Implementation of simplex algorithm to optimize toddler’s balanced nutrition needs with minimum costs

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Abstract. Nutrition is an important element needed by humans, including toddlers. The unfulfilled nutritional needs can cause several diseases, such as malnutrition and stunting. It was caused because of human inability to fulfill the nutrition needs of all family members with good quality and the lack of parental knowledge about nutritious food ingredients and how to feed properly. It is necessary to optimize the fulfillment of food nutrition for infants with a minimum cost. One of the efforts is to make the right combination of food ingredients with cost minimum so that it can be reached by all levels of society. This research was analyzed using Simplex algorithm with QM for Windows software. The results was obtained in the form of the amount of food that can be consumed by user to fulfill the nutritional intake needs along with the minimum cost.

1. Introduction
Nutrition is a balance proportion substance in the human body. Balanced nutrition is the composition of food consumed by humans that contains nutrients in their type and amount needed. \cite{5} stated that the level of nutrition fulfillment for each person is different. It is because the human body has the ability to absorb different nutrients at each stage of age. One of the causes of malnutrition, known as malnutrition, is a lacking or not fulfilling balanced nutritional needs condition. Poor nutritional status in toddlers can cause many effects that can inhibit physical growth, mental and thinking ability which will ultimately the reduce work productivity. The increasing in the price of food needs has also an impact on the decline in purchasing power, especially in groups of people in poverty line. Households with children under age five years need more costs to be able to meet the intake of nutritional needs optimally. Fulfillment of nutrition at the age of five is considered very important.

Delay in fulfilling good nutrition can lead to diseases such as poor nutrition and stunting in infants, whereas adult human growth depends on nutritional and health conditions as a toddler. Based on the description above, optimization techniques are needed to meet the nutritional intake of toddler foods at the lowest possible cost. One of the effort is to make the right food ingredients combination with minimum cost so that it is available for all levels. As a first step, a mathematical model was developed to find the optimum food combination model with a minimum cost and match with the nutritional requirements set by the AKG (Nutrition Requirement Number). This research is expected to be one of efforts to choose the right food menu to improve the nutritional status of children under five with minimum cost. In this research, the cost minimization in fulfilling balanced nutrition for toddlers was reviewed and analyzed by looking the levels of the elements contained in several foods. This study is analyzed using the concept of a linear program, which uses the Simplex Algorithm with the help of QM.
for Windows software. The Simplex is one of the Algorithms in a linear program used to optimize. The Simplex algorithm will provide results in the form of (number) of food that can be consumed by the user to meet the nutritional intake needs along with the minimum costs.

2. Related Works

2.1. Toddler’s Nutrition
According to [6], toddlers are children who have reached the age of one year or more popular with children under five years old. Toddler age is a stage of development of children who are quite susceptible to various diseases, including malnutrition. This is because the body has different nutrient absorption abilities at each stage of age. Nutrition Adequacy Rate (RDA) or Recommended Dietary Allowances (DRA) is a daily average adequacy of nutrients for all people according to age group, sex, body size, body activities to achieve optimal health degrees. The RDA for Indonesians consists of: energy, protein, fat, carbohydrates, water, fiber, 14 types of vitamins including vitamin A, vitamin D, vitamin E, vitamin K, vitamin B1, vitamin B2, niacin, vitamin B6, folic acid, vitamins B12, pantothenic acid, biotin, choline and vitamin C; and 13 types of minerals including calcium, phosphorus, magnesium, sodium, potassium, iron, iodine, zinc, copper, chromium, selenium, manganese, and fluoride [5].

2.2. Causes and Effects of Bad Nutrition
Another indication of the lack of adequate nutrition in infants and toddlers can be seen from the changes in body weight over time. Infants or toddlers who do not gain weight twice their initial weight in a 6-month period are at risk of experiencing malnutrition 12.6 times compared to toddlers who gain weight continuously. Some of the causes that influence the occurrence of malnutrition include inadequate food intake, lack of parents' knowledge of nutritious food ingredients, and lack of knowledge about how to properly feed. In 2017, the World Health Organization (WHO) revealed that Indonesia in fifth rank in the world with a number of toddlers suffering from stunting.

Stunting is indeed a chronic problem for Indonesian toddlers. As a result of inadequate nutritional intake, physical growth of infants is stunted (stunting) which also affects brain performance. Poor nutritional status can arise as a result of low food security at the household level, namely the ability of households to meet the food needs of all family members in sufficient quantities and good quality, especially if there are still family members who are under five [8].

2.3. Simplex Algorithm
The Simplex algorithm is used to solve linear program problems that involve many inequalities and many variables. Linear programming problems consist in maximizing or minimizing a linear objective function subject to a set of linear constraints. In 1947, George Dantzig proposed the Simplex algorithm for solving linear programming problems. The Simplex algorithm is a pivoting method that proceeds from a first feasible extreme point solution of a linear program problem to another feasible solutions, by using matrix manipulations, the so-called pivoting operations, in such a way as to continually increase the objective value [3].

In using the Simplex, the linear program model must be changed to a general form called "standard form". The characteristics of the standard form of a linear program model are all the constraints in the form of equations with the non-negative Right Hand Side (RHS), the objective function can maximize or minimize. The form of a standard model in the Simplex is to provide additional variables to the constraint function, in the form of: slack variable for the constraint function with the sign "≤", a surplus variable for the constraint function with the sign "≥", and an artificial variable for the constraint function with the sign "=". Standard forms that have been obtained, must be made in the form of tables. All variables that are not base variables have a solution (right value) equal to zero and the coefficient of the base variable on the destination row must be 0. Therefore, the establishment of
the initial table must be distinguished based on the initial base variable. The next following are the stages in the Simplex algorithm [1][9][10].

1. Check the feasibility of the table
2. Determine the pivot column
3. Determine the pivot line
4. Determine the pivot element
5. Form a new Simplex table
6. Check table optimization

3. Methodology

The data that has been collected was analyzed using the Simplex algorithm in accordance with the constraints faced and the objectives to be achieved. The assumptions used in making the model is the nutritional content of each fixed ingredient. The steps are as follows:

a. Arranging the objective function to minimize the cost of spending for the purchase of food with nutritional content that still meets the health requirements of toddlers.

b. Arranging the function constraints and model parameters will be used.

c. Constructing a constraint or limitation function:

d. Designing the data into mathematical models in the form of linear programs.

e. Obtaining the optimal solution

4. Results and Discussion

4.1. Data Collection

The data needed is the composition of the nutrient content from the ingredients of selected food, nutritional adequacy rate for toddlers and the food prices. The following two tables presents nutritional adequacy figures for toddlers (12 - 60 months) per person per day [2][4][7].

Table 1. Nutritional Content of Each Food Item

| Nutrient | Rice | Tofu | Tempe | Fish | Egg | Spinach | Carrot | Banana | Papaya |
|----------|------|------|-------|------|-----|---------|--------|--------|--------|
| Nutrient-1 (Energy) | 3.6  | 0.68 | 1.49  | 1.13 | 1.62| 0.36    | 0.42   | 1.18   | 0.46   |
| Nutrient-2 (Protein) | 0.068| 0.078| 0.183 | 0.17 | 0.128| 0.035   | 0.012  | 0.012  | 0.05   |
| Nutrient-3 (Fat) | 0.007| 0.046| 0.04  | 0.045| 0.115| 0.005   | 0.003  | 0.002  | 0.0    |
| Nutrient-4 (Carbohydrate) | 0.789| 0.016| 0.127 | 0    | 0.007| 0.065   | 0.093  | 0.31   | 0.122  |
| Nutrient-5 (Calcium) | 0.06 | 1.24 | 1.29  | 0.2  | 0.54 | 2.67    | 0.39   | 0.07   | 0.23   |
| Nutrient-6 (Vit A) | 0   | 0    | 0.5   | 1.5  | 9   | 60.9    | 1800   | 1.12   | 3.65   |
| Nutrient-7 (Vit C) | 0   | 0    | 0     | 0    | 0.8 | 0.06    | 0.04   | 0.78   |        |
| Nutrient-8 (Fe) | 0.008| 0.08 | 0.1   | 0.01 | 0.027| 0.039   | 0.008  | 0.003  | 0.017  |

Table 2. AKG Value of Toddlers by Age

| Nutrient | 1-3 year | 4-5 year | Nutrient | 1-3 year | 4-5 year |
|----------|----------|----------|----------|----------|----------|
| Nutrient-1 (Energy) | 1125     | 1600     | Nutrient-5 (Calcium) | 650  | 1000     |
| Nutrient-2 (Protein) | 26       | 35       | Nutrient-6 (Vit A) | 400  | 450      |
| Nutrient-3 (Fat) | 44       | 62       | Nutrient-7 (Vit C) | 40   | 45       |
| Nutrient-4 (Carbohydrate) | 155 | 220 | Nutrient-8 (Fe) | 8    | 9        |
Table 3. List of Food Prices Oct-Nov 2019 (Based on Survey)

| Food | Kepatihan Market | Tanjung Market | Mean |
|------|------------------|----------------|------|
|      | Price (kg) | Price (g) | Price (kg) | Price (g) | Price (kg) | Price (g) |
| Rice | 11.500     | 11.5 | 11.000     | 11 | 11.250     | 11.25 |
| Tofu | 12.000     | 12 | 10.000     | 10 | 11.000     | 11 |
| Tempe| 10.000    | 10 | 10.000     | 10 | 10.000     | 10 |
| Fish | 24.000     | 24 | 20.000     | 20 | 22.000     | 22 |
| Egg  | 18.500     | 18.5 | 19.500     | 19.5 | 19.000     | 19 |
| Spinach | 10.000 | 10 | 10.000     | 10 | 10.000     | 10 |
| Carrot | 14.000 | 14 | 16.000     | 16 | 15.000     | 15 |
| Banana | 10.000 | 10 | 8.000      | 8 | 9.000      | 9 |
| Papaya | 8.000  | 8 | 9.000      | 9 | 8.500      | 8.5 |

4.2. Linear program model in food nutrition

1. The combination of food ingredients that are formed:
   a. Main food: rice
   b. Side dishes, consisting of 2 types. Main side dishes and side dishes.
      1) Main side dishes, consisting of two choices namely fresh fish and chicken eggs.
      2) Side dishes, consisting of two choices namely tofu and tempeh.
   c. Vegetables, consisting of two choices, namely spinach and carrots.
   d. Fruits consist of two choices, banana and papaya

2. Decision Variable Determination: $x_j$, $j = 1,2,3,4,5$.

In stating the decision variable stated as follows:

- $x_1 =$ Main foods (Rice)
- $x_2 =$ Types of main side dishes in food combinations.
- $x_3 =$ Types of side dishes in food combinations
- $x_4 =$ Types of vegetables in a food combination
- $x_5 =$ Types of fruit in food combinations

From these variables, an optimum food combination for toddlers will be calculated with a minimum cost provisions on the nutritional requirements set by AKG.

3. Toddler Food Combination Model

Here the 16 combinations and the constraints were obtained for each food combination.

- Rice + Tofu + Fish + Spinach + Banana
- Rice + Tofu + Fish + Spinach + Papaya
- Rice + Tofu + Fish + Carrot + Banana
- Rice + Tofu + Fish + Carrot + Papaya
- Rice + Tofu + Egg + Spinach + Banana
- Rice + Tofu + Egg + Spinach + Papaya
- Rice + Tofu + Egg + Carrot + Banana
- Rice + Tofu + Egg + Carrot + Papaya
- Rice + Tempe + Fish + Spinach + Banana
- Rice + Tempe + Fish + Spinach + Papaya
- Rice + Tempe + Fish + Carrot + Banana
- Rice + Tempe + Fish + Carrot + Papaya
- Rice + Tempe + Egg + Spinach + Banana
- Rice + Tempe + Egg + Spinach + Papaya
- Rice + Tempe + Egg + Carrot + Banana
- Rice + Tempe + Egg + Carrot + Papaya
The following are the objective functions, constraint functions, and mathematic equation form of 8 combination from 16 combinations above which are solved by using QM for windows software.

Table 4. Optimal Solution for Each Combination

| Type of Combination | $x_1$ (g) | $x_2$ (g) | $x_3$ (g) | $x_4$ (g) | $x_5$ (g) | RHS (Rp) |
|---------------------|-----------|-----------|-----------|-----------|-----------|---------|
| 1st combination     | 173.58    | 924.67    | 0         | 50        | 0         | 12.624  |
| 2nd combination     | 169.9     | 930.25    | 0         | 3.72      | 47.463    | 12.585  |
| 3rd combination     | 0         | 913.04    | 0         | 0         | 1000      | 19.043  |
| 4th combination     | 169.63    | 930.69    | 0         | 0.12      | 51.27     | 12.583  |
| 5th combination     | 179.56    | 364.47    | 165.69    | 0         | 10.602    |         |
| 6th combination     | 179.56    | 364.47    | 165.69    | 0         | 10.602    |         |
| 7th combination     | 0         | 378.8     | 215.69    | 0         | 1000      | 17.210  |
| 8th combination     | 178.2     | 416.7     | 205       | 0         | 51.28     | 10.921  |
| 9th combination     | 16.75     | 1090.82   | 0         | 50        | 0         | 11.597  |
| 10th combination    | 11.79     | 1097.936  | 0         | 0         | 51.28     | 11.548  |
| 11th combination    | 0         | 1049.99   | 0         | 0         | 999.99    | 19.500  |
Based on calculations using QM for windows, as shown in the table, it is known that the optimal solution is obtained in the 13th and 14th combinations. The minimum cost obtained in the 13th and 14th food combinations is Rp. 10,137 with as many menu compositions: Rice (145,04 g), Tempe (278,66 g), Egg (274,68), and Spinach (50 g).

5. Conclusion

Based on the discussion, the optimization model used to determine the nutritional needs of toddlers with a minimum cost that meets the optimal nutritional content for toddlers is the 13th and 14th combination. It compositions are: Rice (145,04 g), Tempe (278,66 g), Egg (274,68), and Spinach (50 g) with minimum cost Rp. 10.137.

6. References

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