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Applications of Linear Programming on Diet Problem for Subways' Sets Menu in Malaysia

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ABSTRACT

Consuming a proper and balanced diet is necessary for each and every individual. It makes them fit, healthy, and keep them safe from chronic diseases. However, in today's world, many individuals frequently buy fast food without realising that the food may not provide all the daily nutrients that the body needs. Therefore, this study aims to propose a mathematical modelling on diet problem for the subways sets menu in Malaysia. The proposed mathematical model will be solved by using the Microsoft Excel Solver in order to produce optimal solution, which mean that the chosen menu from the Subway fulfil the daily requirements of calories, protein, carbohydrates, and fats for both men and women.

1. Introduction

In today's data-driven and complex world, mathematical modelling has evolved into an essential instrument to solve the complex problems. By using mathematical models, decision-makers can gain valuable insights, make informed decisions, and optimise outcomes. For instance, the studies carried out by Mohd Saifizi Saidon *et al.,* [1,2] demonstrate the use of ARX (and ARMAX) models to develop a dynamic model of a cooling system integrated with TEC. The finite element method is widely used in mathematical modelling to approximate and solve complex physical phenomena by dividing them into smaller, manageable elements. This method had been used by researchers like Mohamad *et al.,* [3], Mohd *et al.,* [4], and Law Ruen *et al.,* [5] in numerous studies to look into a variety of topics, including structural analysis, fluid dynamics, heat transfer, and electromagnetic simulations. On the other hand, the Lagrange method is usually employed in mathematical modelling to optimize systems by formulating and solving constrained optimization problems. This method is applied in a study conducted by K.Gulnaz and Refail [6] to solve problem on aircraft maintenance routing and a study done by Touaibi *et al.,* [7] to minimize the thermal Energy Consumption of an absorption cooling machine.

Aside from Langrage method, linear programming can also be one of the tools to optimise various aspects [8], including time management, travel planning, and financial management as per

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studies conducted by Ijiri *et al*., [9] and Massood Yahya-Zadeh [10], in context with problems encountered in daily life. For example, it can help people to organising their daily schedules to make the best use of their time while taking tasks, priorities, and constraints into account. Ablan *et al.,* [11] demonstrated the application of LP in their study on time management of weekly class schedule with activity constraints for college students. Similar to this, linear programming can be used to optimise travel routes, reduce travel time, and save fuel. For instances, a study conducted by Filscha and Yuri [12] develops the group first route second method for resolving the routing issue of the poverty program handled by Bogor Regency, Indonesia.

One of the best approaches for maximising the diet problem is by using the linear programming approach [13]. We can discover the best solutions within given constraints and variables. Variables such as calorie intake, carbohydrates, protein, and fat consumption are required to meet a person's nutrient requirements for each day. The method allows us to efficiently share resources, lower costs, and increase our desired outcomes by resolving issues as linear programming models. Cristina and Ciprian [15] demonstrate the use of linear programming to solve a diet problem which aims to identify an optimal combination of advised foods while at the same time satisfy a person's daily nutritional requirements. Okubo *et al.,* [16] focused on women aged 31 to 69 and men aged 32 to 69 living in three regions of Japan. In their study, linear programming models were created to meet the Dietary Reference Intakes for a group of 28 nutrients while minimising the differences between observed and optimised food intake patterns.

Furthermore, diet plan optimisation can be carried out using linear programming [14]. LP models can generate the best diet plan to achieve specific dietary goals by considering the needs, restrictions, and financial constraints. As stated by Alaini *et al.,* [17], Boufous [18] also agreed that linear programming can be utilized to translate nutritional requirements based on chosen Dietary Guidelines to achieve a healthy and cost-effective menu. Similar to Alaini *et al.,* [17], Boufous [18] focused on finding a balanced and cost-effective menu to avoid overweight and obesity that affect 9 to 18 years-old girls in U.S. In this study, Boufous discovered that a healthy diet that meets all of the daily nutrients and calories intake could be obtained for a daily cost of 13$. Furthermore, this value shows that a young girl can get 0.23 lbs. of vegetables and 21 lbs. of grains from the vegetables and grains food list for $13.22 per day.

Aside from food diet and cost optimization, linear programming models can be used to solve a lot of other problems. One example of its application is in the design and optimization of energy management systems. In their study, Bourbon *et al.,* [19] found that linear programming can be used during the design step as an energy management for sizing the smart wind power plant components. Additionally, it can be used in the future to improve the real-time applicability of algorithm-based rules or laws of optimal control. The study made by Ali *et al.,* [20] studied multiple readings to solve a vehicle routing problem with pickup and delivery (VRPPD) based on a real-life case. Ali *et al.,* [20] developed three different Mixed Integer Linear Programming (MILP) models, where each model covers a different set of constraints.

All these past researches show that the linear programming model can be used to solve problems in various kinds of real-world situations. Because it is adaptable, linear programming can be used to address a range of problems, from energy management to social welfare programmes, ultimately resulting in more effective and efficient processes for making decisions for a better future. In this paper, a mathematical modelling of a diet problem involving Subways' sets menu in Malaysia by using integer linear programming is proposed. Then, we used the Microsoft Excel solver to solve this integer linear programming in order to get the optimal solution. The optimal solution means that the chosen menu from the Subways' set menu satisfy the required nutrients needed by body for men dan women in daily. The methodology of this research will be explained in the next section.

2. Methodology

In this section, a model formulation of the daily diet problem by using integer linear programming is proposed for both men and women for Subways' sets menu in Malaysia.

2.1 Model Formulation

The integer linear programming problem consists of an objective function, a set of constraints, a set of decision variables, and parameters. In this paper, the aim is to maximize calorie intake, while satisfying the required number of calories and the other nutrients which are carbohydrates, protein and fats. We solved the mathematical model to determine the menus that will be selected, that fulfilled all the requirement needed by a body of man and woman. This section explains the formulation of the mathematical model of the diet problem of Subway's sets menu. Table 1 shows the notations used in the mathematical modelling for diet problem of Subways' sets menu in Malaysia.

Table 1
The notations in the mathematical modelling for diet problem of Subways' sets menu in Malaysia

Notation	Explanation
x_i	Sets menu for food in Subway
c_i	Calories for the set menu x_i
p_i	Carbohydrates for the set menu x_i
q_i	Protein for the set menu x_i
r_i	Fats for the set menu x_i

While Table 2 is the recommended nutrient intakes for Malaysia for men and women.

Table 2
Recommended Nutrient Intakes for Malaysia (2017) recommended daily nutrients for a diet of 2500 Kcal per day for men and 2200 Kcal per day for women

Number of nutrients	Nutrients	Recommended for	Quantity of calories	
			2500 Kcal (men)	2200 Kcal (women)
1.	Carbohydrates	Less than	375	375
2.	Protein	Less than	63	63
3.	Fats	Less than	80	80

The integer linear programming for the diet problem of Subways' menu for men and women is shown as below:

$$\text{Max } c_1x_1 + c_2x_2 + \cdots + c_{24}x_{24} \quad (1)$$

Subjected to

$$c_1x_1 + c_2x_2 + \cdots + c_{24}x_{24} \leq 2500/2200 \quad (2)$$

$$p_1x_1 + p_2x_2 + \cdots + p_{24}x_{24} \leq 375 \quad (3)$$

$$q_1x_1 + q_2x_2 + \cdots + q_{24}x_{24} \leq 60 \quad (4)$$

$$r_1x_1 + r_2x_2 + \cdots + r_{24}x_{24} \leq 80 \quad (5)$$

$$x_1, x_2, x_3, \ldots x_{24} \geq 0 \quad (6)$$

The objective function represents by Eq. (1) aims to determine the maximum number of calories that a person can consume. A person's consumption of calories is limited by Eq. (2) to 2500 kcal for men in a a day and 2200 kcal for women in a day. Eq. (3) limits a person's carbohydrate intake to 375 grams for a day. Eq. (4) ensures that a person's daily protein intake is no more than 63 grams in a day. Eq. (5) makes sure that in a day, an individual consumes not more than 80 grams of fat. Eq. (6) ensures that the variables are integer numbers. The nutrients for each Subway set are shown in Tables 3.

Table 3
The nutrients for each Subway menu, x_i

Variable, x_i	**Calories (kcal)**	**Carbohydrates (g)**	**Proteins (g)**	**Fats (g)**
x_1	300	41	20	6.3
x_2	362	46	27	7.3
x_3	324	39	25	7.1
x_4	331	41	23	8.0
x_5	317	44	19	7.3
x_6	383	47	20	11.7
x_7	346	40	21	7.1
x_8	320	42	17	8.9
x_9	409	42	22	16.7
x_{10}	325	41	21	7.1
x_{11}	321	42	18	8.6
x_{12}	290	41	17	6.6
x_{13}	507	39	22	29.1
x_{14}	266	39	10	5.7
x_{15}	340	42	11	12.7
x_{16}	421	41	17	20.7
x_{17}	250	39	10	5.7
x_{18}	366	40	26	10.6
x_{19}	425	58	16	13.2
x_{20}	412	44	22	16.1
x_{21}	369	48	28	7.1
x_{22}	398	42	22	22.8
x_{23}	472	44	27	31.3
x_{24}	449	42	25	26.6

By using the Microsoft Excel Solver, we solve the proposed integer linear programming for the diet problem of Subways' menu for men and women.

3. Results

In this paper, a mathematical model for the diet problem of Subway's food sets menu in Malaysia is proposed. The model's objective function is to determine the maximum number of calories from the Subway food menu sets that a person can consume in a day while satisfying all the nutritional requirements. In this mathematical model, all daily food set menus met the needs of a person, which are total amounts of calories, carbohydrates, protein, and fats. Based on this diet problem, an integer linear was built in a Microsoft Excel and then solved by using the Excel Solver method.

The results obtained are the same for both men and women. The number of calories obtained for both men and women (2500 Kcal and 2200 Kcal, respectively) is 1818 Kcal and the daily Subway menus intake that satisfy the daily nutrients needed are provided in Table 4 as below:

Table 4
The daily Subway menu in Malaysia that satisfy the daily nutrient needed for men and women

Set	Number of sets need to be taken
x_{14}	3
x_{15}	3

The number of calories obtained by using the Solver tool in Microsoft Excel is maximal while satisfying all the daily nutrient requirements, indicating that the solution obtained is optimal.

4. Conclusions

In this research, the proposed integer linear programming for the diet problem of Subways' menu for men and women are solved by using the Microsoft Excel solver. The solutions obtained are optimal, means that the selected menus fulfilled the required number of calories and other requirement of nutrients for men and women in a day. It means that consumers of the fast-food restaurants can make their decision wisely. For the future research, we can propose the integer linear programming for the diet problem from the other fast-food restaurants.

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