Optimization of Foodstuffs for Patients with Hypertension Using the Improved Particle Swarm Optimization Method

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ABSTRACT

Hypertension is when a person's blood pressure exceeds the reasonable limits determined by experts. A person who suffers from high blood pressure or hypertension risks developing non-communicable diseases that can endanger the sufferer's life, such as stroke and heart attack. One of the causes that can increase and worsen hypertension is an unhealthy lifestyle. Due to a lack of knowledge in regulating food composition, it is difficult for ordinary people to vary the composition of food in the next few days, which is usually done by simply avoiding foods ordered by doctors or experts. The Improved Particle Swarm Optimization (IPSO) method was chosen because it can be used to solve the problem of optimizing optimal food composition. In addition, the IPSO method can also remember the worst position ever visited so that particles can pass through a bad position and always try a better position. Based on the research conducted, the IPSO method succeeded in producing recommendations for the composition of foods consumed by people with hypertension consisting of 3 portions, namely breakfast, lunch, and dinner. Breakfast and lunch contain staple foods, plant sources, animal sources, vegetables, fruits, or complementary foods. At the same time, dinner contains only staple foods, animal sources, plant sources, and vegetables. This research found that the iteration that can produce optimal results is 400 iterations and the most optimal particles are 10 particles. This happens because the price of food ingredients is included in the calculation.

Keywords : Intelligent decision support system; Hypertension; Optimization; Improved Particle Swarm Optimization

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I. INTRODUCTION

Hypertension is when a person's blood pressure exceeds the reasonable limit determined by experts. Someone who suffers from high blood pressure or hypertension risks developing non-communicable diseases that can endanger the sufferer's life, such as stroke and heart attack [1]. Hypertension is also a global public health challenge, where hypertension can significantly reduce the quality of life of sufferers and is also a factor that is closely related to cardiovascular disease and mortality or death at a young age due to hypertension [2].

One of the causes that can increase and worsen hypertension is an unhealthy lifestyle [3]. People's consumption patterns are also caused by technological developments that change instantaneous eating patterns coupled with a myriad of activities that make Indonesians prefer fast food and junk food. If left unchecked, this unhealthy diet will emerge from complications such as stroke or heart infarction [4].

Especially in this difficult era, food prices have increased, which is difficult for people struggling economically. Since the price of foodstuffs has increased drastically, there has been a decrease in the community's frequency of foodstuffs consumption [5]. So, before deciding to buy a food ingredient, people will consider the price of the food product [6]. Poor money management will be difficult for people to determine what food to consume next.

Due to a lack of knowledge in regulating food composition, it is difficult for ordinary people to vary the composition of food in the next few days, which is usually done only by avoiding foods told by doctors or experts [4]. Moreover, people with hypertension must consider the price in determining the food intake they choose. These two things will make it difficult for ordinary people to meet their nutritional needs. The solution to this problem is to develop software that can help recommend food composition for hypertension sufferers with several variations so that optimal food composition results for hypertension sufferers will be obtained at the minimum possible cost [7].

Research related to optimizing food composition for people with hypertension has been carried out using the Genetic Algorithm method by Purnomo (2019). However, the food composition resulting from this study using population data aged 50 years still

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does not follow the nutritional needs of people with hypertension. As with carbohydrates, the standard set is 520.67 grams, while the recommendation from the system only reaches 193.91 grams, so the nutritional penalty rate as recommended is more than 200%, with a total penalty of 5,439.83. This exceeds the tolerance set by the experts, where the nutritional sanctions limit consumed by people with hypertension should not be more than 10% of the nutrition determined by the experts. Moreover, the calculation has not included the food price factor in this research.

A similar study was also conducted by Boestari (2017) regarding the optimization of food composition for people with hypertension using the Particle Swarm Optimization method. The system recommendation results show that the average difference in nutrition from the recommendation of the system with the user's need for breakfast is 9.9% from the maximum limit of 10%. And also, this research did not include the price of each food ingredient. The price is one of the important variables in marketing, where the price can influence consumers in decision-making to buy a product [8]. It could be that users do not carry out the results of the system recommendations due to price issues that are not considered.

A similar study on optimizing food composition was also conducted by Gregory (2018) using the Improved Particle Swarm Optimization (IPSO) method for people with Diabetes Mellitus, which showed better results. The maximum difference in nutritional results between system recommendations and expert recommendations only reaches 8.9% of the maximum nutritional difference recommended by experts is 10%. The Improved Particle Swarm Optimization method has better results than the previous Particle Swarm Optimization method. However, the research also did not include the price of food ingredients as one of the considerations in the preparation of these foodstuffs, so it could be that the results of the research recommendations were not carried out because the prices were not optimal.

In this research, the Improved Particle Swarm Optimization (IPSO) method will determine the optimal food composition, both in terms of nutrition and the price of food ingredients, for people with hypertension. The IPSO method was chosen because it is a refinement of the previous Particle Swarm Optimization method and can be used to solve the problem of optimizing optimal food composition. In addition, the IPSO method can also remember the worst position ever visited so that particles can pass through a bad position and always try a better position [9]. In this research, the optimization of food composition is intended to find the optimal composition of food by considering nutritional parameters that hypertensive patient must consider to keep their blood pressure under control and the price of each component of food ingredients in the preparation of optimal food compositions for patients with hypertension so that it will be obtained optimal food composition for hypertensive patients.

II. METHOD

This research is included in implementing research with the type of design because the results of this study are an information system that people with hypertension can use to adjust the composition of food according to their needs as sufferers of hypertension which will be displayed in the form of a website-based application. For food price data, researchers will look for the data directly in accordance with what has been determined in the problem boundary. Then for the nutritional data of foodstuffs to be used, secondary data will be used, which have been determined on the problem boundary. Using data on weight, height, and hypertension level from the user will be processed using the Improved Particle Swarm Optimization algorithm to produce a recommendation for a good food composition for its users with minimal costs. This research begins with conducting a literature study on topics related to the problem or problem formulation raised in this research. The literature sources used are journals, news, articles, books, and other reliable sources. In this stage, researchers seek and collect information related to food composition for people with hypertension, such as previous studies that discussed this topic. Then the same thing was done in previous studies using the Improved Particle Swarm Optimization method. The information collection was carried out to know the development of the topic of food composition for people with hypertension, such as what algorithms or methods have been used in dealing with similar topics, and also to find out the advantages and disadvantages of each of the other methods that have been used previously.

A. Hypertension

The condition in which the amount of blood pumped by the heart exceeds the capacity that the arterial walls can accommodate, increasing systolic blood pressure (when the heart beats) by more than 140 mmHg and diastolic blood pressure (the heart relaxes) by more than 90 mmHg is often referred to as hypertension or high blood pressure [10] as seen Table I. One of the causes that can increase and worsen hypertension is an unhealthy lifestyle, such as uncontrolled eating patterns, smoking, consuming alcohol, strenuous physical activity, and stress. Hypertension is one of the main causes of mortality and morbidity in Indonesia, so the management of this disease is a very common treatment carried out at various levels of health facilities [4]. Therefore, clinical practice guidelines have been prepared to make it easier for medical personnel to treat patients with hypertension. In contrast, the classification of patients with high blood pressure or hypertension can be seen in Table 1. Systolic blood pressure is the main measurement that forms the basis for determining the diagnosis of hypertension. The distribution of the severity of hypertension in a person is one of the bases for determining hypertension management, according to the Ministry of Health of the Republic of Indonesia *http://p2ptm.kemkes.go.id/*.

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TABLE I
HYPERTENSION CLASSIFICATION

Category	Systolic	Diastolic
Hypertension I	120-139	80-89
Hypertension II	140-159	90-99
Hypertension III	>160	>100

B. Food Composition

One of the causes that can increase and worsen hypertension is an unhealthy lifestyle. Various studies have shown that certain nutrients, certain food ingredients, and daily food intake patterns have a role in preventing and treating hypertension [11]. Adjusting the food intake pattern to match the standards that the experts have determined can reduce the risk of developing complications due to hypertension. So that it can help people who suffer from hypertension, they can continue to carry out their daily activities normally. Patients with hypertension take 65% carbohydrates, 15% protein, and 20% fat from the total energy requirement [12]. And also do a diet for foods that contain sodium and potassium [13]. There are 2 calculations to determine the nutritional needs of people with hypertension, namely energy calculations and nutritional calculations.

1) Calculating Body Mass Index and Ideal Body Weight. The calculation of the energy intake needed for people with hypertension is the latest in theory based on Harris-Benedict, taking into account each patient's weight, height, and age [14]. Before doing so, first, calculate the Body Mass Index (BMI) using Equation (1) to determine overweight and obesity in adults. BMI is an indicator that is often used in estimating whether a person is obese or not and correlates with the body (Lisbet, 2004). Then, the results of the BMI calculation are entered into the BMI classification in Table II.

$$BMI = \frac{Weight\ (\text{Kg})}{Height^2 (\text{Cm})} \quad (1)$$

TABLE II
CLASSIFICATION

Classification	BMI
Thin	<18.5
Normal	18.5 - 22.9
Fat	23.0 24.9
Obesity	>24.9

If the BMI is in the normal category, the bodyweight has entered the ideal category [4]. However, if it falls into another category, then using Equation (2):

$$Ideal\ Body\ Weight\ (IBW) = (Height - 100) - 10\%(Height - 100) \quad (2)$$

2) Calculating Basal Metabolic Rate (BMR). BMR shows the energy required by a person to maintain body functions at rest [15]. BMR can be calculated using the Harris-Benedict formula for male patients using Equation (3a) and female patients using Equation (3b).

$$BMR = 66 + (13{,}7\ x\ IBW) + (5\ x\ Height) - (6{,}8\ x\ Umur) \quad (3a)$$
$$BMR = 65{,}5 + (9{,}6\ x\ IBW) + (1{,}7\ x\ Height) - (4{,}7\ x\ Umur) \quad (3b)$$

3) Calculating Energy Needs (EN). Energy needs can be calculated using Equation (4) based on the energy needed and energy expenditure for physical activity in daily life.

$$EN = BMR\ X\ Physical\ Activity\ X\ Stress\ factor \quad (4)$$

According to Almatsier (2006), physical activity and stress factors vary depending on the activity undertaken. The weight data for each activity can be seen in Table III and the stress factor in Table IV [18].

TABLE III
PHYSICAL ACTIVITY

Activity	Man	Woman	Information
Very light	1.30	1.30	A lifestyle in which engaging in moderate activities is generally considered a healthy life.
Light	1.65	1.55	Little exertion and may not cause breathing or resistance.
Normal	1.76	1.7	The force required is intense, force, or rhythmic in moving the muscles.
Heavy	2.1	2	Requires strength and has something to do with exercise, making you sweat.

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TABLE IV
STRESS FACTOR

Type of Stress	Weight
No stress. The patient is in good condition	1.3
Mild stress	1.4
Moderate stress	1.5
heavy	1.6
very heavy	1.7

4) Calculating Nutritional Needs. After knowing the patient's energy needs, calculate the patient's nutritional needs using Equation (5), namely carbohydrates, protein, fat, potassium, and sodium. Recommendations for a low-salt diet I (200-400 mg sodium) for severe hypertension and not adding salt to food. Low salt diet II (600-800 mg sodium) for less severe hypertension. Meanwhile, for mild hypertension, applies III salt diet (1000-1200 mg sodium) [13]. In comparison, the need for potassium is estimated at 2000 mg per day [16]. Calculations for the nutritional needs of carbohydrates, fats, and proteins based on research conducted by Anggi (2019) were carried out using the following method:

$$Carbohydrates = \frac{65\% \; x \; EN}{4}; \quad Protein = \frac{15\% \; x \; EN}{4}; \quad Fat = \frac{20\% \; x \; EN}{9} \tag{5}$$

C. Food Prices

Foodstuffs are closely related to the price of the food ingredients themselves. Especially for people who are still struggling from an economic perspective, the price of food ingredients will be a consideration that cannot be separated from each other. Economic conditions greatly affect a person's diet [6]. So, people, before deciding to buy a food ingredient, will consider the price of the food product. And in the conditions of the COVID-19 pandemic, which make food ingredients soar or income decreased compared to before the pandemic, people think twice when they want to buy food. Since the price of foodstuffs has increased drastically, there has been a decrease in the community's frequency of foodstuffs consumption [3]. Therefore, it is very important to arrange a good food intake at a minimum cost so as not to make it difficult for someone the next day.

D. Improved Particle Swarm Optimization (IPSO) Method

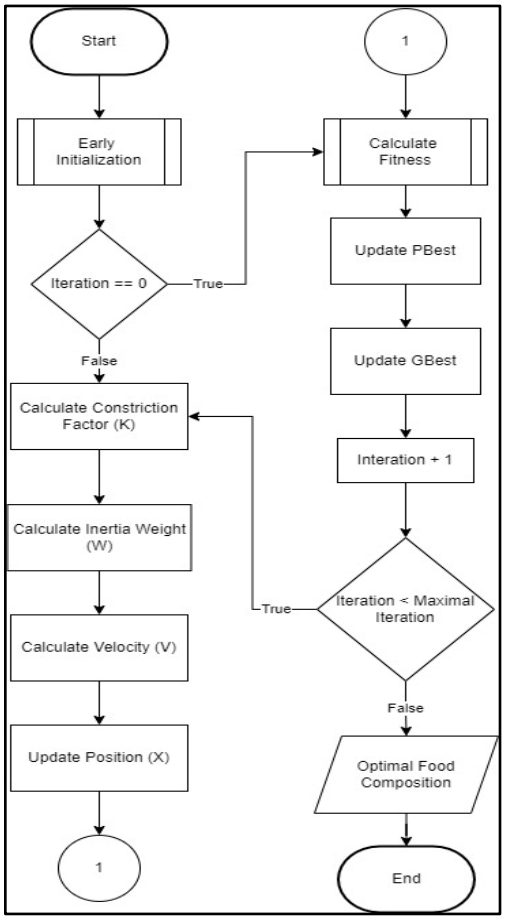

Fig. 1. Flowchart IPSO Method

The Improved Particle Swarm Optimization method develops the Particle Swarm Optimization method by adding two parameters, namely the inertia weight and the constriction factor at the initial initialization, as seen in Fig. 1. These two parameters allow the IPSO method to remember the worst position visited so that particles can pass through a bad position and always try a better position [9]. IPSO method applying inertia weight (*w*) and constriction factor (*K*) asynchronously has proven to be the best IPSO model because it can produce the best fitness value with a relatively fast or short convergence time [17]. Inertia weight is an important parameter in IPSO that determines the result of IPSO operation and balances global and local browsing. The constriction factor on IPSO is used to ensure the best convergence is achieved [18].

1) Early Initialization

$$X_{ij} = X_{ymin} + rand[0,1](X_{ymax} - X_{ymin}) \quad (6)$$

Early Initialization process using Equation (6). Where X_{ij} variable is particle position *i-th*, dimension *j-th*, X_{jmin} variable is the smallest index value of type-y, X_{jmax} variable is the largest index value of type-y, and *rand [0,1]* variable is the upper limit of permutation number

2) Calculate Fitness

$$fitness_i = \frac{1}{FoodPrice_i + (penalty_i * a)} K \quad (7)$$

Calculate Fitness process using Equation (7). Where the *fitness* variable is the fitness value of the *i-th* particle, the $FoodPrice_i$ variable is the total cost of the *i-th* particle, the *penalty* variable is the penalty value of the *i-th* particle, α variable is the constant value of 20, and *K* variable is constant with a value of 100000

3) Update GBest and update PBest. The next step is the PBest update process which takes the largest fitness value before and after iteration. The GBest update selects the best particles from all swarm members obtained from the highest PBest fitness value.

4) Calculate Constriction Factor (K)

$$K = \frac{cos\left(\frac{2\pi}{T_{Max}} x \left(\frac{t - T_{Max}}{2}\right)\right) + 2.428571}{4} \quad (8)$$

Calculate Constriction Factor using Equation (8). Where *K* variable is Constriction Factor, *Tmax* variable is maximum iteration, and *t* variable is iteration at this point

5) Calculate Inertia Weight (W)

$$W = \begin{cases} 0.857143 + \left((1 - 0.857143)\, x\, \left(1 - \frac{t}{T_{Max}}\right)\right) \\ 0.857143,\ gBest_j = X_{ij} \end{cases} \quad (9)$$

Calculate W using Equation (9). Where *W* variable is inertia weight, *Tmax* variable is maximum iteration, *t* variable is iteration at this point, X_{ij} variable is particle position *i-th*, dimension *j-th* , and $gBest_j$ variable is the best position of the particle in the j-th swarm

6) Calculate Velocity (V)

$$V_{ij} = \begin{cases} W \text{ x } V_{ij} + C_1 \text{ x } r1\left(PBest - X_{ij}\right) + C_2 \text{ x } r2\left(GBest - X_{ij}\right), t < \frac{Tmax}{2} \\ K \text{ x } 0.7 \text{ x } V_{ij} + C_1 \text{ x } r1\left(PBest - X_{ij}\right) + C_2 \text{ x } r2\left(GBest - X_{ij}\right), t \geq \frac{Tmax}{2} \end{cases} \quad (10)$$

The value of V is obtained using calculations using Equation (10). Where V_{ij} variable is *i-th* particle velocity and *j-th* dimension, *W* variable is inertia weight, *K* variable is Constriction Factor, *Tmax* variable is maximum iteration, *T* variable is iteration at this point, $gBest_j$ variable is the best position of the particle in the j-th swarm, $pBest_j$ variable is the best position of the *j-th* particle, X_{ij} variable is particle position *i-th*, dimension *j-th*, and *r1&r2* variable is random value 1 (random value between 0-1, kept constant only for manual calculation)

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7) Update Position (X)

$$x_i^{j+i} = x_i^j + v_i^{j+i} \quad (11)$$

The value of V is obtained using calculations using Equation (11). Where x_i^{j+i} variable is the position of the *i-th* particle in the iteration *(j+1)*, v_i^{j+i} variable is *i-th* particle velocity in the iteration *(j+1)-th*, and x_i^j variable is the position of the *i-th* particle in the *j-th* iteration [20].

III. RESULT AND DISCUSSION

Testing here is used to test whether the system successfully runs according to what has been previously implemented. In this research, the test was carried out to determine whether the chosen method, namely the improved particle swarm optimization method, succeeded in producing a food composition according to the user's needs. The improved particle swarm optimization method used random data to obtain optimal food composition in terms of nutrition and cost. From these data, 2 types of tests will be carried out, namely iteration testing and particle testing 10 times in each experiment. The first test used 200 iterations and 5 particles with the following fitness values in Table V.

TABLE V
TEST RESULTS 200 ITERATIONS AND 5 PARTICLES

Test	Best Iteration	Fitness
1.	120	1.92
2.	195	2.52
3.	129	2.57
4.	119	2.4
5.	173	2.51
6.	186	2.52
7.	119	1.61
8.	117	1.83
9.	146	2.23
10.	170	1.98

TABLE VI
TEST RESULTS 200 ITERATIONS AND 10 PARTICLES

Test	Best Iteration	Fitness
1.	157	2.95
2.	194	2.96
3.	124	2.42
4.	164	1.98
5.	152	2.11
6.	130	2.35
7.	131	2.14
8.	155	2.73
9.	120	1.82
10.	151	2.83

From the two tests, it can be seen that using 10 particles has a higher fitness value than using only 5 particles, as shown in Table VI. Then tested using 400 iterations. To determine whether using 400 iterations has better results than the previous condition. In the 400 iteration test, 5 and 10 particles will be used. The results are as in Tables VII and VIII.

TABLE VII
TEST RESULTS 400 ITERATIONS AND 5 PARTICLES

Test	Best Iteration	Fitness
1.	245	2.44
2.	225	2.06
3.	256	1.93
4.	228	2.33
5.	328	2.27
6.	262	2.43
7.	246	2.87
8.	290	2.15
9.	269	2.61
10.	256	2.26

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TABLE VIII
TEST RESULTS 400 ITERATION AND 10 PARTICLES

Test	Best Iteration	Fitness
1.	240	2.6
2.	264	2.55
3.	233	3.07
4.	233	2.98
5.	242	2.68
6.	249	3.45
7.	232	2.78
8.	240	2.6
9.	236	3.83
10.	340	3.7

From the tests that have been carried out, it is found that the system can reach its highest fitness value when the Improved Particle Swarm Optimization method uses 400 iterations, and the particles used are 10 Particles.

After several previous tests, the results showed that the system got an increased fitness value when the system used 200 iterations and 10 particles compared to when the system used 5 particles at 200 iterations. These tests found that the use of 10 particles was better than when using 5 particles. Then when the iteration is increased to 400, by using 5 particles and 10 particles, there is also a better increase in fitness value when the system uses 10 particles. When compared when the system uses 200 iterations and 10 particles with when the system uses 400 iterations and 10 particles, the results obtained are better fitness values if the system uses 400 iterations and 10 particles with the highest fitness value obtained, which is 3.83, much different from when using 200 particles and 10 particles with the best fitness value of 2.96. With the average difference between the nutrients produced by the system and the user's needs, it reaches 30%. This difference was obtained due to price considerations as one of the factors in selecting food ingredients to be produced. So the system will look for food ingredients with the maximum content at the lowest possible price that can be obtained.

Overall the system can run as it should by successfully producing recommendations for optimal food composition in terms of nutrition and price according to the conditions entered by the user. And the system has succeeded in producing recommendations for varied food compositions, as evidenced by the results of different food ingredients when carrying out the process.

IV. CONCLUSION

Based on the research conducted and the results obtained, a recommendation for the composition of food that people with hypertension should consume is produced, consisting of 3 portions, namely breakfast, lunch, and dinner. Breakfast and lunch contain staple foods, vegetable sources, animal sources, vegetables, and fruits or complementary foods. While dinner contains only staple foods, animal sources, plant sources, and vegetables. Based on this research, it can be concluded that the Improved Particle Swarm Optimization (IPSO) method can be used to overcome the problem of optimizing food composition for people with hypertension, with varying results for each user who runs the system. By considering the price and nutrition of food ingredients, the results for the highest fitness value in the Improved Particle Swarm Optimization method reached 3.83 using 400 iterations and using 10 particles. However, the fitness value cannot always be obtained due to the initial initialization and velocity calculation of the improved particle swarm optimization method using random values. In addition, in this research, it was found that the IPSO method has not been able to produce maximum food recommendations in terms of nutrition, as seen from the level of nutritional sanctions resulting from system recommendations which reached 30%. This happens because price considerations are included in the calculation, so the IPSO method will seek recommendations for optimal food composition by considering the nutrition and price of each food ingredient used.

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