | Fried eggplant and basil with TVP | 0.07 |
| 5 | Stir fried tofu with ginger | 0.05 |

### 4.4 The result of consider the consistency ratio (CR)

This procedure performs a consistency ratio analysis (Table 8). For example, the weight of the diabetes criteria is shown below.

$$A_{Diabetes} = \begin{pmatrix} 1 & 2 & 1/5 & 1/4 & 1/3 \\ 1/2 & 1 & 1/6 & 1/5 & 1/4 \\ 5 & 6 & 1 & 2 & 3 \\ 4 & 5 & 1/2 & 1 & 2 \\ 3 & 4 & 1/3 & 1/2 & 1 \end{pmatrix} \times \begin{pmatrix} 0.07 \\ 0.05 \\ 0.42 \\ 0.27 \\ 0.17 \end{pmatrix} = \begin{pmatrix} 0.39 \\ 0.25 \\ 2.19 \\ 1.40 \\ 0.89 \end{pmatrix}$$

$$\lambda_{max} = \frac{\dfrac{0.39}{0.07} + \dfrac{0.25}{0.05} + \dfrac{2.19}{0.42} + \dfrac{1.40}{0.27} + \dfrac{0.89}{0.17}}{5} = 5.09$$

Based upon the size of the matrix $n = 5$, the random index of Table 3 is 1.12, which when placed into equation **2** obtains the following consistency ratio:

$$CR = \frac{CI}{RI} = \frac{\dfrac{\lambda_{max} - n}{n-1}}{RI} = \frac{\dfrac{5.09 - 5}{5 - 1}}{1.12} = 0.02$$

The importance of appropriate food for patients with three chronic diseases: high blood pressure, diabetes, and dyslipidemia and five menus, namely, menu1: spicy mixed vegetable soup, menu2: stirred-fried tofu with

ginger, menu3: bitter melon with mixed Chinese herbs soup, menu4: fried eggplant and basil with TVP, menu5: sour soup with mixed vegetables.

**Table 8.** Consistency ratio (CR).

| Chronic diseases | Consistency Ratio (CR) |
| --- | --- |
| High blood pressure | 0.008 |
| Diabetes | 0.021 |
| Dyslipidemia | 0.018 |

The results of the priority are discussed as follows: food evaluation results for high blood pressure patients show that spicy mixed vegetable soup and stir-fried tofu with ginger have the highest weight, 0.31. Therefore, both menus are most appropriate for patients. According to Table 5, the next most appropriate foods for high blood pressure patients are bitter melon with mixed Chinese herbs soup, fried eggplant and basil with TVP, and sour soup with mixed vegetables, weighing 0.18, 0.11, and 0.06, respectively. As shown in Table 6, the most appropriate food for diabetes patients is bitter melon with mixed Chinese herbs soup, which weights 0.42. The next most appropriate foods for diabetes are fried eggplant and basil with TVP, sour soup with mixed vegetables, spicy mixed vegetable soup, and stir-fried tofu with ginger, with respective weight values of 0.27, 0.17, 0.07, and 0.05. Finally, food evaluation results for dyslipidemia patients show that sour soup with mixed vegetables has the highest weight of 0.39 and is the most appropriate food for patients, as shown in Table 7. The next most appropriate foods for dyslipidemia are spicy mixed vegetable soup, bitter melon with mixed Chinese herbs soup, fried eggplant and basil with TVP, and stir-fried tofu with ginger, with respective weight values of 0.27, 0.19, 0.07, and 0.05. The results of the consistency ratio determination show that the CR for high blood pressure is 0.0081, the CR for diabetes is 0.0271, and the CR for dyslipidemia is 0.0189. Table 8 indicates that all of the CR values are less than 0.1, which means that the criteria for making decisions are consistent.

## 5 Conclusion

The objective of this research is to prioritize the appropriate vegetarian food menu for patients with three chronic diseases as appropriate for each disease by using the analytic network process. This is a decision made under quantitative and qualitative decision-making criteria. The goal of the decision is to identify appropriate foods for all three chronic conditions: high blood pressure, diabetes, and dyslipidemia. The decision criterion is all five menus: menu1: spicy mixed vegetable soup, menu2: stirred-fried tofu with ginger, menu3: bitter melon with mixed Chinese herbs soup, menu4: fried eggplant and basil with TVP, menu5: sour soup with mixed vegetables. The right nutritional value for each chronic disease determines which foods are most important for that disease. The results indicate that the analytic network process can prioritize nutritionally

appropriate food for chronic disease patients. The two most appropriate food for high blood pressure patients is spicy mixed vegetable soup and stirred-fried tofu with ginger. The most appropriate food for diabetes patients is bitter melon with mixed Chinese herbs soup. The most appropriate food for dyslipidemia is a sour soup with mixed vegetables. The reliability of the evaluation is indicated by a C.R. value of less than 0.1. The benefits of this research contribute to the promotion of dietary guidelines for chronic disease patients. The recommendations of this analysis allow consumers to select foods that are nutritionally appropriate for their health. Vegetarian food that is appropriate for an individual is considered to be part of a sustainable food system (SFS). Sustainable food systems must be reformed in order to become more productive and capable of providing suitable, healthy, and nutritious food to all people on a sustainable basis. Vegetarian food has numerous advantages in terms of human health, especially for patients with chronic diseases. As a result, a vegetarian diet is a logical way to promote sustainable food development and consumption. More fruits and vegetables are grown to support a vegetarian diet for people with chronic diseases when there are more vegetarians. It is an increase in agricultural productivity that is sustainable. For future research, the number of chronic diseases and foods should be increased to better match the daily situation. The results of this research could be improved by studying weight scales that are both more reliable and more widely accepted. These weight scales should be based upon expert assessments of each disease. Furthermore, modern technologies such as artificial intelligence (AI) may be used to determine and compare the appropriate foods for chronic disease patients to the foods in this study.

## Acknowledgements

## References

[1] Division of Non-Communicable Diseases, Department of disease control, Ministry of Health in Thailand, NCD Situation Report 2019 Diabetes, Hypertension and Related Risk Factors, (2019)

[2] K.L. Hon, K. K. Y. Leung, J. W. Tang, A. K. C. Leung, Y. Li, COVID-19 in Hong Kong – public health, food safety, and animal vectors perspectives, Journal of Virological Methods, 290 (2020)

[3] V. Mehta, Vegetarian Diet: A Boon or Bane for Health, Journal of Medical Research and Innovation, 2 (2017)

[4] B. Chaniphun, Vegetables and Fruits Consumption at Least 400 g Per Day for Health: Evidence-based Approach, Journal of Nutrition Association of Thailand, 55(2020):53–65

[5] J. Saintila, Y. E. Calizaya-Milla, D. J. Aliaga, Knowledge of Vegetarian and Nonvegetarian Peruvian Dietitians about Vegetarianism at Different Stages of Life, Journal of Nutrition and Metabolic Insights, 14 (2021):1-9

[6] A. Kengpol, P. Neungrit, A decision support methodology with risk assessment on prediction of terrorism insurgency distribution range radius and elapsing time: An empirical case study in Thailand, Computers & Industrial Engineering, 75 (2014):55-67

[7] Y.-H. Chang, W.-M. Wey, and H.-Y. Tseng, Using ANP priorities with goal programming for revitalizations strategies in historic transport: A case study of the Alishan Forest Railway, Expert Systems with Application, 36 (2009):8682-8690

[8] H. D. Vries, M. Donner, M. Axelos, Sustainable food systems science based on physics' principles, 123 (2022):382-392

[9] A. Jabri, A. Kumar, E. Verghese, A. Alameh, A. Kumard, M. S. Khan, S. U. Khan, E. D. Michos, S. R. Kapadia, G. W. Reed, A. Kalra, Meta-analysis of effect of vegetarian diet on ischemic heart disease and all-cause mortality, American Journal of Preventive Cardiology, 7(2021)

[10] A. J. Glenn, E. Viguiliouk, M. Seider, B. A. Boucher, T. A. Khan, Relation of Vegetarian Dietary Patterns with Major Cardiovascular Outcomes: A Systematic Review and Meta-Analysis of Prospective Cohort Studies, Nutrition, 6(2019):1-12

[11] O. O. Elekofehinti, E. O. Ariyo, M. O. Akinjiyan, O. S. Olayeriju, A. O. Lawal, I. G. Adanlawo, J. B. T. Rocha, Potential use of bitter melon (Momordica charantia) derived compounds as antidiabetics: In silico and in vivo studies, Journal of Pathophysiology, 25,4(2018):327-333

[12] H. Hasani, A. Arab, A. Hadi, M. Pourmasoumi, A. Ghavami, M. Miraghajani, Does ginger supplementation lower blood pressure? A systematic review and meta-analysis of clinical trials, Journal of Phytotherapy, 33,1(2019)

[13] V. Mehta, Vegetarian Diet: A Boon or Bane for Health?, Jounal of Medical Research and Innovation, 2(2017)

[14] C. Agnoli, L. Baroni, I. Bertini, S. Ciappellano, A. Fabbri, M. Papa, S. Sieri, Position paper on vegetarian diets from the working group of the Italian Society of Human Nutrition. Journal of Nutrition, Metabolism and Cardiovascular Diseases, 27(2017):1037-1052

[15] A. U. Khank, Analytical hierarchy process (AHP) and analytic network process (ANP) methods and their applications: a twenty year review from 2000-2019, 12 (2020):369-459

[16] P. Chemweno, L. Pintelon, A. V. Horenbeek, P. Muchiri, Development of a risk assessment selection methodology for asset maintenance decision making: an analytic network process (ANP) approach, International Journal of Production Economics, 170(2015):663–676

[17] A. Kengpol, W. Punyota, Deep learning food assessment for the elderly with chronic diseases during the COVID-19 pandemic. 26th International Conference on Production Research (ICPR) 2021, (2021)

[18] L. Xia, W. Cheng, Sustainable development strategy of rural built-up landscapes in Northeast China based on ANP approach, Journal of Energy Procedia, 157(2019):844-850

[19] Y. Hu, S. Xiao, J. Wen, J. Li, An ANP-multi-criteria-based methodology to construct maintenance networks for agricultural machinery cluster in a balanced scorecard context, Journal of Computers and Electronics in Agriculture, 158 (2019): 1-10

[20] Bureau of Nutrition, Department of Health, Ministry of Public Health in Thailand. Homepage. http://nutrition.anamai.moph.go.th/image/file/food/images/files/foodCOVID-19.pdf

[21] T. L. Saaty, *Decision Making with Dependence and Feedback: The Analytic Network Process*. 2nd ed. Pittsburgh :RWS Publications, (2001)