ISSN 2278-3091
Volume 8, No.1.5, 2019
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse1881.52019.pdf
https://doi.org/10.30534/ijatcse/2019/1881.52019

# Application of Linear Programming in Students' Diet Problem

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## ABSTRACT

Nowadays, the prices of everything in Malaysia is steadily increasing due to various factors such as economy, politics and technological advancements. Therefore, the price for necessity such as food has also been increased drastically. Therefore, students are obligated to spend as minimum as possible every day. Due to this, they tend to neglect healthy eating patterns and consume insufficient nutrients per day. This will cause many complications such as diseases, sicknesses and lack of energy to focus in lectures. A survey was distributed to 100 respondents which are UiTM Kuala Terengganu students to collect information regarding their daily diet patterns. This survey is based on the menus of the food provided by the cafeteria in UiTM Kuala Terengganu. Using these data, linear programming models of the diet problems is set up and solved to determine the minimum cost which satisfy the daily recommended nutrients. It is found that the minimum is RM7.90.

**Key words:** Diet problem, Linear Programming, Students, University

## 1. INTRODUCTION

There are a great number of elements that affect health status. The major element which is very modifiable and controllable is diet and nutrition. Diet is basically the sum of food you consume, providing what the body needs and greatly affecting how an individual function physically, rationally and even socially. Nutrition is the main concern with general wellbeing since numerous nutritional choices incline toward poor decision, creating unhealthy habits and the related impacts [1]. College is a critical period involved in unhealthy changes in eating practices among students. The demanding cost of living expenses greatly put a burden on students' budget, since they rely on education loans such as Perbadanan Tabung Pendidikan Tinggi Nasional (PTPTN) for their daily expenses. In 2008, more than 60% of Malaysian students are financed by PTPTN [2]. They may also be inexperienced at budgeting for their essential needs. Also, nutritious meals might be considerably far from reach. Food product costs and individual spending pattern impact students' food choices.

Linear Programming (LP) is well known method in solving many minimization or maximization problems such as diet problems. Linear programming help to find optimal solution such as maximum profit or minimum cost in a given mathematical model and given some list of requirements as a linear equation [3]. LP have been widely used in many fields such as food and agriculture, manufacturing, engineering and transportation. In the diet problem, the cost is set as the objective function and the constraints are the minimum requirement of nutrient intake.

The studies which apply LP to diet problems begin in year of 1950 and 1960 and the exploration for diet solutions started with Jerry Cornfield (1941-1945) which sought to find a low-cost diet that can satisfy the nutritional needs of a soldier [4]. Since then, LP has been widely used in solving many diet cases. One of the latest studies is by Devcic, Belio and Gacina. [5] who applied Linear Programming to minimize the diet cost on the example of a three-day menu. Their paper proposes three-day menus for men from 19 to 50 years and for women from 19 to 50 years.

LP also has been used in modelling other problems. Satheeshkumar [6] used linear programming to solve the problem of nurse shifts and nurse allocation on day-to-day basis to get the optimal allocation that minimizes cost in health unit. Balogun [7] also used linear programming to maximize profit of cola manufacturing company by considering production constraint of different products in the calculations. LP also has been integrated with other method to solve more complex problem. In [8], Linear Program Boosting Classification (LPBC) is used in weather forecasting problem, for categorizing the weather data for predicting future outcomes by constructing the weak learners.

There are many methods that can be used to solved LP problems such as graphical method or Simplex method. It consumes a lot of times to solve the LP models manually by using these methods. Nowadays, the are many softwares have been invented such as WinQSB, LINDO, MS Office Excel and other. With the aids of this computer software, linear programming models can be solved easily in a wider range of constraints.

This paper applied the LP to determine the minimum cost of UiTM Kuala Terengganu students, and the LP model are solved using the Solver function which comes with the Microsoft Excel software.

## 2. METHODOLOGY

### 2.1 Collecting data and formulation

A simple survey is distributed to 100 students of Universiti Teknologi MARA Cawangan Terengganu Kampus Kuala Terengganu (UiTMCTKKT). The purpose of the survey is to discover each students' diet pattern. The survey requires student to answer what they most prefer to eat for breakfast, lunch and dinner. Additionally, the survey also aims to discover students' attitude toward healthy eating habits. The choice of menu and suggested in the survey was obtained through a short interview carried out on a staff of the cafe. While, the nutritional content of each menu is obtained from the website of Ministry of Health. is very important in setting up the LP model. In order to obtain feasible solution for this diet problem, this study only considered 6 nutrients which are protein, fat, carbohydrate, calcium, phosphorus and vitamin C. Furthermore, fulfilling all nutrients at once is realistically not possible.

The LP model for each student is difference, since each student have different preferred menus. Hence, the objective function and constraints for each student will also be different. The formulated constraints are subjected to the recommended daily intake (Table 1) of the following nutrient.

**Table 1:** Recommended Daily Intake

| Nutrient | Recommended daily intake |
|---|---|
| Protein | 55g |
| Fat | 46g |
| Carbohydrate (CHO) | 180g |
| Phosphorus (P) | 700mg |
| Vitamin C | 70mg |
| Calcium | 800mg |

Hence, based on the recommended daily nutrient above, the linear programming models are set up as follows:

$$\text{Minimize } Z = c_1x_1 + c_2x_2 + \ldots + c_nx_n$$

Subject to:

$$a_{11}x_1 + a_{12}x_2 + \ldots + c_{1n}x_n \geq 55\text{g}$$
$$a_{21}x_1 + a_{22}x_2 + \ldots + c_{2n}x_n \geq 46\text{g}$$
$$a_{31}x_1 + a_{32}x_2 + \ldots + c_{3n}x_n \geq 180\text{g}$$
$$a_{41}x_1 + a_{42}x_2 + \ldots + c_{4n}x_n \geq 700\text{mg}$$
$$a_{51}x_1 + a_{52}x_2 + \ldots + c_{5n}x_n \geq 70\text{mg}$$
$$a_{61}x_1 + a_{62}x_2 + \ldots + c_{6n}x_n \geq 800\text{mg}$$
$$x_1, x_2, x_3, x_4 \geq 1$$

where,

$c_n$ = cost of menu n

$x_n$ = menu of type n

$a_{mn}$ = amount of nutrient type m in menu type n

Since the data collected is based on the menu provided by the café in UiTM Kuala Terengganu, hence the LP model will be set up based on the price of food determined by the café. The following are the example of common choices of menu sold at the café (Table 2).

**Table 2:** Choice of common food sold at the cafe

| Menu label | Menu name | Price (RM) |
|---|---|---|
| $x_1$ | Plain rice | 1.00 |
| $x_2$ | Fried Noodle | 4.00 |
| $x_3$ | Fried Rice | 3.50 |
| $x_4$ | Nasi Lemak | 2.50 |
| $x_5$ | Fried Chicken | 2.50 |
| $x_6$ | Fried Egg | 1.00 |
| $x_7$ | Nugget | 1.00 |
| $x_8$ | Curry Puff | 1.00 |
| $x_9$ | Donut | 1.00 |
| $x_{10}$ | White Bread | 0.50 |
| $x_{11}$ | Wholemeal Bread | 0.60 |
| $x_{12}$ | Cream Cracker Biscuit | 0.30 |
| $x_{13}$ | Cereal | 0.90 |
| $x_{14}$ | Fried Eel (Ikan Keli) | 3.00 |
| $x_{15}$ | "Kentang Masak Sambal" | 1.00 |
| $x_{16}$ | "Sayur Campur" | 1.00 |
| $x_{17}$ | Chicken Rice | 4.50 |
| $x_{18}$ | Fried Maggie | 4.00 |
| $x_{19}$ | Fried Mee Hoon | 4.00 |
| $x_{20}$ | Mee Soup | 3.50 |
| $x_{21}$ | Mee Hoon Soup | 3.50 |
| $x_{22}$ | Chicken Soup | 3.50 |
| $x_{23}$ | Chicken Burger | 2.80 |
| $x_{24}$ | Beef Burger | 2.80 |
| $x_{25}$ | Egg Banjo | 2.50 |
| $x_{26}$ | Plain Water | 0.00 |
| $x_{27}$ | Iced Tea | 1.00 |
| $x_{28}$ | Iced Tea with Milk | 1.50 |
| $x_{29}$ | Iced Syrup | 1.00 |
| $x_{30}$ | Orange Juice | 1.00 |
| $x_{31}$ | Iced Milo | 1.50 |

### 2.1 Implementation

The following are the choice of menu for 3 meals session in a day choose by Student 26 (Table 3) and the nutrient content in each menu.

**Table 3:** Nutritional content of menu choose by Student 26

| Menu | $x_1$ | $x_{15}$ | $x_3$ | $x_{25}$ |
|---|---|---|---|---|
| Protein (g) | 2.3 | 6.2 | 6.7 | 7.6 |
| Fat (g) | 0.1 | 15 | 5.3 | 9.4 |
| Carbohydrate (g) | 30 | 53 | 26 | 23 |
| Phosphorus (mg) | 26 | 0 | 203 | 145 |
| Vitamin C (mg) | 0 | 7.6 | 0.5 | 4 |
| Calcium (mg) | 3 | 36 | 16 | 42 |

Hence, based on the information collected from Student 26, the LP model for student 26 is as follow:

$$\text{Minimize } Z = x_1 + x_2 + 3.5x_3 + 2.5x_4$$

Subject to:

$$2.3x_1 + 6.2x_2 + 6.7x_3 + 7.6x_4 \geq 55\text{g}$$

$$0.1x_1 + 15x_2 + 5.3x_3 + 9.4x_4 \geq 46\text{g}$$

$$30x_1 + 53x_2 + 26x_3 + 23x_4 \geq 180\text{g}$$

$$26x_1 + 0x_2 + 203x_3 + 145x_4 \geq 700\text{mg}$$

$$0x_1 + 7.6x_2 + 0.5x_3 + 4x_4 \geq 70\text{mg}$$

$$3x_1 + 36x_2 + 16x_3 + 42x_4 \geq 800\text{mg}$$

$$x_1, x_2, x_3, x_4 \geq 1$$

This LP model then is solved using the Solver (Figure 1) function which comes with the Microsoft Excel software.

**Figure 1:** Excel Solver Solution for Student 26

| | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | |
| 2 | | Student 26 | | | | | | | |
| 3 | | Choice of food | $X_{22}$ | $X_{26}$ | $X_{35}$ | $X_{46}$ | | | |
| 4 | | Suggested Serving Quantity | 1 | 18 | 1 | 4 | Total Cost | | |
| 5 | | Price per each serving | 1 | 1 | 3.5 | 2.5 | 32.5 | | |
| 6 | | | | | | | | | |
| 7 | | | | | | | | Minimum Nutrient | Total Nutrient Intake |
| 8 | | Protein | 2.3 | 6.2 | 6.7 | 7.6 | >= | 55 | 151 |
| 9 | | Fat | 0.1 | 15 | 5.3 | 9.4 | >= | 46 | 313 |
| 10 | | Carbohydrate | 30 | 53 | 26 | 23 | >= | 180 | 1102 |
| 11 | | Phosphorus | 26 | 0 | 203 | 145 | >= | 700 | 809 |
| 12 | | Vitamin C | 0 | 7.6 | 0.5 | 4 | >= | 70 | 153.3 |
| 13 | | Calcium | 3 | 36 | 16 | 42 | >= | 800 | 835 |

The Solver is specialized to solve linear programming problems and the chosen solving method is the Simplex method. Through this Solver, the values of x will be calculated such that all the constraints are satisfied, and Z is minimized.

In case that no solution is found for any one model, the menu of diet for that student is neglected. The solutions found are discussed based on various factors such as price, quantity and feasibility. The many possible diets are then suggested to all students of UiTMCTKKT.

## 4. RESULTS AND DISCUSSION

Based on the survey answers given by students, 100 diets are calculated using Microsoft Excel Solver software. The following are four of the lowest-cost diets found (Table 4).

**Table 4:** Example of the low-cost diets

| Cost (RM) | Menu content (3 meals) |
|---|---|
| 13.00 | 2 glasses of iced tea with milk, 2 pieces of white bread, 1 plate of plain rice, 1 serving of fried egg, 2 pieces of fried chicken and 2 servings of "sayur campur" |
| 17.40 | 2 bottles of plain water, 2 servings of "sayur campur", 9 pieces of cream cracker biscuits, and 5 pieces of fried chicken |
| 17.80 | 1 bottle of plain water, 1 glass of orange juice, iced tea, 1 piece of fried chicken, 1 serving of beef burger, egg banjo, and 26 pieces of white bread |
| 17.90 | 1 bottle of plain water, 1 glass of iced tea, 1 plate of plain rice, fried chicken, mee hoon soup, 2 servings of "sayur campur", 9 pieces of cream cracker biscuit, and 4 glasses of iced tea with milk |

If all available menus are considered in the LP model, a minimum diet of RM7.90 is obtained which consists of 2 pieces of white bread, 18 pieces of cream crackers, 4 bowls of cereals and 2 servings of "sayur campur". However, this menu might not satisfy the preferences of many students because of the repeated choice of menu for 3 meals.

By observation, most of the diet under RM20 have menu choices with high Calcium or Vitamin C to cost ratio such as wholemeal bread, white bread, cereal, ice tea with milk, fried chicken and especially "sayur campur".

Some students choose the wrong type of food, hence it is difficult to fulfill all recommended nutrient intake with low cost. Some of the diets cost more than RM100, which is unreasonable. This is caused by the student's menu choices having too little content of certain nutrients.

## 5. CONCLUSION

It is very important to select good choice of food in order to satisfy the daily recommended nutrient intake. Based on the diets discovered, the best menus are such as vegetables, bread, cereals, cream crackers, and fried chicken. Vegetables are rich in vitamins and fried chicken is a good resource for protein. However, based on the survey conducted, many students in UiTM Kuala Terengganu does not prefer vegetable menu in their daily diet. This is mostly because of preferences and limited choices of menu that contain vegetable.

The diets discovered from this research might only be best suited for students of UiTMCTKKT. This is because the menus considered in the LP models are chosen based on the menus easily available for the students, and the daily recommended intakes are based on the age of the students. Other universities or institutions will have different menu choices and different prices. Therefore, a separate research can be carried out on those places to obtain diets which are suitable for those places, using similar methods and procedures. In addition, a further research for diets of students with special needs can also be considered, for example student with gastric problem or athletic students who require different nutrient intake than regular student.

**ACKNOWLEDGMENT**

The authors would like to acknowledge UiTM Terengganu Branch Kuala Terengganu Campus for its support.

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