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Optimization of Nutritional-Menu Planning for Toddlers by Goal Programming Model

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ABSTRACT
Food or nutrient intake is required to increase human resources. However, there are several problems that arise such as difficulties in preparing a nutritious menu for toddlers and lack of public understanding of nutritional fulfillment despite governmental efforts. Apparently, good quality nutrient is not always costly. Nutritionists often use the material exchange method in calculating the amount of nutrients contained in food as recommended in the standard menu for a toddler. However, this method can cause deviations above or below the expected amount of nutrition. The problem is a multi-objective one because it involves many goals to optimize simultaneously. The targets in preparing this menu are to meet the number of calories and nutritional content and to minimize the expenses. One model for solving this multi-objective problem is goal programming. This model aims to minimize deviations of calorie and nutrient content at optimal costs. The study resulted in the model and solution minimizing the total deviation from the target in accordance with the nutritional requirements set for toddlers.

Keywords: *nutrient, menu, toddlers, multiobjective, Goal Programming.*

1. INTRODUCTION

A nutrition issue is a necessary topic to discuss since it involves human resources. Nutrition problems that occur in the community include macro and micro nutrition. Macro nutrients usually measured in grams are needed by the body in large quantities, consisting of carbohydrates, proteins and fats. They are defined to provide calories or energy and are needed in large quantities to maintain bodily functions and carry out daily life activities. Meanwhile, micronutrients, as the name implies, are needed in small quantities. They include vitamins and minerals, for example vitamins A, B, C, D, E and K and minerals, such as iron, zinc, potassium and magnesium. The optimal amount of nutritional content which is energy, carbohydrate, fat, protein, iron, and vitamin C intake should be observed. Preparing a toddler menu based on food exchangers can sometimes cause deviations above or below the recommended amount. Therefore, it is necessary to compose a toddler menu whose deviation is as small as possible from the recommendation. The mathematical model that can be used to solve such a problem is the Goal Programming model.

Goal programming is derived from linear programming to achieve the desired goals or objectives. Its basic approaches are to set a goal expressed by a certain number for each goal, formulate an objective function, and find a solution by minimizing the number of deviations from the goal function [1]. This mathematical method solves problems to be optimal with multi objectives. Mathematically, in this method the decision variable must be defined first. Expected objectives must be specified based on their level of importance. Then the optimal solution is sought to minimize the total deviations of goals from the specified target.

Reference [2] discussed to minimize the amount of cost for toddler consumption every day in poor fishermen families, to analyze toddler food consumption habits as well as lower and upper limits of the weight of food consumed, and to get menu planning for toddlers as an effort to improve nutrition. In [3] the research discussed about to get the optimal solution in the selection of food intake. By using the goal programming model this research can minimize deviations from the objectives to be achieved. In 2007 Anis et al. conducted a study using goal programming without priority target", succeeding in forming a more profitable product combination by prioritizing company profits.[4]

See in [5] and [6], Dhoruri et al managed to determine food variations for patients with diabetes mellitus optimally. Based on the description above, the Goal programming model has the potential to be used because of its ability to solve the problem optimally with more than one objective (multi objective). Furthermore, many literatures about goal programming can be seen in [7], [8], [9], and [10]. In this research, both of the weighted and lexicographic goal programming are used in the model.

In this case the objectives are to meet the amount of energy, meet the target of nutritional content, and minimize the expense. This model havebeen applied with data from respondents to get the optimal menu.

2. NUTRITION PLANNING FOR TODDLERS

The nutritional needs of toddlers are greater than those of adults, especially energy and protein needs because toddlers are in a phase of growth and development. Guidelines or references for food consumption as nutritional intake for toddlers use the Nutrition Adequacy Rate (NAR). Nutrition Adequacy Rate is a value that shows the amount of nutrients needed by the body to stay healthy every day for almost all populations according to age groups, sex, and certain physiological conditions such as pregnancy and breastfeeding [11]. This is useful to prevent the body from deficient or excessive intake of nutrients. The amount of nutrients needed by the body refers to the Table 1.

Table 1. Nutrition adequacy rate [12]

Age (in year)	Energy (calories)	Protein (gram)	Fats (gram)	Carbohydrates (gram)	Iron (Mg)	Vitamin C (Mg)
4 – 6	1400	25	50	220	10	45

3. MATHEMATICAL MODEL

3.1. Assumption

The following is the assumptions needed in the formation of mathematical models according to nutritionists at regional public hospital:

a. Toddlers are considered to have no allergies to certain foods.
b. Toddlers have normal weight at birth and are not premature.
c. Toddlers to be the respondents aged 4-6 years.
d. Toddlers are not sick, so they do not need special care.
e. Calculation of the analysis of the amount of costs used for food is in terms of average income of middle class families.
f. Food for the menu is always available as needed.
g. Prices of types of food do not change during the study.
h. Prices of types of food are prices of raw food.
i. Cooking costs (operational) are ignored.

3.2. Data

In this study the data obtained was in the form of eating habits per day from toddlers 4-6 years old attached. The data was taken from toodlers in Pasuruhan, Mertoyudan, Magelang. The sample is toddlers at Healthcare Centre in Pasuruhan. From these data the upper and lower quartiles were counted as limits on the amount of food consumed per day by toddlers. The data were obtained by conducting interviews with respondents assisted by Integrated Healthcare Center officers in Pasuruan. The data obtained included the condition of the child at birth, weight at birth, whether they had been hospitalized in the last 3 months, whether they had suffered from tuberculosis, and the amount of the habitual food consumption of the child. Based on the interview results, data were obtained from 35 child respondents aged 4 - 6 years at Healthcare Centre in Pasuruhan. All of the respondents were healthy so that they met the model assumptions. Furthermore, Table 2 shows the lower and upper quartiles of the food consumption habits of toddlers.

Table 2 Toddlers' food consumption habits

No	Food Type	Q_1 (gr)	Q_3 (gr)	No	Food Type	Q_1 (gr)	Q_3 (gr)
1	Rice	150	250	16	Mustard Greens	20	60
2	Vermicelli	35	70	17	Carrot	20	60
3	Bread	20	50	18	Potato	50	150
4	Biscuit	50	100	19	Water Spinach	25	75
5	Cassava	75	150	20	Spinach	25	100
6	Chicken Meat	50	200	21	Vegetable Soup	50	100
7	Beef	50	100	22	Beans	25	50
8	Chicken Egg	30	120	23	Cauliflower	25	50
9	Milkfish	25	50	24	Orange	30	100
10	Shrimp	25	50	25	Banana	20	60
11	Sweetened Condensed Milk	42	100	26	Papaya	50	100
12	Soybean Cake	25	75	27	Jelly	45	95
13	Tofu	25	75	28	Milk Powder	10	30
14	Green Beans	50	100	29	Oil	2.5	5
15	Sayur Asam	50	100				

Table 3 is the nutritional content in each of the consumed food type. The value in Table 3 will be the technology coefficient (a_{ij}) of the decision variable (x_j). Adequacy rates for nutrients needed by toddlers (b_i) are taken from Table 1. Meantime, food prices adjusted for data collection areas data (c_j) are presented in Table 4.

3.3. Weighted Goal Programming Model (Non-Preemptive Goal Programming)

Weighted goal programming is a model used to minimize more than one objective function using weighting techniques. In this model each variable deviation in the objective function can be given different weights according to interests. The most important goal has the highest weight value. The notation w_i is a positive weight that reflects the decision makers' preferences regarding the relative importance of each objective function [14].

Thus, the general form of weighted goal programming is as follows:

Minimize:

$$Z = \sum_{i=1}^{m} w_i \, (d_i^+ + d_i^-) \qquad (1)$$

With constraints:

$$\sum_{j=1}^{n} a_{ij} X_j + d_i^- - d_i^+ = b_i \qquad (2)$$

For $i = 1,2, \ldots, m$ and $j = 1,2, \ldots, n$

And

$$X_j, d_i^-, d_i^+ \geq 0 \qquad (3)$$

Where,

w_i : the weight given to the deviation from the goal b_i $(w_i \geq 0)$. This value based on the nutritionist

d_i^+ : the number of deviation units used is greater than the value b_i

d_i^- : the number of deviation units used is less than the value b_i

3.4. Goal Programming Model with priority goals (Preemtive / Lexicographic Goal Programming)

Lexicographic Goal Programming is a goal programming model that has goals each of which has an order of priority level. The notation used to mark the priority of goals is $P_i (i = 1,2,3, \ldots, m)$. Priority factors have the following relationships:

$$P_1 \gg P_2 \gg \cdots \gg P_m \qquad (4)$$

According to [1], the general form of lexicographic goal programming is as follows:

Minimize

$$Z = [P_1(d_1^-, d_1^+), P_2(d_2^-, d_2^+), \cdots, P_m(d_m^-, d_m^+)] \qquad (5)$$

With constraints

The constraint function based on the target

$$\sum_{i=1}^{m} a_{ij}x_j + d_i^- - d_i^+ = b_i$$

for $i = 1,2,\ldots,m$ and $j = 1,2,\ldots,n$ (6)

Non negative constraints

$x_j, d_i^-, d_i^+ \geq 0$ (7)

Information:

d_i^- = The number of deviation units lacking (-) the goal b_i

d_i^+ = The number of deviation units excess (+) goal b_i

P_m = Priority to-m

a_{ij} = The technology coefficient of the decision making variable x_j

x_j = Decision making variable

b_i = Goal or target to be achieve

Non negative constraints:

$x \geq 0,\ d_i^+ \geq 0, and\ , d_i^- \geq 0$ (8)

for j= 1, 2, . . . , n

Table 3. Nutrient content in each of the food types [13]

No	Food Type	Energy (kkal)	Protein (g)	Fat (g)	Carbohydrate (g)	Iron (mg)	Vit.C (mg)
1	Rice	180	3	0.3	39.8	1.8	0
2	Vermicelli	348	4.7	0.1	82.1	1.8	0
3	Bread	248	8	1.2	50	1.5	0
4	Biscuit	458	6.9	14.4	75.1	2.7	0
5	Cassava	154	1	0.3	36.8	1.1	31
6	Chicken Meat (fresh)	298	18.2	25	0	1.5	0
7	Beef (floss)	358	14.6	16.1	38.6	14.6	0
8	Chicken Egg	154	12.4	10.8	0.7	3	0
9	Presto Milkfish	296	17.1	20.3	11.3	1.9	69
10	Shrimp	91	21	0.2	0.1	8	0
11	Sweetened Condensed Milk	343	8.2	10	55	0.2	1
12	Soybean Cake	201	20.8	8.8	13.5	4	0
13	Tofu	80	10.9	4.7	0.8	3.4	0
14	Green Bean (boiled)	109	8.7	0.5	18.3	1.5	3
15	Sayur Asam	29	0.7	0.6	5	3.1	0
16	Fresh Mustard Greens	28	2.3	0.3	4	2.9	102
17	Carrot	36	1	0.6	7.9	1	18
18	Potato	62	2.1	0.2	13.5	0.7	21
19	Water Spinach	28	3.4	0.7	3.9	2.3	13
20	Spinach	16	0.9	0.4	2.9	3.5	41
21	Vegetable Soup	27	1.3	2	1	1.8	0
22	Bean	34	2.4	0.3	7.2	0.7	11
23	Cauliflower	25	2.4	0.2	4.9	1.1	69
24	Orange	45	0.9	0.2	11.2	0.4	49
25	Banana	108	1	0.8	24.3	0.2	9
26	Papaya	46	0.5	12	12.2	1.7	7.8
27	Jelly	0	0	0.2	0	5	0
28	Milk Powder	513	24.6	30	36.2	0.6	6
29	Oil	884	0	100	0	0	0

Table 4. Food prices

No	Food Type	Price per 100gr(rupiah)	No	Food Type	Price per 100gr(rupiah)
1	Rice	1500	16	Sawi	500
2	Vermicelli	1000	17	Carrot	700
3	Bread	3000	18	Potato	1200
4	Biscuit	4000	19	Water Spinach	600
5	Cassava	500	20	Spinach	800
6	Chicken Meat	3000	21	Vegetable Soup	1000
7	Beef (floss)	20000	22	Bean	400
8	Chicken Egg	2500	23	Cauliflower	700
9	Milkfish	3000	24	Orange	2500
10	Shrimp	8000	25	Banana	1500
11	Sweetened Condensed Milk	3000	26	Papaya	900
12	Soybean Cake	1500	27	Jelly	1300
13	Tofu	1700	28	Milk Powder	9000
14	Green Bean	1500	29	Oil	2000
15	Sayur Asam	1000			

Assume that each goal function is optimal. The first step is completing first priority,

Priority 1. Minimize $d_1^+ + d_1^-$

With constraints: Goal equation

Constraint Function

Non negative constraints

Suppose the solution obtained is the value of the goal function, v_1. Thus, the Lexicographic Goal Programming model for the second priority is as follows:

Priority 2. Minimize $d_2^+ + d_2^-$

With Constraints: Goal equation

Constraint Function

$$d_1^+ + d_1^- = v_1$$

Non negative constraints

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Priority n. Minimize $d_n^+ + d_n^-$

With Constraints: Goal equation

Constraint Function

$$d_1^+ + d_1^- = v_1$$

$$d_2^+ + d_2^- = v_2$$

$$\vdots$$

$$d_{n-1}^+ + d_{n-1}^- = v_{n-1}$$

Non negative Constraints

4. RESULT AND DISCUSSION

In previous, researcher uses goal programming without target priority. In this study, two methods were used, namely a weighted goal programming and a lexicographic goal programming. In the first method, objective functions are given equal weight based on nutritionist opinion. Then the second method, the first priority are meet energy and protein needs. So, that the deviation from the objective function with the first priority is minimized first. Then, the deviation from the results obtained is entered into the constraint function in the model with the second priority (meet carbohydrate and fat needs). At last, this is done for the model with the third priority (meet iron and vitamin C needs, also minimize expense). The result is the solution of the lexicographic model. Both of the model with those method are done by using A simplex method. The calculation is helped by LINGO program. The following is an example of a menu design served.

Tabel 5. Menu design

No	Food Type	No	Food Type
1	Rice	8	Tofu
2	Bread	9	Carrot
3	Cassava	10	Vegetable Soup
4	Chicken Meat	11	Orange
5	Chicken Egg	12	Banana
6	Sweetened Condensed Milk	13	Oil
7	Soybean Cake	14	Milk Powder

The variables and parameters used are as follows:

a_{ij}= the nutrient content to-i in 100 grams of food type x_j

x_j = the amount of the food to-j per 100 grams

y = food consumption expenditure for toddlers every day

i = nutrient

content: 1(Energy),2(Protein),3(Fat),4(Carbohydrate), 5(Iron), 6(Vitamin C) and 7(food price)

j= 1,2,3, ..., p

a_p = food price to-p in 100 grams

b_i = Recommended Nutritional Adequacy Rate to-i

d_i^-= negative deviation of nutritional elements i

d_i^+ = positive deviation of nutritional elements i

b_{1j} = the lower quartile of food types x_j in 100 grams

b_{2j} = the higher quartile of food types x_j in 100 grams

Formulation of menu constraints for day -1:

Meet the needs of macro nutrients (energy, protein, fat and carbohydrates),

Energy: $180x_1 + 248x_3 + 154x_5 + 298x_6 + 154x_8 + 343x_{11} + 201x_{12} + 80x_{13} + 36x_{17} + 27x_{21} + 45x_{24} + 108x_{25} + 513x_{28} + 884x_{29} + d_1^- - d_1^+ = 1400$

Protein: $3x_1 + 8x_3 + 1x_5 + 18.2x_6 + 12.4x_8 + 8.2x_{11} + 20.8x_{12} + 10.9x_{13} + 1x_{17} + 1.3x_{21} + 0.9x_{24} + 1x_{25} + 24.6x_{28} + 0x_{29} + d_2^- - d_2^+ = 25$

Fat: $0.3x_1 + 1.2x_3 + 0.3x_5 + 25x_6 + 10.8x_8 + 10x_{11} + 8.8x_{12} + 4.7x_{13} + 0.6x_{17} + 2x_{21} + 0.2x_{24} + 0.8x_{25} + 30x_{28} + 100x_{29} + d_3^- - d_3^+ = 50$

Carbohydrate: $39.8x_1 + 50x_3 + 36.8x_5 + 0x_6 + 0.7x_8 + 55x_{11} + 13.5x_{12} + 0.8x_{13} + 7.9x_{17} + 1x_{21} + 11.2x_{24} + 24.3x_{25} + 36.2x_{28} + 0x_{29} + d_4^- - d_4^+ = 220$ (9)

Meet micronutrients (iron and vitamin C)

Iron: $1.8x_1 + 1.5x_3 + 1.1x_5 + 1.5x_6 + 3x_8 + 0.2x_{11} + 4x_{12} + 3.4x_{13} + 1x_{17} + 1.8x_{21} + 0.4x_{24} + 0.2x_{25} + 0.6x_{28} + 0x_{29} + d_5^- - d_5^+ = 10$

Vitamin C: $0x_1 + 0x_3 + 31x_5 + 0x_6 + 0x_8 + 1x_{11} + 0x_{12} + 0x_{13} + 18x_{17} + 0x_{21} + 49x_{24} + 9x_{25} + 6x_{28} + 0x_{29} + d_6^- - d_6^+ = 45$ (10)

Minimize costs spent.

Cost: $1500x_1 + 3000x_3 + 500x_5 + 3000x_6 + 2500x_8 + 3000x_{11} + 1500x_{12} + 1700x_{13} + 700x_{17} + 1000x_{21} + 2500x_{24} + 1500x_{25} + 9000x_{28} + 2000x_{29} + d_7^- - d_7^+ - F = 0$ (11)

Mathematical model of day 1 menu formed:

Weighted Goal Programming:

Minimize: $d_1^- + d_2^- + d_3^- + d_4^- + d_5^- + d_6^- + d_7^- + d_7^+$ (12)

Toward equality constraints in Equation 8 – 10.

Lexicographic Goal Programming:

According to the results of discussions with nutritionists, the priority order of goals to be achieved is obtained, namely

P1: meet energy and protein needs

P2: meet the needs of fat and carbohydrates

P3: meet the needs of iron and vitamin C and minimize costs.

Mathematical model that is formed:

Minimize: $P1(d_1^- + d_2^-) + P2(d_3^- + d_4^-) + P3(d_5^- + d_6^- + d_7^- + d_7^+)$ (13)

Toward equality constraints in Equation 8 – 10.

The results of calculations with the LINGO program that using a simplex method are as follows.

Table 6. The results of weighted Goal Programming

Time	Food Type	Weight (g)	URT	The nutrient content						Price
				Energy (kkal)	Protein (g)	Fat (g)	Carbohydrate (g)	Iron (mg)	Vit.C (mg)	
Breakfast	Rice	37.5	$\frac{1}{4}$ cup	67.5	1.12	0.11	14.92	0.67	0	562.5
	Vegetable Soup	25	$\frac{1}{4}$ cup	6.75	0.325	0.5	0.25	0.45	0	250
	Chicken Egg	30	1 with small size	46.2	3.72	3.24	0.21	0.9	0	750
	Soybean Cake	25	1 slice with medium size	50.25	5.2	2.2	3.37	1	0	375
	Orange	100	1 with medium size	45	0.9	0.2	11.2	0.4	49	2500
	Milk powder	14.62	2 tablespoons	75	3.59	4.38	5.29	0.08	0.87	1315.8
	Oil	1.67	2 tablespoons	14.73	0	1.67	0	0	0	33.34
Snack	Bread	10	1 slice	24.8	0.8	0.12	5	0.15	0	300
	Cassava	75	$\frac{3}{4}$ slice	45.5	0.75	0.23	27.6	0.82	23.25	250
Lunch	Rice	56.25	$\frac{1}{2}$ cup	101.25	1.68	0.16	22.38	1.01	0	843.75
	Vegetable Soup	25	$\frac{1}{4}$ cup	6,75	0.325	0.5	0.25	0.45	0	250
	Chicken Meat	41.63	1 slice with medium size	124.05	7.57	10.4	0	0.62	0	1248.9
	Tofu	25	$\frac{1}{2}$ slice with big size	20	2.72	1.27	0,2	0.85	0	425
	Oil	1.67	2 tablespoons	14.73	0	1.67	0	0	0	33.34
	Sweetened Condensed Milk	50	$\frac{1}{2}$ cup	171.5	4.1	5	27.5	0.1	0.5	1500
	Banana	60	1 with medium size	64.8	0.6	0.48	14.58	0.12	5.4	900
Snack	Cassava	75	$\frac{3}{4}$ slice	45.5	0.75	0.23	27.6	0.82	23.25	250
	Bread	10	1 slice	24.8	0.8	0.12	5	0.15	0	300
Dinner	Rice	56.25	$\frac{1}{2}$ cup	101.25	1.68	0.16	22.38	1.01	0	843.75
	Chicken Meat	41.63	1 slice with medium size	124.05	7.57	10.4	0	0.62	0	1248.9
	Carrot	60	$\frac{1}{2}$ with medium size	21,6	0.6	0.36	4.74	0.6	10.8	420
	Oil	1.67	2 tablespoons	14.73	0	1.67	0	0	0	33.34
	Sweetened Condensed Milk	50	$\frac{1}{2}$ cup	171.5	4.1	5	27.5	0.1	0.5	1500
	Total			1522.27	48.94	49.27	219.99	10.95	113.57	16383
	Ratio (%)			108.73	195.76	98.,54	99.99	109.5	252.37	

Table 7. The results of Lexicographic Goal Programming

Time	Food Type	Weight (g)	URT	The nutrient content						Price
				Energy (kkal)	Protein (g)	Fat (g)	Carbohydrate (g)	Iron (mg)	Vit.C (mg)	
Breakfast	Rice	53.25	$\frac{1}{2}$ cup	104.85	1.74	0.17	23.18	1.04	0	873.75
	Vegetable Soup	25	$\frac{1}{4}$ cup	6.75	0.32	0.5	0.25	0.45	0	250
	Soybean Cake	25	1 slice with medium size	50.25	5.2	2.2	3.37	1	0	375
	Milk Powder	30	3 tablespoons	153.9	7.38	9	10.86	0.18	1.8	2700
	Oil	1.67	2 tablespoons	14.73	0	1.67	0	0	0	33.34
Snack	Cassava	37.5	$\frac{1}{2}$ slice	57.75	0.37	0.11	13.8	0.41	11.62	187.5
	Bread	10	1 slice	24.8	0.8	0.12	5	0.15	0	300
	Banana	60	1 with medium size	64.8	0.6	0.48	14.58	0.12	5.4	900
Lunch	Rice	87.37	$\frac{3}{4}$ cup	153.27	2.62	0.26	34.77	1.57	0	1310.62
	Vegetable Soup	25	$\frac{1}{4}$ cup	6.75	0.32	0.5	0.25	0.45	0	250
	Chicken Meat	33.12	1 slice with medium size	98.69	6.02	8.28	0	0.49	0	993.6
	Tofu	25	$\frac{1}{2}$ slice with big size	20	2.72	1.17	0.2	0.85	0	425
	Oil	1.67	2 tablespoons	14.73	0	1.67	0	0	0	33.34
	Sweetened Condensed Milk	50	$\frac{1}{2}$ cup	171,5	4,1	5	27,5	0,1	0,5	1500
Snack	Cassava	37.5	$\frac{1}{2}$ slice	57.75	0.37	0.11	13.8	0.41	11.62	187.5
	Bread	10	1 slice	24.8	0.8	0.12	5	0.15	0	300
	Orange	30	$\frac{1}{2}$ with medium size	13.5	0.27	0.06	3.36	0.12	14.7	750
Dinner	Rice	87.37	$\frac{3}{4}$ cup	153.27	2.62	0.26	34.77	1.57	0	1310.62
	Chicken Meat	33.12	1 slice with medium size	98.69	6.02	8.28	0	0.49	0	993.6
	Carrot	20	$\frac{1}{2}$ with small size	7.2	0.2	0.12	1.58	0,2	3.6	140
	Oil	1.67	2 tablespoons	14.73	0	1.67	0	0	0	33.34
	Sweetened Condensed Milk	50	$\frac{1}{2}$ cup	171.5	4.1	5	27.5	0.1	0.5	1500
	Chicken egg	30	1 with small size	46.2	3.72	3.24	0.21	0.9	0	750
	Total			1538.44	50.34	49.99	219.99	10.78	49.75	16097
	Ratio (%)			109.88	201.36	99.98	99.99	107.8	110.5	

Table 6 shows the objective function of fulfilling energy, fat, carbohydrate and iron needs is achieved. It can be seen from the last row in coloumn 5, 7, 8, and 9 the percentage of tolerance for achieving nutritional needs, namely 90-110% of the expected. Meanwhile, from the last row in column 6 and 10 the need of protein and vitamin C is not achieved because it is above the target. This can be overcome by reducing a number of the types of food that have a big influence on these nutrients but do not reduce the need for other nutrients. Besides, the variation of food types can be changed. The expense for this menu is IDR 16,383.00.

Table 7 describes all of the objective function of fulfilling a nutritional needs is achieved except a protein need. It can be seen from the percentage of protein needs, more than 110% of the expected value. Meanwhile the expense for this menu is IDR 16,097.00. It can be seen from Table 6 and Table 7, in this case The Lexicographic Goal Programming has many advantages than The Weighted Goal Programming in terms of achieving its goals.

5. CONCLUSIONS

Mathematical model for menu planning for toddlers is in the form of a linear program with several (multi-objective) functions. The objective functions to be achieved are to meet the need for macronutrients (energy, protein, fat, and carbohydrates), to meet micronutrients (iron and vitamin C), and to minimize expenses. The approach used to complete the Goal Programming Model includes Weighted Goal Programming and Lexicographic Goal Programming. Weighted Goal Programming with the same weighted objective function resulted in a given menu variation the objective function of fulfilling energy, fat, carbohydrate and iron needs is achieved. The need of protein and vitamin C is not achieved because it is above the target. This can be overcome by reducing the types of food that have a big influence on these nutrients but do not reduce the need for other nutrients. The expense for this menu is IDR 16,383.00. Meanwhile, Lexicographic Goal Programming is a model with an order of priority. According to nutritionists, the first priority is to meet energy and protein needs, the second priority is to meet the needs of fat and carbohydrates, and the third priorities are to meet iron and vitamin C needs and to minimize expenditure costs. The result are the objective function of fulfilling a nutritional needs is achieved except a protein need. The expense for this menu is IDR 16,097.00. It can be seen that The Lexicographic Goal Programming more advantages than The Weighted Goal Programming in terms of achieving its goals based on the expense.

AUTHORS' CONTRIBUTIONS

DL forms mathematical models and simulates computer programs. AMA and AD analyze data. AIT and EH compile an interpretation of the results. all authors also compile the article as a whole

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