Menu Design For Pregnant Women Diet
For Stunting Prevention Using Genetic Algorithm

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Abstract

Indonesia is one of the countries that is still experiencing stunting problems and it is estimated that there will be an increase due to the Covid 19 pandemic. Stunting is an obstacle to growth in children, one of which is the lack of balanced nutritional intake during pregnancy. A pregnant woman’s diet should contain macro nutrients, carbohydrates, proteins and fats as well as micronutrients such as folic acid, iron and zinc. Folic acid is believed to be a micro nutrient for preventing stunting. Genetic algorithms are used to design the composition of food by computational processes. In this study, food ingredients are converted into chromosomes with real code chromosome representations. In the Crossover and Mutation processes using the One-Cut Point Crossover and Reciprocal Exchange methods and the best selection process is used. The output is a recommendation of food ingredients with three meals a day, namely breakfast, lunch and dinner. Based on the results of testing the application to practice at community health centers, it produces an average percentage error of 0.7% energy needs, 3.8% carbohydrates, 9.7% protein, 12.5% fat, 0.5% folic acid, 15.5% iron and 17.6% zinc. Overall, the validation test using statistics at the accuracy level of 95% states that the genetic algorithm results are not significant for the practice at the public health center.

Keywords
Stunting, Pregnant Women Diet, Folic Acid, Genetic Algorithm

1. Introduction

The UNICEF Indonesia Institute reminded that without timely action, the number of malnourished children (wasting) is expected to increase by 15% (or around 7 million) worldwide in the first year of the Covid 19 Pandemic. The Ministry of Health itself noted that Indonesia is one of the a country with three problems related
to nutrition, namely stunting, wasting and obesity. A case study of under-five nutrition in 34 provinces in Indonesia in 2019 shows that the stunting rate reaches 27.67% (Ramanditha, 2020) as shown in Figure 1.

![Figure 1. Prevalence of children under five with stunting in Indonesia 2013-2019 (Ramandhita, 2020)](image-url)

Stunting is a condition of failure to thrive in children under five years of age as a result of chronic malnutrition so that children are too short for their age (UNICEF, 2010). Malnutrition occurs since the baby is in the womb and in the early days after the baby is born. However, the condition of stunting only appears after the baby is 2 years old. Short (stunted) and very short (severely stunted) toddlers are toddlers with body length (PB / U) or height (TB / U) according to their age compared to WHO standard standards.

According to regulation of Indonesian Ministry of Health No. 97 of 2014 the factors that aggravate the condition of pregnant women are too young, too old, too frequent childbirths, and too close the birth distance. Pregnant mothers who are too young (under 20 years) are at risk of giving birth to low birth weight babies (LBW). LBW babies account for about 20% of the incidence of stunting. In the Republic of Indonesia Minister of Health Regulation No. 41 of 2014 pregnant women need more nutrients than those who are not pregnant. During pregnancy, a mother must increase the amount and type of food eaten to meet the growing needs of the baby and the needs of the mother who is carrying a baby and to produce breast milk.

Research conducted by Salman et al. (2017) noted that there was no real relationship between a mother's knowledge of nutrition and stunting. Research by Sutarto et al. (2018) states that stunting is caused by many factors, not only nutritional problems, even so the study still recommends fulfilling pregnant women nutrition as a prevention of stunting. Research by Alfarizi et al (2019) found clear evidence that the nutritional status of pregnant women shows stunting conditions in infants aged 6-59 months. Handayani et al (2020) have used genetic algorithm methods to design pregnant food menus, but this research has not paid attention to the special needs of preventing stunting. Thus, this study was conducted with the aim of designing an improved diet for pregnant women as an effort to prevent stunting.

2. Methodology

In general, the research methodology is divided into two stages, first is determining the minimum nutritional requirements for pregnant women from the perspective of preventing stunting, second is determining the composition of the diet for these pregnant women. The first stage uses an energy demand approach for pregnant women which can be done in three steps, namely calculating the Basal Energy Expenditure (BEE), Total Energy Expenditure (TEE) and additional energy according to gestational age, while the second stage uses the Genetic Algorithm. In general, the research stages are shown in Figure 2a.

In designing the genetic algorithm, several stages are carried out, namely initialization of user data parameters and genetic algorithm parameters, initial population formation by chromosome initialization,
crossover, mutation, fitness evaluation and selection. The stages of designing a genetic algorithm are presented in Figure 2b.

![Flowchart of the genetic algorithm method](image)

**Figure 2. Research Methodology**

3. Result and Discussion

3.1. Result

3.1.1. Calculation of Nutritional Requirements for Pregnant Women

*Basal Energy Expenditure* (BEE) is the minimum amount of energy the body needs when the body is in a resting state to maintain and maintain various vital body functions, such as heart work, respiratory activity, hormonal activity, muscle activity. To calculate the *Basal Energy Expenditure* (BEE), the Harris-Benedict equation can be used as shown in Equation 1 as follows:

\[
BEE = 655 + (9.6 \times \text{weight (kg)}) + (1.8 \times \text{height (cm)}) - (4.7 \times \text{age (year)})
\]

*Total Energy Expenditure* (TEE) is the development of a calculation formula for energy needs with an Activity Multiplier or activity factor, namely the multipliers used to find the total energy spent in a day depending on the level of activity, which is known as Total Energy Expenditure (TEE). To calculate TEE in healthy people, the BEE must be multiplied by 1.3 and the Activity Factor so that it can be formulated

\[
TEE = BEE \times \text{Activity Factor} \times 1.3
\]

The activity factors are shown in Table 1.

<table>
<thead>
<tr>
<th>Activity Factor</th>
<th>Activities of Pregnant Woman</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Rest</td>
</tr>
</tbody>
</table>

Table 1. Activity Factors
Pregnant women need to get additional energy and nutrition aimed at supporting the growth and development of the fetus in the womb, the amount of which is shown in Table 2 as follows:

Table 2. Additional nutritional requirements according to gestational age

<table>
<thead>
<tr>
<th>Gestational Age</th>
<th>0 - 12 Weeks</th>
<th>13 – 27 Weeks</th>
<th>28 – 40 Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional Carbohydrates</td>
<td>25 g</td>
<td>40 g</td>
<td>40 g</td>
</tr>
<tr>
<td>Additional Protein</td>
<td>20 g</td>
<td>20 g</td>
<td>20 g</td>
</tr>
<tr>
<td>Additional Lipid</td>
<td>6 g</td>
<td>10 g</td>
<td>10 g</td>
</tr>
<tr>
<td>Additional Folic Acid</td>
<td>200 µg</td>
<td>200 µg</td>
<td>200 µg</td>
</tr>
<tr>
<td>Additional Iron</td>
<td>0 mg</td>
<td>9 mg</td>
<td>13 mg</td>
</tr>
<tr>
<td>Additional Zinc</td>
<td>2 mg</td>
<td>4 mg</td>
<td>10 mg</td>
</tr>
</tbody>
</table>

After getting the total daily energy value, the next step is to calculate the macro nutritional needs using the following series of equations, according to the Regulation of the Minister of Health (Permenkes) RI No. 75 of 2013 concerning the Recommended Nutritional Adequacy Rate as follows:

- Carbohydrate = \( \frac{1}{4} \times (60\% \times TEE) + \) Additional Carbohydrates according to gestational age
- Protein = \( \frac{1}{4} \times (15\% \times TEE) + \) Additional Protein according to gestational age
- Lipid = \( \frac{1}{9} \times (25\% \times TEE) + \) Additional Lipid according to gestational age
- Folic Acid = 400 + Additional Folic Acid according to gestational age
- Iron = 26 + Additional Iron according to gestational age
- Zinc = 10 + Additional Zinc according to gestational age

As a trial, this study used data on pregnant women with various variables, such as age, weight, height, gestational age, and dominant daily activities. Next Calculation of the daily needs of pregnant women before and after pregnancy is carried out with the calculation results as follows:

Table 3. Application trials

<table>
<thead>
<tr>
<th>General Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
</tr>
<tr>
<td>Weight</td>
</tr>
<tr>
<td>High</td>
</tr>
<tr>
<td>Gestational Age</td>
</tr>
<tr>
<td>Main Daily Activities</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Diet Requirements</th>
<th>Unit</th>
<th>Before pregnancy</th>
<th>After pregnancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>KKcal</td>
<td>2297,3</td>
<td>2297,3</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>gram</td>
<td>344,6</td>
<td>369,6</td>
</tr>
<tr>
<td>Protein</td>
<td>gram</td>
<td>86,1</td>
<td>106,1</td>
</tr>
<tr>
<td>Lipid</td>
<td>gram</td>
<td>63,8</td>
<td>69,8</td>
</tr>
<tr>
<td>Folic Acid</td>
<td>µgram</td>
<td>400</td>
<td>600</td>
</tr>
<tr>
<td>Iron</td>
<td>miligram</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Zinc</td>
<td>miligram</td>
<td>10</td>
<td>12</td>
</tr>
</tbody>
</table>

3.1.2. Genetic Algorithm Computation

*Genetic Algorithm Parameters*
In this study, the average fitness of each generation is used as an indicator, so the following parameters are used:

- \( \text{PopSize} = 30 \)
- \( \text{Generation} = 5 \)
- \( \text{Cr (Crossover Rate)} = 0.95 \)
- \( \text{Mr (Mutation Rate)} = 0.01 \)

Initialization of chromosomes gives rise to a new random set of solutions consisting of a number of chromosomes and placed in reservoirs called populations. Chromosome initialization is carried out randomly, however, we must pay attention to the solution domain and the existing problems. In this study, a population size of 30 was determined.

**Crossover**

The crossover method used in this study is the One-Cut Point Crossover which is carried out by selecting two random parents from individuals, determining the intersection point randomly, and exchanging genes in chromosomes that are limited by the intersection points.

**Mutation**

The mutation method used in this study is reciprocal exchange mutation which is done by choosing one parent randomly, choosing two points randomly but with the same conditions and exchanging each point as shown in Figure 3 as follows:

![Figure 3. Chromosome Mutation Results](image)

**Evaluation**

The fitness function is used to measure the level of goodness or suitability (fitness) of a solution with the solution being sought. The fitness function can be directly related to the objective function, or it can be slightly modified to the objective function. The number of solutions generated in the population will be evaluated using the fitness function. In this study, to calculate the fitness value it has been adjusted using Equation as follows:

\[
 f = \frac{1}{[(r-\sum a)+[(k-\sum b)+((p-\sum c)+[(l-\sum d)+[(af-\sum e)+[(zb-\sum f)+[(s-\sum g))]+small \text{ number}]
\]

Notes:
- \( r \) = Daily Energy Requirements (Calculation result).
- \( k \) = Carbohydrates needs in one day (Calculation result).
- \( p \) = Protein needs in one day (Calculation result).
- \( l \) = Lipid needs in one day (Calculation result).
- \( af \) = Folic Acid needs in one day (Calculation result).
$zb = $ Iron needs in one day  (Calculation result).
$s = $ Zinc needs in one day  (Calculation result)
$a = $ Energy content of food ingredients in one day
$b = $ Carbohydrates of food ingredients in one day
$c = $ Protein of food ingredients in one day
$d = $ Lipid of food ingredients in one day
$e = $ Folic acid contents of food ingredients in one day
$f = $ Iron contents of food ingredients in one day
$g = $ Zinc contents of food ingredients in one day

small number = Numbers to avoid with division 0.

Following are the results of the calculation of the fitness value of each gene on the chromosome which can be seen in Figure 4 as follows

![Figure 4](image-url)  
Figure 4. Chromosome Fitness Values

**Selection**

The selection used in this study is Elitism Selection, which is a selection method in which one or more chromosomes with the highest fitness value are copied directly to the next generation without experiencing manipulation which can be seen in Figure 5 as follows

![Figure 5](image-url)
3.2. Discussion

This study included folic acid micronutrients in one of the parameters as an effort to supplement pregnant women nutrition for stunting prevention. Astriningrum et al. (2017) include folic acid as one of the micro nutrients in the intake of pregnant women for the prevention of anemia which is commonly experienced in pregnancy. Natural Tube Defects (NTD) in infants can also be caused by folic acid deficiency (Partearroyo et al., 2017). According to an article entitled Important Guidelines for Preventing Stunting from Pregnancy (Joseph, 2017), preventing stunting can be done early on since pregnancy. The key is to increase the nutritional intake of pregnant women with good quality food. Folic Acid, Iron and Zinc are important nutrients that pregnant women must fulfill to prevent anemia and maintain optimal fetal growth in other words to prevent stunting. Research by Nizar et al. (2020) recommends zinc and folic acid supplements for pregnant women to prevent stunting.

The need for folic acid in the system is designed with a value of 600 ug per day, according to the Harvard recommendation (2020). Under normal circumstances, the body needs 50 micrograms of folic acid every day. If the body absorbs less than 50 micrograms of folic acid in a day, then in the next four months folic acid deficiency can occur. The need for folic acid will increase during pregnancy, reaching 800 micrograms to 1 mg per day (Moore et al., 2015).
The genetic algorithm process was tested to obtain the best ONE chromosome value with the best fitness value as follows:

Best Chromosome : B019, B023,
B036, B037,
B042, B049,
B074, B100,
B123, B122, B1

Best Fitness : 0.02065

Based on the chromosomes with the best fitness values, the chromosome value values are converted into the list of foodstuffs in the database resulting in an example menu design as Table 4. Of course, rice as a source of carbohydrates and staple food for Indonesians can be included as the main alternative.

The best sources of folic acid in natural foods are legumes such as red beans, green beans, peas, peanuts and a number of other cereals. Harvard (2020) notes some good sources of folic acid including green vegetables such as spinach, lettuce, asparagus, broccoli, a number of cereals, seafood, sunflower seeds, eggs, and liver.

Table 4. Design of diet for pregnant women for prevention of stunting

<table>
<thead>
<tr>
<th>Meals Schedule</th>
<th>Food Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakfast</td>
<td>Sago flour, Cheese, Dark Chocolate, Taro leaves, Grape, Milk, Pastels</td>
</tr>
<tr>
<td>Lunch</td>
<td>Macaroni, Wheat Bread, Red Snapper, Red Beans, Chives, Guava</td>
</tr>
<tr>
<td>Dinner</td>
<td>Wheat Flour, Fresh Shrimp, Mushrooms, “Katuk” Leaves, Cow’s Milk, “Fried Getuk”</td>
</tr>
</tbody>
</table>

Application testing was carried out on 40 pregnant women with various variable values, such as daily activities, gestational age, height, weight and age of pregnant women. Then a comparison is made between the results of calculations manually and the results of calculations using the system to the value of the content in food ingredients obtained from the genetic algorithm process. Tests conducted on pregnant women to determine their energy needs, macro nutritional needs which include calories, carbohydrates, protein, and fats as well as micronutrient needs including folic acid, iron and zinc by entering data from public health service and interviews pregnant mother. Fulfilling the needs of energy, macro nutrients and micronutrients with a list of food ingredients produced from the genetic algorithm process has an error value compared to manual calculations as shown in Table 5.

Table 5. Trial comparison of GA calculations against which recommendations from the Public Health Center

<table>
<thead>
<tr>
<th>No</th>
<th>Energy (Kcal)</th>
<th>Carbohydrates (gram)</th>
<th>Protein (gram)</th>
<th>Lipid (gram)</th>
<th>Folic Acid (microgram)</th>
<th>Iron (milligram)</th>
<th>Zinc (milligram)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manual Calculation from the Public Health Center</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2231</td>
<td>359,6</td>
<td>103,7</td>
<td>68</td>
<td>600</td>
<td>39</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>2268,2</td>
<td>365,2</td>
<td>105,1</td>
<td>69</td>
<td>600</td>
<td>26</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>2105,8</td>
<td>340,9</td>
<td>99</td>
<td>64,5</td>
<td>600</td>
<td>35</td>
<td>14</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>40</td>
<td>2301,5</td>
<td>370,2</td>
<td>106,3</td>
<td>69,9</td>
<td>600</td>
<td>26</td>
<td>12</td>
</tr>
</tbody>
</table>

| Genetic Algorithm Computation | | | | | | | |
| 1  | 2228         | 328                  | 95             | 53           | 596                   | 36               | 10               |
| 2  | 2271         | 351                  | 95             | 62           | 589                   | 21               | 9                |
| 3  | 2125         | 323                  | 104            | 59           | 600                   | 29               | 13               |
| ...| ...          | ...                  | ...            | ...          | ...                   | ...              | ...              |
| 40 | 2315         | 367                  | 93             | 62           | 596                   | 26               | 9                |

| Deviation | | | | | | | |
| 1  | 0.001        | 0.088                | 0.084          | 0.221        | 0.007                 | 0.077            | 0.167            |
| 2  | 0.001        | 0.039                | 0.096          | 0.101        | 0.018                 | 0.192            | 0.250            |
| 3  | 0.009        | 0.053                | 0.051          | 0.085        | 0.000                 | 0.171            | 0.071            |
| ...| ...          | ...                  | ...            | ...          | ...                   | ...              | ...              |
Validation test using statistics From the table above it can be seen that the Mean Percentage Error (MPE) is (0.7%) for energy needs, (3.8%) for carbohydrate needs, (9.7%) for protein needs, (12.5%) for fat needs, (0.5%) for folic acid needs, (15.3%) for iron needs and (17.6%) for zinc needs. The statistical trial shows that for the accuracy level of 95%, all the results of the composition of food ingredients are calculated as "not significantly different" from the calculation of practice at the Public Health Services.

4. Conclusion

One of the efforts to prevent stunting in Indonesia can be done through improving nutrition and diet in pregnant women. In determining a good diet, each diet must meet the macro nutritional composition in the form of carbohydrates, proteins and fats as well as micro nutrients such as folic acid, iron and zinc which can prevent stunting. Folic acid has an important role in preventing stunting.

From the results of the research that has been done, it can be concluded that the Genetic Algorithm method can be used to design a list of foodstuffs for pregnant women in an effort to prevent stunting at birth. With predetermined method parameters, this application is able to produce recommendations for a list of food menus in a day that have been adjusted to the basic energy needs of pregnant women.

The Genetic Algorithm parameters defined are Pop Size of 30, Crossover Rate of 0.95, Mutation Rate of 0.01, the determination of these parameters is based on the fact that the average fitness of each generation is used as a calculation indicator and uses various data variables from pregnant women. Elitism selection is used because it ensures that the best individuals will always pass to the next stage.

The trial was carried out by taking data samples from pregnant women from the Public Health Service recommended by the Bogor City Health Official. Data for pregnant women are first selected so that data is suitable for application needs. The number of data that has been tested is 40 with various variables depending on the condition of the pregnant woman, the variables used are various such as daily activities, gestational age, height and weight of the pregnant woman.

Based on the results of application trials using the Mean Percentage Error (MPE) method along with the accuracy for an average error of 0.7% for energy needs, 3.8% for carbohydrate needs, 9.7% for needs Protein, 12.5% for lipid needs, 0.5% for folic acid needs, 15.3% for iron needs and 17.6% for zinc needs. The validation test using statistics shows that for the accuracy level of 95%, all the results of the composition of food ingredients are calculated as "not significantly different" from the calculation of practice at the Public Health Services.

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**Biography / Biographies**

**Hermawan** is a lecturer at the Department of Computer Science, Universitas Pakuan, Bogor. Obtained a Doctorate degree from Agro-industrial Technology IPB through research on food safety management. His research concentration to date has been the application of computer science to the food and agriculture industries. The author is a member of ASQC, IEOM, ILCan, Agrin, IEEE, Mastan.

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**Mutiara Prihatini** is a bachelor and master of nutrition science, is a senior researcher at the Center for Research and Development of Biomedical and Basic Health Technology, Ministry of Health of the Republic of Indonesia. He has done a lot of research in the field of nutrition according to his competence.