

# Optimal Diet Planning for Eczema Patient Using Integer Programming

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**Abstract.** Human diet planning is conducted by choosing appropriate food items that fulfill the nutritional requirements into the diet formulation. This paper discusses the application of integer programming to build the mathematical model of diet planning for eczema patients. The model developed is used to solve the diet problem of eczema patients from young age group. The integer programming is a scientific approach to select suitable food items, which seeks to minimize the costs, under conditions of meeting desired nutrient quantities, avoiding food allergens and getting certain foods into the diet that brings relief to the eczema conditions. This paper illustrates that the integer programming approach able to produce the optimal and feasible solution to deal with the diet problem of eczema patient.

## 1. Introduction

Eczema patients should have a proper intake of diet as the key to their body health. A considerate menu specified for eczema patients can help to control and relief the eczema condition. The eczema may get worse if the person having food intolerance to one or more of the chemical contents found in foods. Some common trigger foods cause people prone to allergic reaction are dairy product, shellfish and peanuts. The simplest method is avoiding those foods in the diet whenever these types of foods are confirmed to give rise to the skin dermatitis. However, that is some foods such as fatty fish which is rich in omega-3 fatty acids should include in the food prescription. Numerous dermatologists had emphasized the importance of fish in the diet to prevent skin inflammation and stave off condition such as eczema.

In global, the eczema is a kind of skin disease with a prevalence of 2-5% in children and teens nearly 10% [1]. In 2012, The Star Malaysia stated that is 10-20% of children and two in every ten individuals in Malaysia to be afflicted with eczema [2]. Eczema patients deal with their difficulty in choosing the diet that meets the nutrition requirements. There is no previous research about conducting optimization approach in solving the diet problem of eczema patients. Integer programming techniques can be used to optimize the nutrients intake and costs for the eczema patients.

## 2. Literature Review

Operational research is a scientific approach which is used to select the best alternatives in operating a system, production planning, resource allocation, and menu planning. Every optimization problem has its objective function and the decision variables as the constraints. Research [3] shows the application of linear programming in designing different food planning model for French family from all socioeconomic class. Reference [4] also use the same method to build a linear programming model to fulfill a week of predetermined nutritional contents from economic food combination such as chicken,



macaroni, spaghetti and others. The method was extended to generate the fish feed formulation which in turn to increase the productivity of fishes [5]. Reference [6] presents the method of integer programming to develop the menu planning model for satisfying the nutritional requirements of people who aged 40 to 45 and to minimize the diet cost simultaneously. However, the food combinations in this menu planning model are limited. Study [7] develops a goal programming model which to build healthy nutrition menu planning. The result of the study is able to produce a feasible solution and compromise between the food cost, micronutrients and macronutrients intake.

In research [8], the fuzzy linear programming is used for generating a model for patients that can fulfill their nutrition requirements in the fuzzy environment. The fuzzy concept is applied as there is an uncertainty in the nutrient contents intake. Besides, paper [9] also discusses the use of fuzzy linear programming in planning diet menu for eating disorder and disease-related lifestyle. The method is used to compute the amount of nutrient in food taken in the daily routine. Reference [10] shows that using the binary integer programming to prepare the menu planning for Malaysian School Children Aged 13-18. In this paper, the use of Delete-Reshuffle Algorithm to produce a 7 days healthy menu planning which consists of different of food each day. The mathematical model produces the diet plans that satisfies the nutritional requirement and minimize the costs for the students.

### 3. Data Description

The related data which is the nutrients requirements for a 25 year-old man, is collected from the interviews with the dietician in Pantai Batu Pahat Medical Centre. The data obtained is the lower bound or upper bound of nutrient contents requirements. Next, the secondary data used in this research are extracted from 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. The food items that take into the model only involve 426 food items from the Malaysian recipes in the book of Nutrient Composition of Malaysian Foods. The patient in this study is a 23-aged adult who actives in sport, with a height of 180cm and weight of 60kg. His trigger food is the dairy product which will initiate the eczema condition. Besides, he adopt an eating habit of avoiding beef in his die to religion reasons.

**Table 1.** Nutrient requirement per day (Male, active, BMI 18.52 kg/m<sup>2</sup>).

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 (µg)	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

#### 3.1 Model Description

There is total of 426 food items are divided into 10 food group and included in this study. Each type of food has its own available range of selection as presented in Table 2. 18 dishes from 10 types of food per day are designed for the eczema patients. This menu planning follows the Malaysian culture to have compulsory food items such as cooked rice and plain water in the everyday diet. Based on Table 2, there is a sum of 18 food items per day. The foods are arranged in an order of breakfast, morning tea, lunch, evening tea, dinner and supper as Table 3.

**Table 2.** Food Requirement per Day.

Food Group	No. of requirement per day (n)
Beverage	6 (included 2 serving of plain water)
Cereal Flour Based	1
Rice Flour Based	1
Cereal Based Meal	2 (included 1 serving of cooked rice)
Meat Dishes	1
Seafood	1
Vegetable	2
Fruits	2
Wheat Flour Based	1
Miscellaneous	1
Total Dishes Per Day	18

**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
	Meat/Seafood	1
	Vegetables	1
	Fruits	1
Evening Tea	Beverages	1
	Wheat Flour Based	1
Dinner	Beverages	1
	Cereal Meal Based	1
	Meat/Seafood	1
	Vegetables	1
	Fruits	1
Supper	Beverages	1
	Miscellaneous	1
	Total	18

#### 4. Formulation of the diet problem

The Integer Programming (IP) are used to build the menu planning model problem (with 426 variables). The program used is LPSolve IDE.

$$\text{Minimize the cost function} = \sum_{i=1}^{426} c_i x_i \quad (4.1)$$

Subject to constraints with 11 nutrient requirements based on Table 1,

$$\text{lower bound} \leq \sum_{i=1}^{426} \text{nutrient} * x_i \leq \text{upper bound}; \quad (4.2)$$

and 10 food group requirements per day based on Table 2,

$$\sum_{i=1}^{10} \text{food group of } x_i \leq y; \quad (4.3)$$

where  $x_i \geq 0$  and integer and  $y$  = the food group's requirement. Based on Sufahani& Zuhaimy (2010), Delete-Reshuffle Algorithm is applied to ensure the food variety consumption, food items included for each day are different except for the two compulsory food items such as plain water and the cooked rice. The purpose of this algorithm is excluding the foods items that have been served on the first day and considering the remaining foods for the next day menu. The looping process will be continued to develop a 4 days menu planning. [10]

$$\begin{aligned} [\text{Remaining food, } x''] &= [\text{Available food, } x] - [\text{Food included in previous day, } x'] \\ x'' &= x - x' \\ &= \begin{bmatrix} 1_1 & 1_2 & 1_3 & 1_4 & \dots & 1_{137} & 1_{138} & 1_{139} & 1_{140} & \dots & 1_{426} & 1_{427} \end{bmatrix} \\ &- \begin{bmatrix} 1_1 & 0_2 & 0_3 & 0_4 & \dots & 1_{137} & 1_{138} & 0_{139} & 0_{140} & \dots & 0_{426} & 0_{427} \end{bmatrix} \\ &= \begin{bmatrix} 0_1 & 1_2 & 1_3 & 1_4 & \dots & 0_{137} & 0_{138} & 1_{139} & 1_{140} & \dots & 1_{426} & 1_{427} \end{bmatrix} \end{aligned} \quad (4.4)$$

Plain water = 8 (2 glass per day x 4 days)

Cooked rice = 4 (1 serving per day x 4 days)

#### **Delete-Reshuffle Algorithm [10]**

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Input: (i) Lower Bound = zero\*[1,426] matrix  
(ii) Upper Bound = one\*[1,426] matrix (except for plain water = 8 and cooked rice = 4)  
(iii) Food (0) = Lower Bound (food that are selected on day 0)  
(iv) u (0) = Upper Bound (food that are available on day 0)  
(v) d = 4 (4 days)  
\*\*Equation (4.1) until (4.3)

Output (1): Cost (1 → d) and Food (1 → d) (Delete and Reshuffle Food Available)  
For a = (1 → d) do  
Step 1: u(a) = u(a-1) – Food(a-1)  
Step 2: Solve (looping until d)  
Step 3: Print Cost (a)  
Step 4: Print Food (a)  
\*\*Equation (4.4)

Output (2) Scheduling Menu  
For a = (1 → d) do  
Step 1: Optimal variable of MIS(a) must be assigned during Supper  
Step 2: Optimal variable of CFB(a) must be assigned during Breakfast

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Step 3: Optimal variable of RFB(a) must be assigned during Morning Tea  
 Step 4: Optimal variable of WFB(a) must be assigned during Evening Tea  
 Step 5: Optimal variable of BEV(a) must be assigned randomly one each during Breakfast, Morning Tea, Evening Tea and supper  
 Step 6: Plain water must be assigned during Lunch and Dinner  
 Step 3: Optimal variable of CMB(a), VEG(a) and FRU(a) must be assigned randomly one each during Lunch and Supper  
 Step 4: Optimal variable of MEAT(a) and SEA(a) must be assigned randomly during Lunch or Dinner

Step 9: Print menu schedule, print cost(a)

End

\*CFB = Cereal Flour Based, RFB = Rice Flour Based, WFB = Wheat Flour Based, MIS = Miscellaneous, BEV = Beverage, CMB = Cereal Meal Based, VEG = vegetables, FRU = Fruit, MEAT = Meat, SEA = Seafood

## 5. Results

The mathematical modeling is developed which serves as the optimal solution of diet problem for eczema patient. The results for integer programming for menu planning for four days and the nutrients consumption for four days are as shown as table 4-8 below:

**Table 4.** Meal structure per day using integer programming (Day 1).

Meals	Food Item, <i>i</i>	Amount
Breakfast	Milo	1
	Biscuit soda/plain	1
Morning tea	Lengkong	1
	Rempeyek	1
Lunch	Plain water	1
	Noodle, rice	1
	chicken_satay	1
	Mengkudu	1
	Guava	1
Evening tea	Sugar cane juice	1
	Kuih kapit	1
Dinner	Plain water	1
	Rice, cooked	1
	Anchovy, dried, fried in chilli	1
	Soya bean sprout	1
	Guava	1
Supper	Plain water	1
	Candy, coconut	1
Total number of food per day		18
Total cost (RM)		5.5

**Table 5.** Meal structure per day using integer programming (Day 2).

Meals	Food Item, <i>i</i>	Amount
Breakfast	Orange flavoured drink, powder	1
	Biscuit, coconut	1
Morning tea	Plain water	1
	Kuih kasui	1
Lunch	Orange flavoured drink, powder	1
	Rice, cooked	1
	Quail egg, whole	1
	Celery(daun seladeri)	1
	Nangka	1
Evening tea	Coconut water	1
	Yau-car-kue	1
Dinner	Coconut water	1
	Rice, chicken	1
	Herring, wolf (ikan parang)	1
	Celery(daun seladeri)	1
	Papaya only	1
Supper	Plain water	1
	Seaweed, agar	1
Total number of food per day		18
Total cost (RM)		5.9

**Table 6.** Meal structure per day using integer programming (Day 3).

Meals	Food Item, <i>i</i>	Amount
Breakfast	Plain water	1
	Cookies, peanut	1
Morning tea	Syrup rose (Sirap ros)	1
	Kuih buah Melaka	1
Lunch	Limau only	1
	Rice, cooked	1
	Chicken curry, canned	1
	Spinach Onion (Daun Bawang)	1
	Banana (pisang tanduk)	1
Evening tea	Syrup rose (Sirap ros)	1
	Curry Puff only	1
Dinner	Limau only	1
	Rice, "oily"	1
	Fish, unspecified, dried, salt	1
	Peas,garden,fresh	1
	Rambutan	1
Supper	Plain water	1
	Satay sauce	1
Total number of food per day		18
Total cost (RM)		6.5

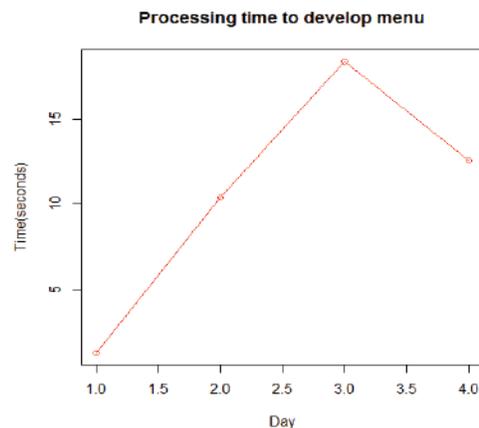
**Table 7.** Meal structure per day using integer programming (Day 4).

Meals	Food Item, <i>i</i>	Amount
Breakfast	Coffee powder, instant	1
	Bread coconut	1
Morning tea	Coffee & Sugar	1
	Lor-mai-fan	1
Lunch	Plain water	1
	Rice, cooked	1
	Fish curry, canned	1
	Tapioca shoots	1
	Watermelon	1
Evening tea	Coffee powder, instant	1
	Kuih ketayap	1
Dinner	Plain water	1
	Char siew rice	1
	Maw satay	1
	Tapioca shoots	1
	Watermelon	1
Supper	Coffee & Sugar	1
	Mysore pak	1
Total number of food per day		18
Total cost (RM)		7.1

**Table 8.** Nutrients Consumption for Four Days.

Nutrients	LB	UB	Day 1	Day 2	Day 3	Day 4
Energy (kcal)	2121	2440	2351	2127	2228	2369
Fat (g)	45	70.7	59.4	66.9	60.3	61.7
Carbohydrate (g)	180	291.6	287.5	261.2	289.2	291
Protein (g)	79.5	-	80.9	100.9	89.2	81.6
Calcium (g)	800	2000	821	804	889	818
Vitamin A ( $\mu$ g)	600	2800	906	657	663	1030
Vitamin B1 (mg)	1.2	-	1.45	1.84	1.25	1.26
Vitamin B2 (mg)	1.3	-	1.92	2.34	1.32	1.97
Vitamin C (mg)	70	1800	403.7	173.6	159.9	187.7
Niacin (mg)	16	30	20.4	25.2	16.2	16.1
Iron (mg)	14	45	18.7	18	20	23.7

Figure 1 illustrates the processing time in seconds to observe each day's performance. The program runs quickly to generate daily menus in day 1 in 1.23 seconds. In the next day, the program used 10.4 seconds for developing the menu planning. Due to the food items included in the menu planning become lesser, the program getting longer time to generate the menu planning for the third day. The program took up 18.43 seconds to search for the foods that satisfy the nutritional and food group requirements. For day 4, the program took up 12.57 seconds to generate the menu for that is lack of food items that meet the constraints and thus the iteration process for computing the diet cost becomes quicker.



**Figure 1.** Processing time.

## 6. Conclusion

The diet cost for the menu planning for four days can be optimized by applying the integer programming approach. This model can offer the healthy diet which provides all the essential minerals and vitamins for the eczema patients. The integer programming provides a feasible solution which the food items are served in a whole unit (integer value). The study helped to understand the eczema patients' nutrients requirements and the use of integer programming to get a considerate and optimal diet. The ongoing research can be performed to prepare balanced diet menu that meets nutritional requirements and bring relief to eczema patients at different ages or other diseases that required diet control.

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