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Optimization of Balanced Menu for Pregnant Women in Grobogan-Central Java Using Simplex Method

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Abstrak. Penelitian ini bertujuan untuk menentukan optimasi komposisi makanan seimbang bagi ibu hamil. Penentuan optimasi makanan seimbang dilakukan dengan membentuk model linear beserta kondisi batas dan fungsi tujuan, serta menginputkan data usia ibu hamil, usia kandungan, dan kebutuhan nutrisi ibu. Kemudian dilakukan perhitungan dengan metode simpleks sehingga diperoleh berat bahan makanan yang harus dikonsumsi untuk mendapatkan gizi yang seimbang yaitu dengan 75 kombinasi yang telah dianalisis terhadap kelompok ibu hamil usia 19-29 tahun dan usia 30-49 tahun pada tiga trimester, meliputi jenis makanan pokok, sayur (bayam, sawi hijau, kembang kol, kangkung, wortel), buah, lauk pauk, kacang-kacangan, gula dan susu dengan angka kecukupan gizi yang dianjurkan untuk kandungan data angka kecukupan air, energi, protein, lemak, karbohidrat (KH), serat, vitamin A, B1, B2, B3 dan vitamin C. Terhadap kelompok ibu hamil usia 19-29 tahun dan usia 30-49 tahun pada tiga trimester, diperoleh bahwa kombinasi 55 adalah kombinasi yang optimal dengan bahan makanan beras, kangkung, semangka, dan tahu.

Abstract. This study aims to determine the optimization of balanced dietary composition for pregnant women. Determination of the optimization of balanced food is carried out by forming a linear model along with boundary conditions and objective functions, as well as inputting data on the age of pregnant women, age of pregnancy and maternal nutritional needs, then the calculation is carried out using the simplex method in order to obtain the weight of food ingredients that must be consumed to get a balanced nutrition, namely with 75 combinations that have been analyzed on groups of pregnant women aged 19-29 years and 30-49 years in three trimesters, including staple foods, vegetables (spinach, green mustard, cauliflower, kale, carrots), fruit, side dishes vegetables, nuts, sugar and milk with the recommended nutritional adequacy rate for the data content of water, energy, protein, fat, carbohydrate (KH), fiber, vitamin A, B1, B2, B3 and vitamin C. In the group of pregnant women aged 19-29 years and women aged 30-49 years in the three trimesters, it was found that the combination of 55 was the optimal combination with rice, kale, watermelon, and tofu.

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1. Introduction

Stunting is one of the nutritional problems experienced by toddlers in the world today. Indonesia is included in the third country with the highest prevalence, in the Southeast Asia region. The average prevalence of toddler stunting in Indonesia from 2005 to 2017 was 36.4%. The nutritional condition of the mother before and during pregnancy and after childbirth affects fetal growth and the risk of stunting. Other factors in the mother's influence are the mother's posture (short), the distance of pregnancy that is too close, the mother who is still a teenager, as well as the lack of nutrient intake at the time of pregnancy. The government designated 1,000 villages a priority for stunting interventions located in 100 districts/cities and 34 provinces. One of the 100 districts/cities that the government prioritizes in stunting is Grobogan Regency, Central Java Province [2].

The nutritional needs of pregnant women are very important for the growth and development of the fetus, therefore the pregnant woman must be sufficient to intake her nutrients so that the fetus can develop normally, malnutrition in pregnant women will result in chronic energy deficiency (KEK) of the case itself due to a lack of food intake that is not in accordance with the needs of the food intake of pregnant women this results in the development of the fetus is hampered.

Data collection is done with field surveys to get data on the market price of food that pregnant women can consume. Determination of balanced foods by forming linear models along with the conditions of the limits and functions of the destination, as well as the nutritional needs of pregnant women, then the data of food ingredients, nutritional content, and the price of ingredients, then done calculations with simplex method so that obtained the weight of food ingredients that must be consumed to get balanced nutrition.

Research on the optimization of nutrition for pregnant women in each trimester has been carried out in Ampana Tete District, Tojo Una-Una District, Central Sulawesi Province, and in this study will be investigated more deeply regarding the optimization of nutrition in pregnant women in each trimester according to the age category located in Grobogan Regency.

This research aims to determine the optimization of the composition of balanced foods for pregnant women using simplex method by considering the price of groceries so that there will be a minimum cost in Grobogan Regency. Course composition that fulfills nutrition for pregnant women in the 1st, 2nd, and 3rd trimesters based on age categories with minimum costs can be solved using a linear programming model. The simplex method can be used in linear programming which functions to find the optimum solution.

2. Research Methods

The research began by conducting preliminary studies to observe stunting problems and conclude mathematical methods used for problem solving. Furthermore, literature studies are conducted to study the theories used to achieve research objectives. Identification of data needs required during research, then data collection is done with field surveys to obtain data on the market price of food that pregnant women can consume. To determine the optimization of balanced foods by input data on the nutritional adequacy of pregnant women according to the age group and trimester of pregnant women, then food data in the form of nutritional content and the price of ingredients, then done calculations with simplex method so that it obtained the weight of food ingredients that should be consumed to get balanced nutrition. Based on the results of determining health status and calculation of food composition can be used as a discussion to establish conclusions.

$$Z_{min} = c_1x_1 + c_2x_2 + c_3x_3 + c_4x_4 + c_5x_5 + c_6x_6 + c_7x_7 \qquad (1)$$

Constraints:

$$a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + a_{14}x_4 + a_{15}x_5 + a_{16}x_6 + a_{17}x_7 \geq b_1 \qquad (2)$$
$$a_{21}x_1 + a_{22}x_2 + a_{23}x_3 + a_{24}x_4 + a_{25}x_5 + a_{26}x_6 + a_{27}x_7 \geq b_2 \qquad (3)$$
$$a_{31}x_1 + a_{32}x_2 + a_{33}x_3 + a_{34}x_4 + a_{35}x_5 + a_{36}x_6 + a_{37}x_7 \geq b_3 \qquad (4)$$
$$a_{41}x_1 + a_{42}x_2 + a_{43}x_3 + a_{44}x_4 + a_{45}x_5 + a_{46}x_6 + a_{47}x_7 \geq b_4 \qquad (5)$$
$$a_{51}x_1 + a_{52}x_2 + a_{53}x_3 + a_{54}x_4 + a_{55}x_5 + a_{56}x_6 + a_{57}x_7 \geq b_5 \qquad (6)$$
$$a_{61}x_1 + a_{62}x_2 + a_{63}x_3 + a_{64}x_4 + a_{65}x_5 + a_{66}x_6 + a_{67}x_7 \geq b_6 \qquad (7)$$
$$a_{71}x_1 + a_{72}x_2 + a_{73}x_3 + a_{74}x_4 + a_{75}x_5 + a_{76}x_6 + a_{77}x_7 \geq b_7 \qquad (8)$$
$$a_{81}x_1 + a_{82}x_2 + a_{83}x_3 + a_{84}x_4 + a_{85}x_5 + a_{86}x_6 + a_{87}x_7 \geq b_8 \qquad (9)$$
$$a_{91}x_1 + a_{92}x_2 + a_{93}x_3 + a_{94}x_4 + a_{95}x_5 + a_{96}x_6 + a_{97}x_7 \geq b_9 \qquad (10)$$
$$a_{101}x_1 + a_{102}x_2 + a_{103}x_3 + a_{104}x_4 + a_{105}x_5 + a_{106}x_6 + a_{107}x_7 \geq b_{10} \qquad (11)$$
$$a_{111}x_1 + a_{112}x_2 + a_{113}x_3 + a_{114}x_4 + a_{115}x_5 + a_{116}x_6 + a_{117}x_7 \geq b_{11} \qquad (12)$$
where $x_1, x_2, x_3, x_4, x_5, x_6, x_7 \geq 0$ $\qquad (13)$

Details:

a_{1i} is the amount of water in the food.

a_{2i} is the amount of energy in the food.

a_{3i} is the amount of protein in the food.

a_{4i} is the amount of fat in the food.

a_{5i} is the amount of carbohydrate in the food.

a_{6i} is the amount of fiber in the food.

a_{7i} is the amount of vitamin A in the food.

a_{8i} is the amount of vitamin B1 in the food.

a_{9i} is the amount of vitamin B2 in the food.

a_{10i} is the amount of vitamin B3 in the food.

a_{11i} is the amount of vitamin C in the food.

where $i = 1,2,3,4,5,6,7$ is sequence of food ingredient.

2.1 Data Collection

Data collection is done in Tanggungharjo market, Grobogan Regency of Central Java to get the price data of groceries to be researched. The food ingredients surveyed included staple foods, vegetables, fruit, side dishes, nuts, sugar and milk. With the following data acquisition:

Tabel 1. List of prices of groceries on the market

No.	Food	Price (Rp/kg)	Price (Rp/g)	No.	Food	Price (Rp/kg)	Price (Rp/g)
1	Rice	9.000	9	10	Green Beans	21.000	21
2	Sugar	12.000	12	11	Peanut	12.000	12
3	Tofu	8.000	8	12	Watermelon	6.000	6
4	Tempe	16.000	16	13	Banana	20.000	20
5	Spinach	12.000	12	14	Red Dragon Fruit	17.000	17
6	Green Mustard	9.000	9	15	Starfruit	14.000	14
7	Cabbage	16.000	16	16	Apple	25.000	25
8	Kale	7.500	7,5	17	Milkfish	25.000	25
9	Carrot	7.000	7	18	Milk powder	100.000	100

Based on the Indonesian Food Composition Table in 2017 published by the Directorate General of Public Health, Directorate of Public Nutrition, Ministry of Health of the Republic of Indonesia obtained food nutritional data for amount of water, energy, fat, carbohydrate (KH), fiber, vitamin A, vitamin B1, vitamin B2, vitamin B3 and vitamin

C as follows:

Table 2. Indonesian Food Composition Table (Per 1 gram)

No.	Food	Water (g)	Energy (kcal)	Protein (g)	Fat (g)	KH (g)	Fiber (g)	Vit. A (mcg)	Vit. B1 (mg)	Vit. B2 (mg)	Vit. B3 (mg)	Vit. C (mg)
1	Rice	0,120	3,57	0,084	0,017	0,771	0,002	0	0,0020	0,0008	0,026	0
2	Sugar	0,054	3,94	0,0	0,0	0,94	0,0	0	0,00	0,00	0,0	0
3	Tofu	0,822	0,80	0,109	0,047	0,008	0,001	1,18	0,0001	0,0008	0,001	
4	Tempe	0,683	1,50	0,14	0,077	0,091	0,014	0	0,0017	0,0044	0,036	
5	Spinach	0,945	0,16	0,09	0,004	0,029	0,007	22,93	0,0004	0,0010	0,001	0,41
6	Green Mustard	0,922	0,28	0,023	0,003	0,04	0,025	64,60	0,0009	0,0023	0,007	0,10
7	Cabbage	0,917	0,25	0,024	0,002	0,049	0,016	0,9	0,0011	0,0009	0,006	0,69
8	Kale	0,910	0,28	0,034	0,007	0,039	0,02	55,42	0,0007	0,0036	0,002	0,17
9	Carrot	0,899	0,36	0,01	0,006	0,079	0,01	71,25	0,0004	0,0004	0,01	0,18
10	Green Bean	0,155	3,23	0,229	0,015	0,568	0,075	2,23	0,0046	0,0015	0,015	0,10
11	Peanut	0,096	5,25	0,279	0,427	0,174	0,024	0,3	0,0044	0,0027	0,014	
12	Watermelon	0,921	0,28	0,005	0,002	0,069	0,004	5,90	0,0005	0,0005	0,003	0,06
13	Banana	0,658	1,2	0,012	0,002	0,318	0,053	9,50	0,0006	0,0014	0,012	0,1
14	Red Dragon Fruit	0,857	0,71	0,017	0,031	0,091	0,032	0	0,0050	0,0030	0,005	0,01
15	Starfruit	0,90	0,36	0,004	0,004	0,088	0,032	1,70	0,0003			0,35
16	Apple	0,841	0,58	0,003	0,004	0,149	0,026	0,9	0,0004	0,0003	0,001	0,05
17	Milkfish	0,740	1,23	0,20	0,048	0,0	0,0	0,45	0,0005	0,0010	0,06	0
18	Milk Powder	0,035	5,13	0,246	0,30	0,362	0,0	4,76	0,0029	0,0139	0,016	0,06

The recommended nutritional adequacy figures for Indonesians are contained in The Minister of Health Regulation of the Republic of Indonesia no. 28 of 2019 on the recommended Nutritional Adequacy Figures for Indonesians, the data required are the age group 19-29 years and 30-49 years for the gender of women and pregnant with the division of trimester 1, trimester 2 and trimester 3. data on water adequacy, energy, protein, fat, carbohydrate (KH), fiber, vitamin A, vitamin B1, vitamin B2, vitamin B3, and vitamin C.

Table 3. Recommended Nutritional Adequacy Rate (per person per day)

Age Group	Weight (kg)	Height (cm)	Water (ml)	Energy (kcal)	Protein (g)	Fat Total	KH (g)	Fiber (g)	Vit A (mcg)	Vit B1 (mg)	Vit B2 (mg)	Vit B3 (mg)	Vit C (mg)
Woman (y.o.)													
19 - 29	55	159	2.350	2.250	60	65	360	32	600	1,1	1,1	14	75
30 - 49	56	158	2.350	2.150	60	60	340	30	600	1,1	1,1	14	75
Pregnant													
Trimester 1			+300	+180	+1	+2.3	+25	+3	+300	+0.3	+0.3	+4	+10
Trimester 2			+300	+300	+10	+2.3	+40	+4	+300	+0.3	+0.3	+4	+10
Trimester 3			+300	+300	+30	+2.3	+40	+4	+300	+0.3	+0.3	+4	+10

3. Result and Discussion

The decision variables used include the types of staple foods, vegetables, fruit, side dishes, nuts, sugar, and milk with the following descriptions:

x_1 is a staple type of food in the combination of food (Rice)

x_2 is a type of vegetable in a combination of foods (Spinach, Green Mustard, Cabbage, Kale, Carrots)

x_3 is a type of fruit in a combination of foods (Watermelon, Banana, Red Dragon Fruit, Starfruit, Apple)

x_4 is a type of side dish in a combination of foods (Tofu, Tempe, Fish)

x_5 is a type of nuts in a combination of foods (Green Beans, Peanuts)

x_6 is sugar in a combination of foods (White Sugar)

x_7 is milk in a combination of foods (Milk Powder)

Based on the food ingredients used are Rice, Spinach, Green Mustard, Cabbage, Kale, Carrots, Watermelon, Banana, Red Dragon Fruit, Starfruit, Apple, Tofu, Tempe, Fish, Green Beans, Peanuts, White Sugar, and Milk obtained probably 75 combinations of food ingredients that some will analyze.

The simplex method used to solve the problem of balanced nutrition optimization in pregnant women with the age group 19-29 years and 30-49 years for the gender of women and pregnant with the division of trimester 1, Trimester 2 and trimester 3 with minimum cost is shaped $\geq$ by variable amount 7 and constraints 11 namely water, energy, protein, fat, carbohydrate (KH), fiber, vitamin A, vitamin B1, vitamin B2, vitamin B3 and vitamin C in Nutrient Adequacy.

To facilitate the above calculation can be completed using the help of WinQSB program with the basic algorithm used in problem solving is simplex method with the following results:

Table 4. The Calculation Result of Food Combination of
Pregnant Women 19-29 y.o. 1st Trimester

Comb	X₁	X₂	X₃	X₄	X₅	X₆	X₇	Prices (Rp)
55	379,1835	1.595,97	319,6961	1.043,46	0	0	0	25.648,29
61	389,9379	1.958,05	0	999,2493	0	0	0	26.188,80
19	357,9672	1.238,59	522,1503	1.194,65	0	0	0	27.221,13

Based on the calculation results on 75 combinations obtained, the 55th combination is the optimal combination for pregnant women aged 19-29 years old of the 1st trimester with x_1 is rice as much as 379,1835 g, x_2 is kale as much as 1.595,97 g, x_3 is watermelon as much as 319,6961 g, x_4 is tofu as much as 1.043,46 g and the total prices is Rp.25.648,29 or can be rounded up Rp.25.700 per day.

Table 5. The Calculation Result of Food Combination of
Pregnant Women 19-29 y.o. 2nd Trimester

Comb	X₁	X₂	X₃	X₄	X₅	X₆	X₇	Prices (Rp)
55	400,095	1.654,08	272,225	1.029,26	0	0	0	25.873,93
61	409,252	1.962,40	0	991,616	0	0	0	26.334,18
19	396,762	1.283,69	482,051	1.185,96	0	0	0	27.504,03

Based on the calculation results on 75 combinations obtained, the 55th combination is the optimal combination for pregnant women aged 19-29 years old of the 2nd trimester with x_1 is rice as much as 400,095 g, x_2 is kale as much as 1.654,08 g, x_3 is watermelon as much as 272,225 g, x_4 is tofu as much as 1.029,26 g, and the total price is Rp.25.873,93 or can be rounded up Rp.25.900 per day.

Table 6. The Calculation Result of Food Combination
of Pregnant Women 19-29 y.o. 3rd Trimester

Comb	X$_1$	X$_2$	X$_3$	X$_4$	X$_5$	X$_6$	X$_7$	Prices (Rp)
55	400,0948	1.654,08	272,2251	1.029,26	0	0	0	25.873,93
61	409,2523	1.962,40	0	991,6156	0	0	0	26.334,18
19	396,7615	1.283,69	482,0511	1.185,96	0	0	0	27.504,03

Based on the calculation results on 75 combinations obtained, the 55th combination is the optimal combination for pregnant women aged 19-29 years old of the 3rd trimester with x_1 is rice as much as 400,0948 g, x_2 is kale as much as 1.654,08 g, x_3 is watermelon as much as 272,2251 g, x_4 is tofu as much as 1.029,26 g and the total price Rp.25.873,93 or can be rounded up Rp. 25.900 per day.

Table 7. The Calculation Result of Food Combination of Pregnant Women 30-49 y.o. 1st Trimester

Comb	X$_1$	X$_2$	X$_3$	X$_4$	X$_5$	X$_6$	X$_7$	Prices (Rp)
55	342,0348	1.461,65	530,3547	961,5567	0	0	0	24.915,25
61	359,8766	2.062,31	0	888,2111	0	0	0	25.811,92
19	339,0892	1.134,35	715,7697	1.100,02	0	0	0	26.355,71

Based on the calculation results on 75 combinations obtained, the 55th combination is the optimal combination for pregnant women aged 30-49 years old of the 1st trimester with x_1 is rice as much as 342,0348 g, x_2 is kale as much as 1.461,65 g, x_3 is watermelon as much as 530,3547 g, x_4 is tofu as much as 961,5567 g and the total prices is Rp.24.915,25 or can be rounded up Rp. 25.000 per day.

Table 8. The Calculation Result of Food Combination
of Pregnant Women 30-49 y.o. 2nd Trimester

Comb	X$_1$	X$_2$	X$_3$	X$_4$	X$_5$	X$_6$	X$_7$	Prices (Rp)
55	362,9461	1.519,76	482,8837	947,3579	0	0	0	25.140,89
61	379,1901	2.066,66	0	880,5773	0	0	0	25.957,29
19	359,8835	1.179,45	675,6705	1.091,33	0	0	0	26.638,62

Based on the calculation results on 75 combinations obtained, the 55th combination is the optimal combination for pregnant women aged 30-49 years old of the 2nd trimester with x_1 is rice as much as 342,0348 g, x_2 is kale as much as 1.461,65 g, x_3 is watermelon as much as 530,3547 g, x_4 is tofu as much as 961,5567 g and the total prices is Rp.24.915,25 or can be rounded up Rp. 25.000 per day.

Table 9. The Calculation Result of Food Combination
of Pregnant Women 30-49 y.o. 3rd Trimester

Comb	X$_1$	X$_2$	X$_3$	X$_4$	X$_5$	X$_6$	X$_7$	Prices (Rp)
55	362,9461	1.519,76	482,8837	947,3579	0	0	0	25.140,89
61	379,1901	2.066,66	0	880,5773	0	0	0	25.957,29
19	359,8835	1.179,45	675,6705	1.091,33	0	0	0	26.638,62

Based on the calculation results on 75 combinations obtained that the 55th combination is the optimal combination for pregnant women aged 30-49 years old of the 3rd trimester with x_1 is rice as much as 362,9461 g, x_2 is kale as much as 1.519,76 g, x_3 is watermelon as much as 482,8837 g, x_4 is tofu as much as 947,3579 g and the total prices is Rp.25.140,89 or can be rounded up Rp. 25.200 per day.

4. Conclusions

Based on the 75 combinations that have been analyzed, based on food ingredients including staple foods, vegetables (spinach, green mustard, cauliflower, kale, carrots), fruit, side dishes, nuts, sugar and milk with the recommended nutritional adequacy rate for the data content of the adequacy of water, energy, protein, fat, carbohydrate (KH), fiber, vitamin A, vitamin B1, vitamin B2, vitamin B3 and vitamin C, for pregnant women aged 19-29 years and 30-49 years old. three trimesters, the results show that the combination of 55 is the optimal combination with food ingredients such as rice, kale, watermelon, and tofu.

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