Optimizing the Nutritional Needs of Toddlers with the Simplex Method Using *POM-QM* for Stunting Prevention

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ABSTRACT

This research aims to develop an optimization mathematical model that can help meet the daily nutritional intake needs of toddlers as an effort to prevent stunting. The Simplex method is applied in this model to determine food combinations that meet the standards of nutritional needs at minimal cost to take into account budget constraints and availability of foodstuffs, so that they can be adapted to diverse socioeconomic conditions. The *POM-QM* application is used as a calculation tool in applying the Simplex method, so that the optimization process becomes more practical and accurate. Mathematical modeling is carried out by compiling a function of objectives in the form of minimizing the cost of consuming foodstuffs that meet the daily nutritional needs of toddlers, including protein, fat, carbohydrates, iron, vitamin A, and vitamin C. The optimization results showed that nutritional needs could be optimally met with a combination of vegetable soup consumption of 22.5 grams (x_2), Tempe 8.476 g (x_4), and banana 4.5 g (x_5), with a total minimum cost of IDR 146,928. The nutrient content of the combination exceeds daily needs, such as protein (241.41 g), fat (274.06 g), Fe (82.93 mg), as well as vitamin A (450 RE) and vitamin C (45 mg), while carbohydrates are fulfilled exactly as much as 220 grams. These results show that the optimization approach can be used to design a balanced, nutritious diet that is cost-efficient as an effort to prevent stunting in toddlers.

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1. INTRODUCTION

Stunting is a serious health problem faced by many developing countries, including Indonesia [1]. This condition is characterized by the height of toddlers who are below the age standard due to chronic malnutrition in the long term, especially in the early period of life [2]. Stunting not only impacts physical growth but also inhibits cognitive development and increases the risk of chronic diseases in adulthood. Given the large impact of stunting on quality of life, prevention efforts are urgently needed, one of which is through the fulfillment of optimal nutritional needs from an early age.

Many consider a child who is short or underdeveloped to be a natural thing, even though stunting can affect the development of the child's brain, intelligence, and immune system [3]. Lack of Education about the importance of proper nutritional intake in the first 1000 days of life, as well as a balanced diet, exacerbates this condition [4]. In addition, limited access to information, lack of socialization from related parties, and social stigma against families with stunted children also worsen the understanding and handling of this problem [5]. Therefore, efforts to increase public awareness through proper counseling are very important to prevent the adverse effects of stunting in the long term.

The fulfillment of balanced nutritional needs for toddlers is often hampered by various factors, such as family economic limitations, limited access to nutritious foodstuffs, and lack of knowledge about nutritional composition [6]. Therefore, an approach is needed that can optimize nutritional intake by considering these limitations. One potential approach is through a mathematical optimization model that can calculate food combinations that meet nutritional needs at an affordable cost.

There are two most common mathematical models of optimization used in linear programming, namely the simplex method and the graph method. The simplex method is a numerical technique developed by George Dantzig to solve a linear programming problem with more than two variables and constraints [7]. This method works in an iterative way, i.e., moving from one basic solution to another that is better, until it achieves optimal results [8]. In the process, the simplex method uses a table form called a simplex table to simplify calculations, especially when the number of variables and constraints is quite large. The advantage of this method is its ability to solve large-scale linear programming problems that are impossible to solve graphically.

Meanwhile, the graphing method is a visual approach used to solve a linear programming problem that involves only two decision variables [9]. This method is carried out by describing the constraints in the form of lines in the Cartesian plane, then determining feasible regions that meet all these constraints. The optimal solution of the objective function will be found at one of the corner points of the feasible area [7]. The graph method is very useful for understanding the basic concepts of linear programming because it provides a clear visual picture of the relationship between objective functions and constraints, although it cannot be used for problems with more than two variables.

Judging from the explanation above, the simplex method is the right optimization mathematical model used in this study. The Simplex method is used as an optimization technique to find the best solution to meet the nutritional needs of toddlers. The Simplex method is able to handle linear optimization problems by considering certain constraints, such as cost and availability of food [10]. To simplify the calculation and implementation process, *the POM-QM application* is used as an auxiliary tool. The application facilitates the calculation of the Simplex method efficiently and accurately, so that the optimization model can be applied more practically by the user.

This study aims to develop a model of optimizing daily nutritional intake for toddlers using the Simplex method applied through the *POM-QM application*. This model is designed to produce menu recommendations that are able to optimally meet the nutritional needs of toddlers, while remaining affordable and in accordance with the family's socio-economic conditions. In addition, the existence of this model can also be used as a practical tool in supporting stunting prevention, especially in areas with limited access to nutritious food and other resources.

Research on nutritional optimization and stunting prevention has been widely conducted, considering the significant impact of stunting on children's health and development. Nutrition optimization models that utilize mathematical approaches, such as the Simplex method, have proven effective in helping to plan a balanced diet at an affordable cost. Several previous studies have used the Simplex method for optimization of nutritional needs, especially in diet management and food planning. For example, research by Eka Febriani and others [11] suggests that the Simplex method can identify the optimal food composition for an individual's daily needs based on certain constraints such as cost and availability of groceries. This study confirms that the Simplex method is effective in maximizing nutritional fulfillment with limited resources, which is very relevant in the context of stunting prevention.

On the other hand, *POM-QM* is an application that is often used to implement optimization methods, including Simplex, in areas such as supply chain management, production, and the fulfillment of nutritional needs. Some studies, such as those conducted by Ryan Clacier and others [12], have demonstrated the effectiveness of *POM-QM* in addressing linear optimization problems, including time savings and ease of use. The app makes it easy for decision-makers to quickly and accurately compile optimization solutions, making it an ideal choice for nutrition fulfillment models for toddlers.

Several other studies, such as those conducted by Nasriyah and her friends [13], focus on the nutrition optimization model as part of stunting prevention efforts in developing countries. The study used a mathematical approach and optimization software to design a balanced diet for children at risk of stunting. The results show that a nutritional optimization model that takes into account economic limitations can help families in providing nutritious food for children, even with limited budgets. Another study conducted by Naulia and friends [14] highlighted the importance of fulfilling balanced nutrition in stunting prevention. This study shows that improved nutritional intake in children at risk of stunting can improve physical growth and cognitive development. The use of technology to help meet nutritional needs is also growing. Some studies have integrated software or mobile apps to help families plan optimal nutritional intake—research by Yunita Rahma and others [15]. Develop mobile-based apps that provide healthy eating recommendations based on user preferences. This kind of technology makes it easier for parents and health workers to implement a nutritious diet according to their needs.

Stunting is still one of the main challenges in the field of child health, especially in families with economic limitations. Based on the studies that have been conducted, this study proposes a new approach by combining the Simplex method and the use of *the POM-QM* application to optimize the nutritional fulfillment of toddlers as a measure to prevent stunting. It is hoped that the results of this study can contribute to a deeper understanding of technical and practical strategies in nutrition planning, especially for families facing economic limitations or access to nutritious food.

Therefore, researchers conducted research in Tinggar Village, Kadugede District, Kuningan Regency, West Java, which in 2024 had a stunting prevalence of 5%; there were still seven children affected by stunting. The purpose of this study is to develop a model of daily nutritional intake optimization for toddlers using the simplex method implemented through *the POM-QM* application. The application of this model is aimed at producing menu recommendations that not only meet the nutritional needs of toddlers optimally, but also remain economical and in harmony with the socio-economic conditions of the local community. In addition, this model can be used as an effective tool in supporting stunting prevention efforts, especially in research sites and other areas that experience limited resources and access to nutritious food.

2. METHOD

This study uses a qualitative approach of case studies combined with a quantitative approach through linear optimization methods, in order to develop a model for meeting the nutritional needs of toddlers in an effort to prevent stunting. The case study approach was used to gain an in-depth contextual understanding of the conditions of the communities in the research site, particularly in terms of consumption patterns and access to nutritious food [16]. Meanwhile, the quantitative approach through linear optimization was chosen because it was able to provide efficient solutions to the problem of limited resource allocation, including in planning nutritious food menus at minimal cost [17]. The combination of these two approaches allows for a more comprehensive analysis of real conditions in the field and rational mathematical modeling. The use of mathematical models in nutrition planning has also been shown to be effective in various previous studies, especially to identify nutritionally and economically optimal food compositions [18].

This process involves several main stages, namely identification of nutritional needs, selection of foodstuffs, formulation of optimization models using the Simplex method, and model implementation using *the POM-QM* application. The flow chart of this research can be seen in **Figure 1** below.

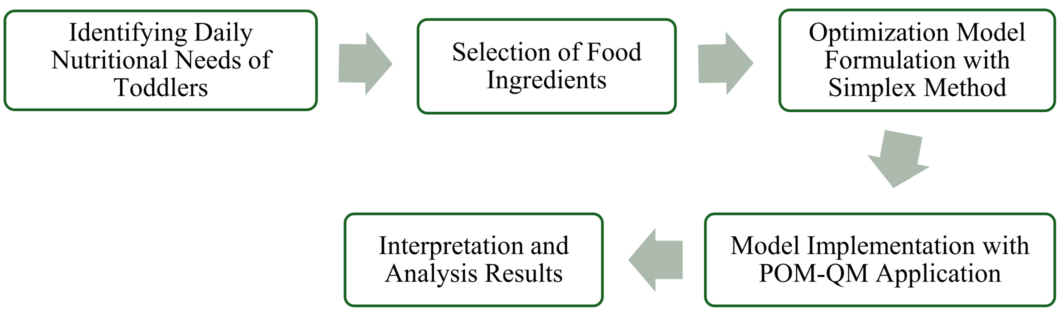


Figure 2. Research Flow

The first stage of the research method carried out is the identification of the nutritional needs of toddlers. At this stage, the researcher identifies the daily nutritional needs of toddlers according to the standards recommended by health institutions, such as the Ministry of Health or *the World Health Organization* (*WHO).*

Table 1. Recommended Vitamin Adequacy Figures (per day)

Age Group	Vit A (RE)	Vit D (mcg)	Vit E (mcg)	Vit B1 (mg)	Vit B2 (mg)	Vit B3 (mg)	Vit B5 (mg)	Vit B6 (mg)	Vit B12 (mg)	Vit C (mg)
4-5 years	450	15	7	0.6	0.6	8	3.0	0.6	1.5	45

This nutritional need data includes macronutrients (carbohydrates, proteins, fats) and micronutrients (vitamins and minerals) that are essential for the growth and development of toddlers [19]. This standard is the main reference in building a nutritional intake optimization model.

Table 2. Infant Nutrition Requirement Rate (AKG) per Day

Age Group	Energy (kkal)	Protein (g)	Fat (g)			Carbohydrates (g)	Fiber (g)	water (ml)
			Total	Omega 3	Omega 6			
4-5 tahun	1400	25	50	0.9	10	220	20	1450

The second step is the selection of foodstuffs. At this stage, various food ingredients available on the market are selected and evaluated for their nutritional content to meet the nutritional needs of toddlers. The selection of foodstuffs also considers the price and availability of foodstuffs, especially those that are affordable and easy to access by the public through *offline* and *online interview methods*. The nutritional content data of each food ingredient is obtained from the food composition table or other reliable sources.

Third, the researcher formulated an optimization model using the simplex method. After the data on nutritional needs and foodstuffs is obtained, the formulation of the optimization model is carried out. The objective function of this model is to minimize the cost of nutritional intake needed by toddlers, with the condition that all daily nutritional needs are achieved. The first step in mathematical modeling is to define the function of the objective [20].

$$Z = c_1x_1 + c_2x_2 + \dots + c_nx_n$$

In this study, the purpose function was formulated to minimize the total cost of the combination of food ingredients used. Vector $c = (c_1, c_2, \dots, c_n)$ expresses the price per unit of each foodstuff. In contrast, the vector $x = (x_1, x_2, \dots, x_n)$ declares the amount of each food ingredient selected. The second step is to determine the constraint of the variable or function of the constraint [21].

$$\begin{array}{c} a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n \geq b_1 \\ a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n \geq b_2 \\ \vdots \qquad \vdots \qquad \cdots \qquad \vdots \\ a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n \geq b_m \\ x_1, x_2, \dots, x_n \geq 0 \end{array}$$

In this study, a_{mn} is the nutrient content in x_n (coefficient of x_n), while b_m is the daily AKG (Adequate Nutritional Intake) needed by toddlers 4-5 years old. This model is formulated in the form of a linear equation, where each food ingredient has a coefficient value that represents its nutritional content as well as its unit price. The Simplex method is then used to find the optimal solution of this model.

The fourth step in this research method is the implementation of the model with *the application of POM-QM*. The model that has been compiled is then implemented with the help of *the POM-QM application* to simplify the optimization calculation process. This application allows researchers to enter data on nutritional needs, foodstuffs, and other limitations, so that the calculation process of the Simplex method becomes faster and more accurate [22]. *POM-QM* will produce an optimal solution in the form of a combination of food ingredients that meet the nutritional needs of toddlers at a minimum cost.

The use of *POM-QM* in linear program solving offers a number of important advantages, especially in improving the efficiency and accuracy of calculations. It simplifies the process of building models and solving optimization problems without having to do complex manual calculations. In addition, *POM-QM* is equipped with an easy-to-understand display and visualization features that assist users in interpreting the results of the solution. Therefore, *POM-QM* is a very supportive tool in analysis and decision-making based on mathematical approaches.

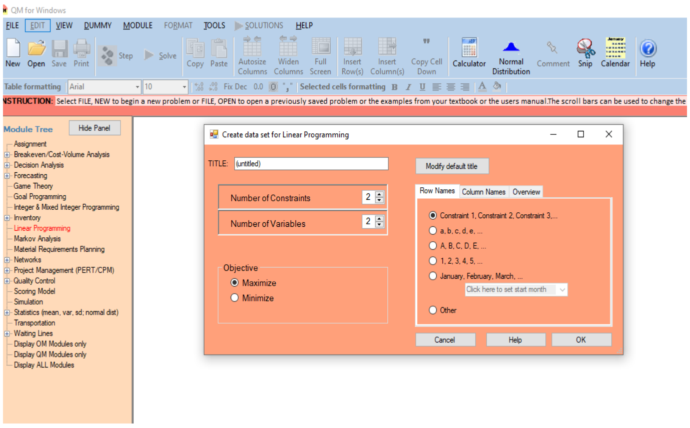


Figure 3. ***Create Data***

The final step is the interpretation and analysis of the results. Once the optimal solution is obtained from *POM-QM*, the next stage is to perform interpretation and analysis of the results. This interpretation involves checking whether the optimization results really meet the nutritional needs according to the standards and evaluating the affordability of costs for families. The analysis was conducted to assess the effectiveness of the model in achieving optimal and cost-effective nutrition fulfillment goals.

3. RESULTS AND DISCUSSION

To determine the level of public understanding of stunting, the researcher collected data through a direct interview method with respondents at the research site. After interviews with the community, data were obtained on the level of public understanding of stunting issues. The data is then presented in diagram form as shown in **Figure 4** below. Based on this diagram, it can be seen that although some people have understood the meaning and impact of stunting, there is still a considerable proportion who do not have adequate knowledge related to this issue. This shows that Education and counseling efforts regarding stunting still need to be improved so that public awareness of the importance of nutrition during the child's growth period can be more evenly distributed.

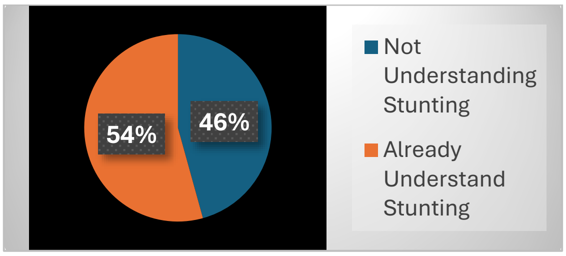


Figure 5. Diagram of the Level of Public Understanding of Stunting

The diagram in **Figure 6** illustrates the distribution of public understanding of the problem of stunting, which is a condition of failure to grow in children caused by chronic malnutrition, recurrent infections, or environmental problems that do not support children's growth and development [2]. The diagram above illustrates that there is a gap in the level of public understanding of stunting. Most people (54%) have a sufficient understanding of stunting, either in terms of its causes, impacts, or ways of preventing it. On the other hand, 46% of people do not fully understand the problem of stunting. Therefore, there needs to be stronger efforts to increase understanding of stunting among the community through more intensive Education, health campaigns, and counseling. This can be due to a lack of access to information or a lack of awareness of the importance of this issue. The lack of understanding of stunting in the community is still a significant problem in many regions. Although stunting or growth disorders in children due to chronic malnutrition have long been known, many parents, especially in remote areas, are not yet fully aware of the long-term impact they cause.

To prevent stunting, it is important for parents to understand and meet their children's daily nutritional needs by the standards that have been set. Based on nutritional recommendation standards from the Ministry of Health and *the World Health Organization* (*WHO), the* daily nutritional needs of toddlers include carbohydrates, proteins, fats, as well as various vitamins and minerals that are important for growth and development [23].

Table 3. AKG Toddlers Age 4-5 years old

Age Group	Protein (g)	Fat (g)	Carbohydrates (g)	Fe (mg)	Vit A (re)	Vit C (mg)
4-5 tahun	25	50	220	10	450	45

The results of the identification show that toddlers need a certain amount of essential nutrients in a certain proportion to grow optimally [24]. This data is the basis for setting the limits of the optimization model, which will later be filled with food intake. Food ingredients are selected based on their availability, affordability, price, and nutritional content. In this study, some local foodstuffs, such as rice, eggs, tofu, vegetables, and fruits, were used as the main source of nutrients [25]. After the researcher conducted interviews with the public both *offline* and *online*, data on the composition of foodstuffs were obtained that were widely chosen by the public, as can be seen in **Table 4**.

Table 5. Data on Combinations of Consumed Foodstuffs

Types of Foodstuffs	Combination of Ingredients	Grocery prices
Staple foods	rice	IDR 12,000.00/Kg
Vegetable Food	Vegetable Soup	IDR 2,000.00/Kg
Animal Fats	Chicken Meat	IDR 40,000.00/Kg
Vegetable Fats	Tempe	IDR 3,000.00/piece
Fruit	Banana	IDR 27,000.00/comb
Milk	UHT Milk	IDR 18,000.00/lt

The nutritional content of each food ingredient used in the menu combination can be seen in Table 5 below.

Table 6. Nutritional Content in Food Combinations

Ingredients	**Rice**	**Vegetable Soup**	**Chicken Meat**	**Tempe**	**Banana**	**UHT Milk**
Protein	3	1.30	18.20	24.50	1	0.032
Fat	0.30	2	25	26.60	0.80	0.035
Carbohydrates	39.80	1	0	10.40	24.30	0.43
Fe	0.40	1.80	1.50	4.90	0.20	0.02
Vitamin A	0	20	245	0	0	1.3
Vitamin C	0	0.20	0	0	9	0.01

Analysis of the nutritional content of foodstuffs shows that the combination of these ingredients can meet most of the nutritional needs of toddlers [26]. The chosen foodstuffs vary in price, so it is important to find the most cost-efficient combination through an optimization model.

Based on the results of interviews and literature review, information was obtained about the combination of food ingredients and their nutritional content, which can then be formulated into the form of an optimization mathematical model as follows: First, formulate the objective function of this research. With the result, variable x_1 representing rice, x_2 representing vegetable soup, x_3 representing chicken, x_4 representing bananas, and x_5 representing UHT milk. Please change it to the form of the destination function with the following thousand units.

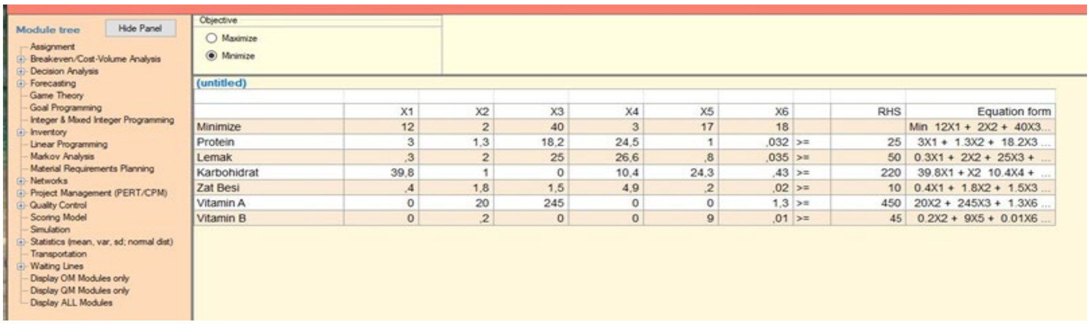
$$Z = 12x_1 + 2x_2 + 40x_3 + 3x_4 + 17x_5 + 18x_6$$

Next, determine the limit of the variable or function of the constraint. The data on the combination of food ingredients and nutritional content are as follows:

$$3x_1 + 1.30x_2 + 18.20x_3 + 24.50x_4 + x_5 + 0.032x_6 \geq 25 \text{ (Protein)}$$
$$0.30x_1 + 2x_2 + 25x_3 + 26.60x_4 + 0.80x_5 + 0.035x_6 \geq 50 \text{ (Fat)}$$
$$39.80x_1 + x_2 + 10.40x_4 + 24.30x_5 + 0.43x_6 \geq 220 \text{ (Carbohydrates)}$$
$$0.40x_1 + 1.80x_2 + 1.50x_3 + 4.90x_4 + 0.20x_5 + 0.02x_6 \geq 10 \text{ (Fe)}$$

$$20x_2 + 245x_3 + 1.3x_6 \geq 450 \text{ (Vitamin A)}$$
$$0.20x_2 + 9x_5 + 0.01x_6 \geq 45 \text{ (Vitamin C)}$$
$$x_1, x_2, x_3, x_4, x_5, x_6 \geq 0$$

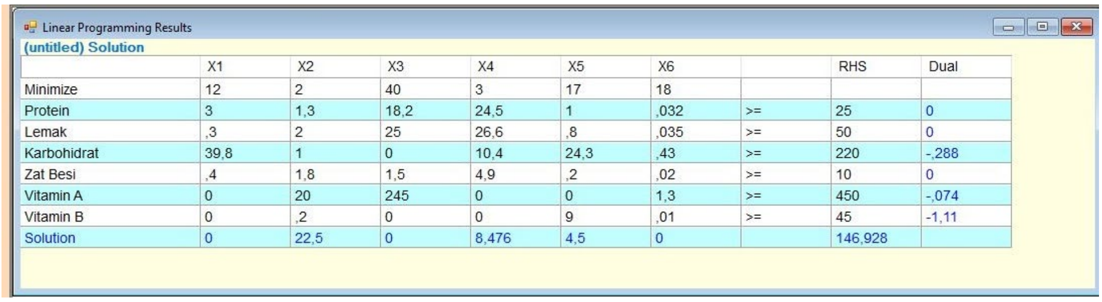
After the data on nutritional needs and nutritional content of foodstuffs are entered into *the POM-QM application*, the Simplex method is run to find the optimal solution after setting the number of constraints and variables as soon as the number of constraints and variable decisions are set. Then set the name of the constraints column according to the mathematical model that has been formulated. And the constant data input of each variable, either in the destination function or in the kendala function.



	X1	X2	X3	X4	X5	X6		RHS	Equation form
Minimize	12	2	40	3	17	18			Min 12X1 + 2X2 + 40X3...
Protein	3	1,3	18,2	24,5	1	,032	>=	25	3X1 + 1.3X2 + 18.2X3 ...
Lemak	,3	2	25	26,6	,8	,035	>=	50	0.3X1 + 2X2 + 25X3 + ...
Karbohidrat	39,8	1	0	10,4	24,3	,43	>=	220	39.8X1 + X2 10.4X4 + ...
Zat Besi	,4	1,8	1,5	4,9	,2	,02	>=	10	0.4X1 + 1.8X2 + 1.5X3 ...
Vitamin A	0	20	245	0	0	1,3	>=	450	20X2 + 245X3 + 1.3X6 ...
Vitamin B	0	,2	0	0	9	,01	>=	45	0.2X2 + 9X5 + 0.01X6 ...

Figure 7. Input Data

POM-QM has succeeded in finding a combination of food ingredients that meet the nutritional needs of toddlers at minimal cost in the 13th iteration.



	X1	X2	X3	X4	X5	X6		RHS	Dual
Minimize	12	2	40	3	17	18			
Protein	3	1,3	18,2	24,5	1	,032	>=	25	0
Lemak	,3	2	25	26,6	,8	,035	>=	50	0
Karbohidrat	39,8	1	0	10,4	24,3	,43	>=	220	-,288
Zat Besi	,4	1,8	1,5	4,9	,2	,02	>=	10	0
Vitamin A	0	20	245	0	0	1,3	>=	450	-,074
Vitamin B	0	,2	0	0	9	,01	>=	45	-1,11
Solution	0	22,5	0	8,476	4,5	0		146,928	

Figure 8. Tabel Solusi *POM-QM*

Based on the solution table above, optimal daily nutritional needs can be achieved with a total minimum cost of IDR 146,928, which is rounded to IDR 147 per day. The composition of daily consumption consists of: x_1 (rice) 0 g, x_2 (vegetable soup) as much as 22.5 g, x_3 (Chicken) as much as 0 gr, x_4 (tempe) as much as 8.476 g, x_5 (Bananas) as much as 4.5 g, and x_6 (milk) 0 g. The optimization results show that this model is able to provide adequate nutritional intake at a lower cost compared to calculations without optimization.

With protein intake reaching 241.412 grams, exceeding the daily requirement of 216.412 grams. The fat content was also met with an amount of 274.0616 grams, which was 224.0616 grams higher than the need. The carbohydrate intake of 220 grams is by daily needs. For Fe, 82.9324 mg was met, exceeding the requirement of 72.9324 mg. Meanwhile, vitamin A and vitamin C were met at 450 RE and 45 mg, respectively, which corresponded to the recommended daily intake. The combination of foodstuffs produced in this model not only meets all nutritional limitations but also fits within a budget that may be limited.

The results of this study show that the Simplex method implemented through the *POM-QM* application is effective in compiling a menu for toddlers that meets nutritional needs at minimal cost. However, there are some limitations regarding food preferences and menu variations, where the resulting menu may require further adjustments to better suit the tastes and eating habits of toddlers. There are challenges in the accessibility of *the POM-QM* application to the general public, especially for those who are not familiar with this software. A short training may be required so that users can understand how this app works and benefit optimally. However, this model shows great potential as a tool in nutrition planning.

4. CONCLUSION

This study uses a model of optimizing nutritional intake for toddlers with the Simplex method, which is implemented through the POM-QM application. This model is applied to meet the daily nutritional needs of toddlers at minimal cost, so that it has the potential to help families with economic limitations in providing nutritionally balanced food. Based on the optimization results, optimal daily nutritional needs can be met with a minimum total cost of IDR 147 per day. The composition of the resulting daily consumption includes: x_2 (vegetable soup) as much as 22.5 grams, x_4 (tempe) as much as 8.476 grams, and x_5 (Bananas) as much as 4.5 grams, while x_1 (rice), x_3 (Chicken), and x_6 (milk) not used in optimal solutions.

The results of the study show that the application of the Simplex method is able to determine the combination of food ingredients that meet nutritional standards with cost efficiency. The POM-QM application simplifies the calculation and analysis process quickly and accurately. This model can be used as a practical tool for health workers and parents in planning optimal nutritional intake for children under five, especially in areas with limited access to nutritious food and a high risk of stunting.

However, there are limitations, such as the need for training in the use of applications and the need to adjust menus to suit children's consumption preferences better. This research recommends the development of more adaptive models and integration into more user-friendly digital platforms. Thus, this model has great potential to support national strategies in preventing stunting and improving the health status of toddlers in Indonesia.

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