

Article

The Diet Problem on Minimizing Vitamin A: Linear Programming Problem

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Abstract - It is essential to practice a good diet in everyday life because human body needs a reasonable amount of nutrients. It is because excessive nutrient intake can lead to internal organs failure, such as kidney damage. This study focuses on minimizing vitamin A's intake in daily diet because vitamin A can give good vision, maintain healthy skin, and improve body's immune system. This research involves a few nutrients, such as calcium, iron, cholesterol, and vitamin A. The diet problem of minimizing vitamin A will be solved by using the graphical method and excel solver. The results are compared to determine which ways is the best. The results obtained are optimal solution, which is the minimal amount of vitamin A from one of the methods.

Keywords— diet problem, linear programming, vitamin A, excel solver

1. INTRODUCTION

Taking a balanced diet is an essential thing for everyone. However, nowadays, most people just focusing on diet and forgot about the balanced diet. They think that diet is about eating less food only, but actually, they are wrong because a balanced diet is more important. This is a common perception among people who do not know the definition of a balanced diet. The real meaning of a balanced diet is the food that gave your body the right nutrients to function correctly. It means we need to take a sufficient amount of nutrients according to how much our body needs certain nutrients.

The amounts of nutrients that body needs depend on some factors such as age, body size, gender, climate, health condition, and occupation. If a balanced diet is taken into consideration, people's lifestyles will indeed have a promising future because there of the benefits gained. Firstly it can increase life span when someone practices a balanced diet with exercise. Therefore it can improve human lifespan. Besides that, a person's productivity will increase because when a large amount of unhealthy food is consumed, the body feels sluggish and tired. However, when a balanced diet is consumed that consists of vegetables, fruits, whole grains, lean meats, and low-fat dairy products, the body has the essential nutrients to increase or maintain level of energy. It shows that having a balanced diet in everyday life is necessary.

Research by British Nutrition Foundation states that the nutrition needed for daily consumption depends on age, gender, level of physical fitness, and the body's ability to absorb nutrition. This research is about how to minimize

vitamin A intake for everyday life. Scientific research by National Institute of Health stated that too much vitamin A's intake could lead to some diseases such as osteoporosis and hip fracture risk. So this is the other reason why intake of vitamin A should be minimized. One of the past research about diet problems was by Susan and Saul (2001). They used the simplex method, LINDO LP, and the linear-programming spreadsheet solver in solving their linear programming. The next one was by Amol and Sidharth (2016). They used the Linear Programming Solver (LiPS) in solving their diet problem.

Susan and Saul (2001) stated that Stigler's diet problem contains nine essential nutrients for daily intake for all stages of people identified by National Research Council in 1943. Stigler needs to find an optimal amount of nutrient taken from a different type of food. Stigler was required to consider the cost of each food to find the lowest price as possible. Back to the Susan and Saul (2001) problem, they used the same problem as Stigler but with the current update by National Research Council about recommend dietary allowance (RDA) and the current food price. Susan and Saul (2001) compared 77 foods and their nutrients that a person needed at the minimum cost as possible with the current update and price. Amol and Sidharth (2016) stated that the problem was human body at the age of 40-45 years needs nutrient as Calcium, Iron, Protein, Vitamin A, Vitamin B1, Vitamin C and Vitamin E in their daily life. Using the given food such as orange, beans, wheat, milk, egg, soya beans, cauliflower, tomato, and potato, they needed to find an optimal intake of each food by following the nutritional requirement given. The set diet must be followed. As compared to Susan and Saul (2001), Amol and Sidharth

(2016) was much more complicated in terms of the constraint because they have more restrictions on their problems.

II. LITERATURE REVIEW

Amol and Sidharth (2016) focused on a man or woman at age 40-45 years old, around five years different. Amol and Sidharth (2016) also explained on the nutrient requirement of the human body at age around 40-45 years old. People at this age start to have negative growth which essential nutrient is a priority. In Amol and Sidharth (2016), the nutrients considered are calcium, iron, protein, Vitamin A, Vitamin B1, Vitamin C, and Vitamin E. It must follow the daily diet requirement, which the total quantity of calcium in the diet must be equal to or greater than 800mg. Iron must be greater than 15mg, protein greater than 50 mg, Vitamin A greater than 8000IU, Vitamin B1 1.2mg, Vitamin C greater than 60mg, and Vitamin E 0.25mg. The objective of Amol and Sidharth (2016) is to minimize the total diet cost from the given foods such as orange, beans, wheat, milk, egg, soya beans, cauliflower, tomato, and potato. Hamdy and Yusuf (2018) stated that a proper diet is important to the body including older people.

Susan and Saul (2001) took the original data of Stigler problem then updated the data. Some of the changes included were the current price of items at the market, new values of Recommend Dietary Allowance (RDA) and also the change of nutrient content of the selected food. Since there is a new nutrient add by National Research Council for (RDA), Susan and Saul (2001) created the new problem on extended Stigler Diet Problem, including the nutrients that were not in the Stigler's original diet problem. Some of the new nutrients that had been added to (RDA) were Vitamin D, Vitamin E, Vitamin K, vitamin B, Phosphorous, Magnesium, Zinc, Iodine, and Selenium. Susan and Saul (2001) included all these items in their new problem, so they solved different types of diet by following the Recommend Dietary Allowance.

Susan and Saul (2001) did not use the same limitation as Stigler, but they chose to calculate the amount needed for a man at age 25-50. They also did the same for a woman at the same age. The problems that Susan and Saul had been solved are the updated of Stigler's problem for the 25-50 years old man and 25-50 years old woman. While the other three extended Stigler problems using current RDA for the man 25-50 years old and woman 25-50 years old and also Stigler's problem using updated RDA and foods nutrients content. Susan and Saul also have repaired some of Stigler's flaws, like the unusual ingredient used in kitchens in the 1990s, such as lard and Crisco (the type of oil) because now people prefer to use vegetable olive oil. So, Susan and Saul (2001) chose these items to replace the items Stigler used. Stigler's diet problem used the price that obtained from Bureau of Labor Statistics (BLS) publication Retail Price of Foods, 1923-1936. The information Stigler received is an average price of 51 cities in 1939 and 56 cities in 1944. It is hard for Susan and Saul (2001) to match it, so they decided to obtain all the items from Giant Foods Supermarket chain in Washington, DC.

Many institutions have a finance generator to fund the institution themselves. It is either from firms or

businesses which can be any economic field such as grocery store, clothing store, laundry service, etc. These businesses will keep their operation undergo either during academic sessions or not during the academic session. When starting a business, a common goal usually has been set, that is, to gain maximum profit. This is also the same as Raimi and Adedayo (2017). To find the maximum profits of the bakery products, the specific method needed to use such as Simplex method. It is to avoid any ingredients to be wasted in production of bread. Raimi and Adedayo (2017) conducted data sample taking at Rufus Giwa Polytechnic Bakery in Ondo State, Nigeria. They only collected the data from a specific type of bread, medium bread, large bread, and extra-large bread. The process of collecting data was conducted for eight weeks in August and September to get accurate data for the research.

Krishna and Bibhash (2018) found the best irrigation planning for Kuls River Basin in India. This is because India is an agricultural country; therefore, it depends on water to sustain the economic income from the agriculture sector. However, in India, the water is limited and hard to get. In addition, the average rate of rainfall in India is not constant and uniform. So the water from the river basin is needed to irrigate the crop. Krishna and Bibhash (2018) considered some aspects while conducting their research, such as water availability, cropland requirement, maximizing net benefit, protein requirement, and caloric requirement. They constructed 13 different plans to get the maximum benefit; they used The Linear Programming Solver to solve their linear problem. The result of their research is shown in Table 1.

Table 1: The plan used and the max benefit gain from it.

Plan	Max Benefit
1	Rs.(2) 26855 Lacs
2	Rs. 8803.912 Lacs
3	Rs.2656.652 Lacs
4	Rs. 78925 Lacs
5	Rs. 48153.33 Lacs
6	Rs. 72349.89 Lacs
7	Rs. 65294.78 Lacs
8	Rs. 58479.67 Lacs
9	Rs. 44849.45 Lacs
10	Rs. 72349.89 Lacs
11	Rs. 72016.81 Lacs
12	Rs. 71273.85 Lacs
13	Rs. 72349.89 Lacs

This shows plan 4 gives the higher benefit Rs. 78925 Lacs followed by plan 6, 10 and 13. These three plans share the same max benefit that is Rs. 72349.89 Lacs, but the most suitable plan is plan 13 because it satisfied the entire requirement.

The transportation problem is some of the famous studies in operational research. This is because operational research usually been used to find the minimum or maximum value from the given constrain. This problem usually sets the goal to minimize the cost of transportation. Therefore, using the available operational research methods as Aliyu et al. (2019) have been researching to find the

minimum cost of transportation from CCNN to Sokoto, Kebbi, Zamfara, and from OBU to Kano, Kaduna, Katsina. For this research, they used three methods to find the minimum cost: North West corner method, least cost method, and Vogel approximation method. Before the optimization, these three methods gave different initial Basic Feasible Solution 2,336,000 - 4,160,900 - 2,331,800, respectively. Still, after the optimization, all the methods gave the same result for minimizing the cost that is 1,972,000. It shows that all methods used can find the minimum cost of transportation. The significant of their study can help and guide the managers at BUA Cement Company to make optimum production from two places to various distributors' destinations.

This research was done by Dike et al. (2016) which discussed the minimizing spanning tree for Global System for Mobile (GSM). Spanning tree is a method where a hub receiver is placed at a different place, then the signal is inserted at the main hub and will be sent from one terminal and hub site to other terminal and hub sites. This process is repeated until the signal comes back to the main hub. The limitation is only limited to Yola South and Yola North (Dike et al., 2016). The image of this area is obtained from Google Earth and Arc Gis (3). They estimated the number of the subscriber for Global System for Mobile (GSM) at Yola North and South is around 200,000 people. From 80 network lines at the research area, they found 28 main network lines within 29 nodes/hub (Dike et al., 2016). If there is any problem or the service down, the service will not be disturbed because there are still 28 main lines to support the lines that go down. One of the benefits of this research is that manufacturing and setting up the nodes/hub for Global System for Mobile (GSM) can be reduced.

III. MODEL FORMULATION and EXPERIMENTAL METHODS

A. Graphical Method

1) Step 1

Generate the constraints from the linear programming problem.

For example: two chocolates and one milk are needed to make a chocolate milkshake, while two chocolates and three kinds of milk are required to produce a chocolate ice cream. There are only 12 milk and 18 chocolates. What is the amount of chocolate ice cream to be produced to avoid waste of ingredients?

Maximum of production= MAXz

Let chocolate as X and milk as Y

$$\text{MAXz} = 2X_1 + 2X_2 \leq 18$$

$$1Y_1 + 3Y_2 \leq 12$$

And $X, Y \geq 0$

2) Step 2

- Replace “ \leq ” and “ \geq ” sign to “ $=$ ” in each constraint (inequality to equality).

$$2X_1 + 2X_2 = 18$$

$$1Y_1 + 3Y_2 = 12$$

- Find each value of the variable in each constraint if one of the variables is equal to 0.
- Plot the value in a graph, then connect the point according to its variable. Repeat this step for each variable. Refer to Diagram 1.

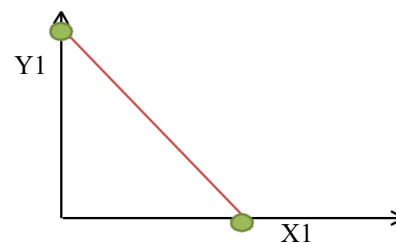


Diagram 1: Step 1

- Shade the part in the graph that crosses (common portion). Refer to Diagram 2.

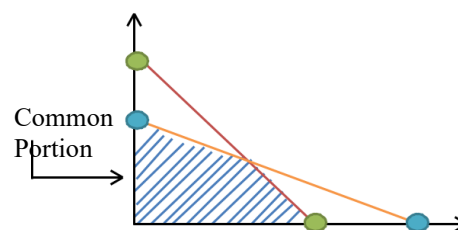


Diagram 2: Example 2

3) Step 3

- Decide the extreme points (corner points) of the feasible region.
- Calculate the objective function value at each extreme point.
- Find out the minimum or maximum value (optimal value) of the objective function.

B. Excel solver

1) Assign the variable

Example:

A company manufactures two products (A and B) and the profit per unit sold is £3 and £5 respectively. Each product

has to be assembled on a particular machine, each unit of product A taking 12 minutes of assembly time and each unit of product B 25 minutes of assembly time. The company estimates that the machine used for assembly has an effective working week of only 30 hours (due to maintenance/breakdown).

Technological constraints mean that for every five units of product A produced at least two units of product B must be produced. Let x be number of units of A produced and y be the number of units of B produced.

2) Write the constraints

Example:

$$12x + 25y \leq 30(60) \text{ assembly time}$$

$$5y \geq 2x \text{ technological}$$

$$x, y \geq 0$$

3) Write the objective function (minimize or maximize)

Maximize

$$\text{Maximize } 3x + 5y$$

4) Open Excel and enter the data

- Type the variable assignments at the top of the spreadsheet.
- Assign decision variable cells.
- Construct table from data in the problem.
- Write the constraint that shows the sum is “less than”, “greater than”, “less or equal to”, “greater or equal to” or “equal to” below the table.

5) Click tools and select solver

- Select the objective function
- Set up the option according to our linear problem
- Solve the problem

C. The Diet Problem on Minimizing Vitamin A: Linear Programming Problem

Given there are two types of diets to start with, Diet A and Diet B. Diet A consists of 3 units of calcium, 20 units of iron, four units of cholesterol, and three units of Vitamin A. At the same time, Diet B consists of 12 units of calcium, four units of iron, six units of cholesterol, and six units of Vitamin A. In the human body, some of the substances that

cannot be broken down are Vitamin A. So if there is an excess amount of Vitamin A in the body, it can cause bone-related diseases such as osteoporosis.

Table 2: Value of nutrient in Diet A and Diet B

	Diet A	Diet B
Calcium	3	12
Iron	20	4
Cholesterol	4	6
Vitamin A	3	6

From Table 2 the following equation can be constructed:

$$\text{Minimize } X+Y \tag{1}$$

Subject to:

$$3X + 12Y \geq 210 \tag{2}$$

$$20X + 4Y \geq 460 \tag{3}$$

$$4X + 6Y \leq 300 \tag{4}$$

$$3X + 6Y \leq 900 \tag{5}$$

$$X, Y \geq 0 \tag{6}$$

The objective function (1) aims to minimize the Vitamin A for the body on two types of diets. Equation (2) restricted the calcium to be taken by the body which must exceed 210 units, while equation (3) restricted the iron that must be taken by the body which must exceed 460 units. While equation (5) and (6) restricted the cholesterol and Vitamin A must exceed by 300 units and 900 units, respectively.

D. RESULTS

To solve the diet problem of minimizing vitamin A, the graphical method and Excel solver are used to calculate the minimum amount of vitamin A required under a specific diet. Both methods show similar results to each other. The result from the Excel solver for X's value is 20.52632, and the value of Y is 12.89474, as shown in Diagram 3.

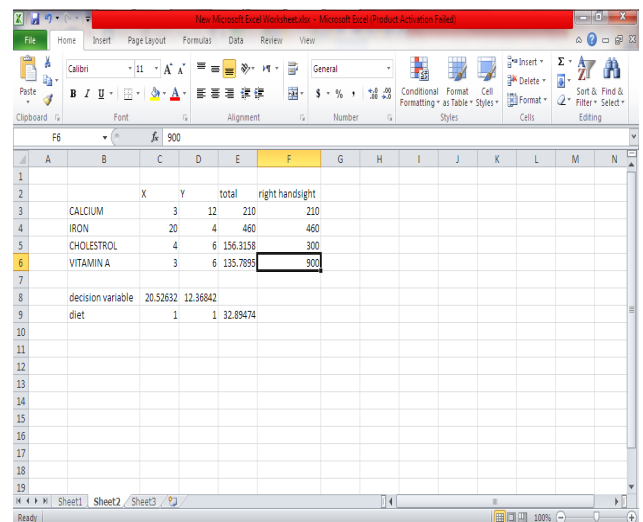


Diagram 3: Results by using the Excel Solver
The value of the decision variable is the amount needed to fulfill the diet required. The result from graphical method is shown in Diagram 4.

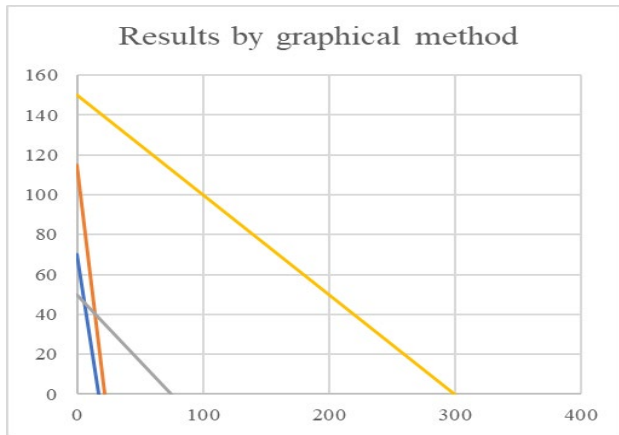


Diagram 4: Result by using Graphical method

The highest point (20, 12) that does not touch X-axis or Y-axis is the value of the optimal solution for the minimum amount of vitamin A needed.

IV. DISCUSSION

Both methods give the same results, but the Excel solver gives more precise value compared to graphical method because the value generated from it is in decimal values. For future research, the problem can be solved by using the simplex method and the comparison between all the methods can be made to determine the approach that gives the optimal solution.

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