

Mathematical modeling technique for diet planning problem: Eczema patient

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Abstract

This paper illustrates the application of linear programming and integer programming to build the model of diet planning for eczema patient. It particularly studied the diet problem of designing diet plan of an adult who is in the age of early twenties. The diet problem specifics its constraints and objective functions. The planning adequate menus involves consideration of several types of constraints such as the desired nutritional content, the amount of food to be consumed and food allergens with the minimum expenditure. The mathematical models were developed which meet all the requirements and restrictions. This paper shows that the linear and integer programming approach which produce an optimal and feasible solution in order to solve the diet problem for eczema patients.

Keywords: linear programming, integer programming, diet scheduling, eczema, optimization, mathematical modeling

Introduction

The balanced diet comprises a variety of foods to provide essential nutrients such as carbohydrates, proteins, vitamins, minerals, fat and fibers to our body. This diet is crucial for everyone to maintain good health and body condition. In fact, a well-planned balanced diet is even more important for those people who suffer from the Eczema.

A well-developed menu specified for eczema patients play a vital role in helping to control and ease the eczema condition. There is some foods commonly will trigger the allergic action of Eczema patients such as dairy product, shellfish, nuts. Whenever these types of foods give rise to the skin dermatitis, they should quit from consuming those foods. Besides, Eczema patients should cut down to eat those foods containing high sugar level. The insulin levels will rocket which leads to inflammation. Salicylates are organic chemicals that serve as protection for vegetables and fruits against the pests and preservatives to prevent rot and disease. Eczema patients should not intake the vegetables which are in high salicylate such as eggplant, broccoli, endive, radish and furthermore.

In global, the eczema is a kind of skin disease with a prevalence of 2-5% in children and teens nearly 10% ^[1]. The eczema cases are in the increasing trend with the prevalence of eczema among primary school children was about 12-13% in 2001^[2]. In 2012, The Star Malaysia stated that is 10-20% of children and two in every ten individuals in Malaysia suffered from eczema ^[3].

Eczema patients deal with their difficulty in choosing the diet that meet the nutrition requirements. There is no previous research about conducting optimization approach in solving the diet problem of eczema patients. The diet planning for eczema patients involved the optimisation method in order to make better decision making to overcome this diet problem. Therefore, a proper and considerate planning diet is indispensable for eczema patients.

Literature Reviews

The application of Linear Programming Technique is in progress in many studies and fields. It is commonly used to encounter personnel management problem, agricultural problem, allocation of aircraft, diet problem and even more. Also, it can also use to determine fish feed compounds and in return to raise the productivity of fishes and minimize the cost for formulation of fish feed ^[4].

An optimization study is to investigate the food choice of French women to prepare the balanced meal with the cost constraint. The method used is linear programming modeling to find the food combination is optimal in nutrition with the lowest cost. The sample for this study consists of 476 of French women from different socioeconomic levels. The diets were developed by linear programming technique which is Simplex procedure of the Premium Solver Platform 5.0 for Excel ^[5].

A linear programming model to fulfill a week of predetermined nutritional requirements and cheapest packages combination of food such as chicken, macaroni, spaghetti and so on. The result obtained is a monotonous diet that included only 46.667 packages of macaroni and cheese with the lowest expenditure at \$88.20 ^[6].

Generally, the food items intake is in whole units in which an integer value is more representative than non-integer value. And thereby, integer programming is introduced to formulate the planning diets for humans at lowest cost. The application of this algorithm is further developed the diet related problem based on numerous types of basic foods that meet the nutritional requirements for certain group of people ^[7].

The nutritional requirement of human differs from age to age. The optimization research was conducted about the nutritional ingredient needed by the human who aged 40 to 45 and to minimize the total diet cost at the same time. There are some nutritional constraints should be complied which is the range of certain nutrients requirements have been determined ^[8].

Goal programming is an extension or generalization of linear programming to handle multiple, normally conflicting objective measures. A model which to enhance healthy nutrition menu planning which within the household food budget expenditure. In the research, the sample concerned consists of 55 most common consumed food items as decision variables. They then developed a goal programming model which is to minimize the deviation of World Health Organization recommended daily nutrients required and subject to the household expenditure constraints [9].

Optimization method also can help to find the solution of diet problem faced by renal patients. Generally, the kidney disease become worsen when a patients intake too much salt, protein and others in the diet. And thus, Fuzzy Linear Programming is used to generate a model for those patients which can satisfy their nutrition requirements in the fuzzy environment. The fuzzy concept is applied on account of the facts that there is uncertain in the amount of nutrients intake [10]. The Application of Fuzzy Linear Programming in planning diet menu for Eating Disorder and Disease-related lifestyle. This approach involves the computation of the amount of nutrients required which subjected to some constraints [11].

The nonlinear programming can resolve the shortcoming of linear approximation of objective function for diet formulation. The assumptions for all variables are linear sometimes are not suitable at all situations and result in limitation of solution for the diet problem. To formulate the nonlinear programming model, it involved complex procedures which are the least square relation between responding variable and explanatory variables of different degrees are conducted. F-test is next applied to find the best fit relation among the variables [12].

Data Descriptions

The relevant data regarding the problem are collected from the dietician from Pantai Batu Pahat Medical Centre. The data obtained is the lower bound and upper bound of nutrient contents requirements. In this study, the food items that take into the model only involve the Malaysian recipes in the book of Nutrient Composition of Malaysian Foods. (Tee *et al.*, 2010) The food items are in standardized portion size and with their respective nutrient contents have stated. As a matter of fact, the diet for eczema patients is not much differ from healthy person. The important things is that the diet excluding the certain food allergens which will worsen the eczema conditions. Hence, the normal diet is assumed for the eczema patients. This study is prior to eczema patients who age of twenties. The patients have different kind of nutritional requirements regarding to their age, activity level, allergens and others. The patients in this study is a 23-aged adult who active in sport, with height of 180cm and weight of 60kg. His allergen is dairy product which will trigger the eczema condition. After the consultation with the dietician, his nutritional requirement for one day is designed. The food items that take into the model only involve the Malaysian recipes in the book of Nutrient Composition of Malaysian Foods from the whole 100 food items.

Table 1: Values of Upper Bound and Lower Bound of the 11 Nutrients

Nutrients	Lower Bound (LB)	Upper Bound (UB)
Energy (kcal)	2121	2440
Fat (g)	45	70.7
Carbohydrate (g)	180	291.6
Protein (g)	79.5	-
Calcium (g)	800	2000
Vitamin A (mg)	600	2800
Vitamin B1 (mg)	1.2	-
Vitamin B2 (mg)	1.3	-
Vitamin C (mg)	70	1800
Niacin (mg)	16	30
Iron (mg)	14	45

Model Descriptions and Development

This study helps the eczema patients to develop their balanced diet menu which meets the nutritional requirements and minimize the cost. The operational research approach is used to find the optimal solution for solving the diet problem. Each type of food has its own available range of selection as presented in Table 2. 18 food items from 10 food groups are designed for the eczema patients per daily meals.

Table 2: Food Requirement per Day

Type of food	No. of requirement per day (n)
Beverage	6 (2 plain water are included)
Cereal Flour Based	1
Rice Flour Based	1
Cereal Based Meal	2 (1 Plain Rice is included)
Meat Dishes	1
Seafood	1
Vegetable	2
Fruits	2
Wheat Flour Based	1
Miscellaneous	1
Total Dishes Per Day	18

The Linear Programming (LP) and Integer Programming (IP) are used to develop and solve the menu planning model problem (with 100 variables).

$$\sum_{i=1}^{100} C_i x_i$$

Minimize the cost function = (4.1)
subject to;

11 nutrient requirements based on Table 3.3,

$$\text{Lower Bound} \leq \sum_{i=1}^{100} \text{Nutrient Value} * x_i \leq \text{Upper Bound} \tag{4.2}$$

10 food group requirements based on Table 2,

$$\sum_{i=1}^{10} \text{Each Food Group } x_i = a \tag{4.3}$$

$$x_i \geq 0 \text{ (LP), } x_i \geq 0 \text{ and integer (IP).}$$

where

x_i = decision variables of food items i

a = the number of food group's requirement

Subsequently, the food are arranged according to breakfast, morning tea, lunch, evening tea, dinner and supper as following table:

Table 3: The Menu Planning of Food Item per Day

Meal	Type of Food Group	Amount
Breakfast	Beverages	1
	Cereal Flour Based	1
Morning Tea	Beverages	1
	Rice Flour Based	1
Lunch	Beverages	1
	Cereal Meal Based	1
	Vegetables	1
	Fruits	1
	Meat/Seafood	1
Evening Tea	Beverages	1
	Wheat Flour Based	1
Dinner	Beverages	1
	Cereal Meal Based	1
	Vegetables	1
	Fruits	1
	Meat/Seafood	1
Supper	Beverages	1
	Miscellaneous	1
	Total	18

Results & Discussion

The mathematical modeling is established which serves as the optimal solution of diet problem for eczema patient. The results for integer and linear programming for menu planning per day as shown as table below:

Table 4: Meal structure per day using linear programming

Meals	Food Item, i	Amount
Breakfast	Plain water	1
	Biscuit soda/plain	1
Morning tea	Milo	0.614
	Rempeyek	1
Lunch	Coconut water	1
	Chicken rice	0.418
	Noodles, rice	0.581
	Fish, unspecified, dried, salt	1
	Mengkudu	1
Evening tea	Nangka	1.909
	Sugar cane juice	1.385
	Kuih kapit	0.756
Dinner	Yau-car-kue	0.243
	Coconut water	1
	Coconut water	1
	Rice, cooked	1
Supper	Chicken satay	1
	Mengkudu	1
	Guava	0.09
	Plain water	1
	Candy, coconut	1
Total number of food per day		18
Total cost (Ringgit Malaysia)		5.26

Table 5: Meal structure per day using integer programming

Meals	Food Item, i	Amount
Breakfast	Sugar cane juice	1
	Biscuit soda/plain	1
Morning tea	Plain water	1
	Rempeyek	1
Lunch	Lengkong	1
	Noodles, rice	1
	Indian mackerel, fried in chilli	1
	Mengkudu	1
Evening tea	Papaya	1
	Milo	1
	Kuih kapit	1
Dinner	Sugar cane juice	1
	Rice, cooked	1
	Chicken satay	1
	Mengkudu	1
Supper	Papaya	1
	Plain water	1
Candy, coconut		1
Total number of food per day		18
Total cost (Ringgit Malaysia)		5.4

Table 4 and Table 5 show the results of a 1 day menu for the LP and IP approaches. The prices are slightly higher for the IP approaches compared to LP; however, the amount of food produced by the IP approach is can be considered and served. On another hand, LP produced an amount of food in decimal solutions which impossible to considered and served. Furthermore, the total summation (decimal numbers) is indeed 18, but the total number of food served or produced by the LP approach is more than 18. This shows that the solution does not meet the constraints and food group requirements perfectly. Therefore, the IP approach is the better technique to solve the menu problem and meet all the constraints and food group requirements.

Conclusions

The expenditure of the food menu can be minimized by applying the linear programming approach and integer programming approach. Besides ensuring the healthy diet which provides all the essential minerals and vitamins, the feasible solution also generated for the eczema patients to plan their diet menu according to the mathematical model. The integer programming provides a more feasible solution which the food items are served in whole units (integer value). The expenditure increased slightly from RM5.26 to RM5.40 when using the integer programming instead of linear programming. The study helped to understand the eczema patients' nutrients requirements and the use of linear programming and integer programming to get a considerate and optimal diet. The further study can be conducted to prepare balanced diet menu that meets nutritional requirements and suitable for eczema patients at all ages or other diseases that required diet control. In addition, more effort has been done on conducting the research by exploring the knowledge of food intolerance, food and their respective nutritional value and to promote healthy lifestyle.

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