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# Applied Mathematical Optimization Technique on Menu Scheduling for Boarding School Student Using Delete-Reshuffle-Reoptimize Algorithm

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**Abstract.** Boarding school student needs to eat well balanced nutritious food which includes proper calories, vitality and supplements for legitimate development, keeping in mind the end goal is to repair and support the body tissues and averting undesired ailments and disease. Serving healthier menu is a noteworthy stride towards accomplishing that goal. Be that as it may, arranging a nutritious and adjusted menu physically is confounded, wasteful and tedious. This study intends to build up a scientific mathematical model for eating routine arranging that improves and meets the vital supplement consumption for boarding school student aged 13-18 and in addition saving the financial plan. It likewise gives the adaptability for the cook to change any favoured menu even after the ideal arrangement has been produced. A recalculation procedure will be performed in view of the ideal arrangement. The information was gathered from the the Ministry of Education and boarding schools' authorities. Menu arranging is a notable enhancement issue and part of well-established optimization problem. The model was fathomed by utilizing Binary Programming and "Delete-Reshuffle-Reoptimize Algortihm (DDRA)".

## 1. Introduction

Arranging sufficient menus faces numerous financial and mental imperatives. It includes synchronous thought of a few sorts of requirements: the coveted healthful substance, the preferences of the individual that it is being gotten ready for, the sum (volume or weight) of nourishment to be devoured, and the normal shape and substance of various types of meals. The menu or eating routine issue was firstly detailed by Stigler in 1945 [5, 17, 18, 19, 20]. This model, as in most operational research models, has been set up on the conventional principal assumption that the decision makers tries to advance or optimize the objective function. The issue has kept on being examined by researchers and nutritionists: [1], [2], [3], [4], [6], [7], [8], [9], [10], [11], [13], [14], [15], [17], [18], [19], [20], [21]. Accordingly in this paper, we extend the present information in menu arranging concentrating on Malaysian formulas, limiting the cost, satisfy the nourishing prerequisites, serve assortment of sustenance serve every day and enhance the client inclination. We utilize binary programming to decide the most nutritious and acceptable suppers for Malaysian boarding school children from 13 to 18 years of age. It is probably going to be utilized by the Ministry of Education Malaysia and Malaysian boarding school. The menu records are given to school's cooks (in all inclusively) who give six meals for each day: breakfast [B], morning tea [M], lunch [L], evening tea [E], supper [D] and dinner [S]. The menu gave is a non-selective menu where the boarding school children are not given the decision to pick favored nourishment. Arranging sufficient and agreeable menus is essential to keep the boarding school children from torment any undesirable sicknesses. Hence, examine on menu arranging by creating mathematical models utilizing operational research and decision making procedures, is critical so as to enable food providers to give nutritious dinners over expanded eras inside the restricted spending distribution.

## 2. Data Collection

There are a few sorts of information expected to construct a menu arranging model. These incorporate the institutionalized cost of every Malaysian menu, the dietary substance for every menu, suggested wholesome day by Recommended Daily Allowance (RDA) which incorporate with upper bound (UB) and lower bound (LB) of every supplement and nutrient for Malaysian boarding school children and the government spending plan for food providers. The data on current month to month of food providers' financial plan and cost per serving for every supper was gathered from the nutritionists of the Ministry of Education, the schools authorities through meeting sessions and school's cook. The monetary allowance is Malaysian Ringgit (RM)15.00 per head each day. There are 11 supplements considered; Vitamins (A, B1, B2 & C), Calcium (Cal), Energy (E), Niacin (Ni), Protein (Pr), Carbohydrate (Car), Iron (I) and Fat (F) as shown in Table 1. Moreover, 10 sorts of nourishment will be considered in this study; Cereal Based Meal (CBM), Rice Flour Based (RFB), Cereal Flour Based (CFB), Wheat Flour Based (WFB), Seafood and Fish (SF), Meat (MT), Fruit (FR), Vegetable (VG), Beverage (BV) and Miscellaneous (MS) as shown in Table 2. There are 426 of nourishment and beverages to be considered. In light of the information, a binary programming model is created and discussed. In this manner we have 426 variables ($x_1,...,x_{426}$). Each sort of sustenance has its own particular accessible scope of choice as exhibited in Table 2.2. For instance Beverage dishes ($x_1$ - $x_{37}$). We require 18 dishes from 10 sorts of nourishment for every day.

**Table 1.** UB and LB of the 11 supplements.

| LB | Supplements (Nutrients) | UB |
|---|---|---|
| 600mg | A | 2800mg |
| 1.1mg | B1 | - |
| 1mg | B2 | - |
| 65mg | C | 1800mg |
| 1000g | Cal | 2500g |

| | | |
|---|---|---|
| 2050kcal | E | 2840kcal |
| 16mg | Ni | 30mg |
| 54g | Pr | - |
| 180g | Car | 330g |
| 15mg | I | 45mg |
| 46g | F | 86g |

**Table 2.** Nourishment requirement each day.

| Type of nourishment | Requirement everyday (*k*) | Variable Notation |
|---|---|---|
| CBM | 1 + 1 plain rice | $(x_{114}$ - $x_{126})$ |
| RFB | 1 | $(x_{86}$ - $x_{113})$ |
| CFB | 1 | $(x_{38}$ - $x_{85})$ |
| WFB | 1 | $(x_{262}$ - $x_{286})$ |
| SF | 1 | $(x_{287}$ - $x_{324})$ |
| MT | 1 | $(x_{127}$ - $x_{158})$ |
| FR | 2 | $(x_{213}$ - $x_{261})$ |
| VG | 2 | $(x_{159}$ - $x_{212})$ |
| BV | 4 + 2 plain water | $(x_{1}$ - $x_{37})$ |
| MS | 1 | $(x_{325}$ - $x_{426})$ |
| **Total Dishes Per Day** | **18** | |

## 3. Model Development

The primary point of this exploration study is to define a menu arranging model that minimize the financial budget given by the government to the school cooks, maximizes the variety of food and nutritious necessity relying on the Malaysian RDA prerequisites. Consequently in seven days we require 126 dishes that will be reasonably chosen from the 426 dishes that are accessible. In the objective function, we minimize the aggregate cost *M*,

$$M = \sum_{i=1}^{426} \text{Cost}(x_i) = \sum_{i=1}^{426} w_i x_i \tag{1}$$

by choosing the dish and giving an acceptable day by day menu. The maximum spending budget gave each day by the government is RM15.00. Along these lines we attempt to limit the cost. The day by day imperatives are,

$$\text{LB} \leq \sum_{i=1}^{426} \text{Supplements}(x_i) \leq \text{UB} \tag{2}$$

where i=1,2,..,11, LB and UB is the vector and give an alternate an incentive for every supplement. This is to guarantee that we meet the supplements prerequisites. We have 11 limitations of supplements with lower and upper bound esteems aside from protein, vitamin B1 and B2 as expressed in Table 2. In light of Table 1 we determine the 10 nourishment prerequisites as,

$$\sum_{i=1}^{10} \text{Type of nourishment } (x_i) = k; \tag{3}$$

where i=1,2,..,10 with the goal that we can serve 18 dishes for each day. Each of the 426 factors are in binary,

$$x_i = \{0, 1\} \quad (4)$$

Every nourishment must be serve once (1 picked and 0 generally) for seven days with the exception of plain water and plain rice. Each time looping, the program will consider distinctive accessible factors. For instance, 18 factors are chosen from the 426 factors that are accessible to be served on Day 1. The chosen factors will be signified as 1 (with the exception of plain water which is 2) and the rest are zeros. As said before all factors are binary with the exception of plain water and plain rice. Binary implies that the lower headed an incentive for the variable is 0 and the upper bound esteem is noted as 1. Before running for Day 2, every variable that are chosen in Day 1 will be wipe out aside from plain water and plain rice. It implies that each one of the nourishment that are served on day(i) will be erased from the model and won't be served again on day(i+1) with the exception of the two mandatory sustenance. We will utilize a circling procedure for running the program for 7 days; erasing the chosen factors from the current model and reshuffle all the ideal factors into a legitimate serving plan. The chosen factors in day(i) will be modify as xi={0,0}, where the lower bound is still 0 and the upper bound is turn down to 0 aside from plain water and plain rice. At that point, the chosen nourishment will be masterminded into appropriate serving plan for all 6 meals.. Despite the fact that an ideal arrangement has been acquired, the clients are as yet being given the adaptability to change any sustenance from the ideal outcomes. As specify prior, for Day 1, 18 nourishments are being chosen from every nutrition classes. If the client wants to have other nourishment on that day, they can supplant the chosen sustenance with whatever other sustenance that is as yet accessible and a recalculation procedure will be done in light of the ideal outcome. The new cost will be,

$$M' = M - w_i x'_i + w_i x''_i \quad (5)$$

where $M'$ is the new aggregate cost, $w_i x'_i$ is the cost of the nourishment that being rejected and $w_i x''_i$ is the cost of the new sustenance that being included. At that point the new every day oblige will be,

$$\text{LB} \leq \sum_{i=1}^{426} \text{Supplements}(x_i) - \text{Supplements}(x'_i) + \text{Supplements}(x''_i) \leq \text{UB} \quad (6)$$

where $\text{Supplements}(x'_i)$ is the supplement of the sustenance that being rejected and $\text{Supplements}(x''_i)$ is the new supplement of the nourishment that being included. The rejected sustenances are accessible to be considered for the remaining days. In the event that the lower bound (LB) and the upper bound (UB) are not fulfilled (through the substitution of the new nourishment), the framework will indicate which supplement does not meet the requirement. Everything is being considered in this count and we present another calculation. We call this calculation as the **"Delete-Reshuffle-Reoptimize Algorithm"**. This present examination includes numerous choice factors, imperatives and parameters. The coding was modified utilizing Matlab with LPSolve and ideal outcomes were obtained through 2.26GHz PC. By eliminating the chosen factors and diminishing the measure of factors, it will enable the program to run speedier. Figure 3.1 shows the flow chart of the model development.

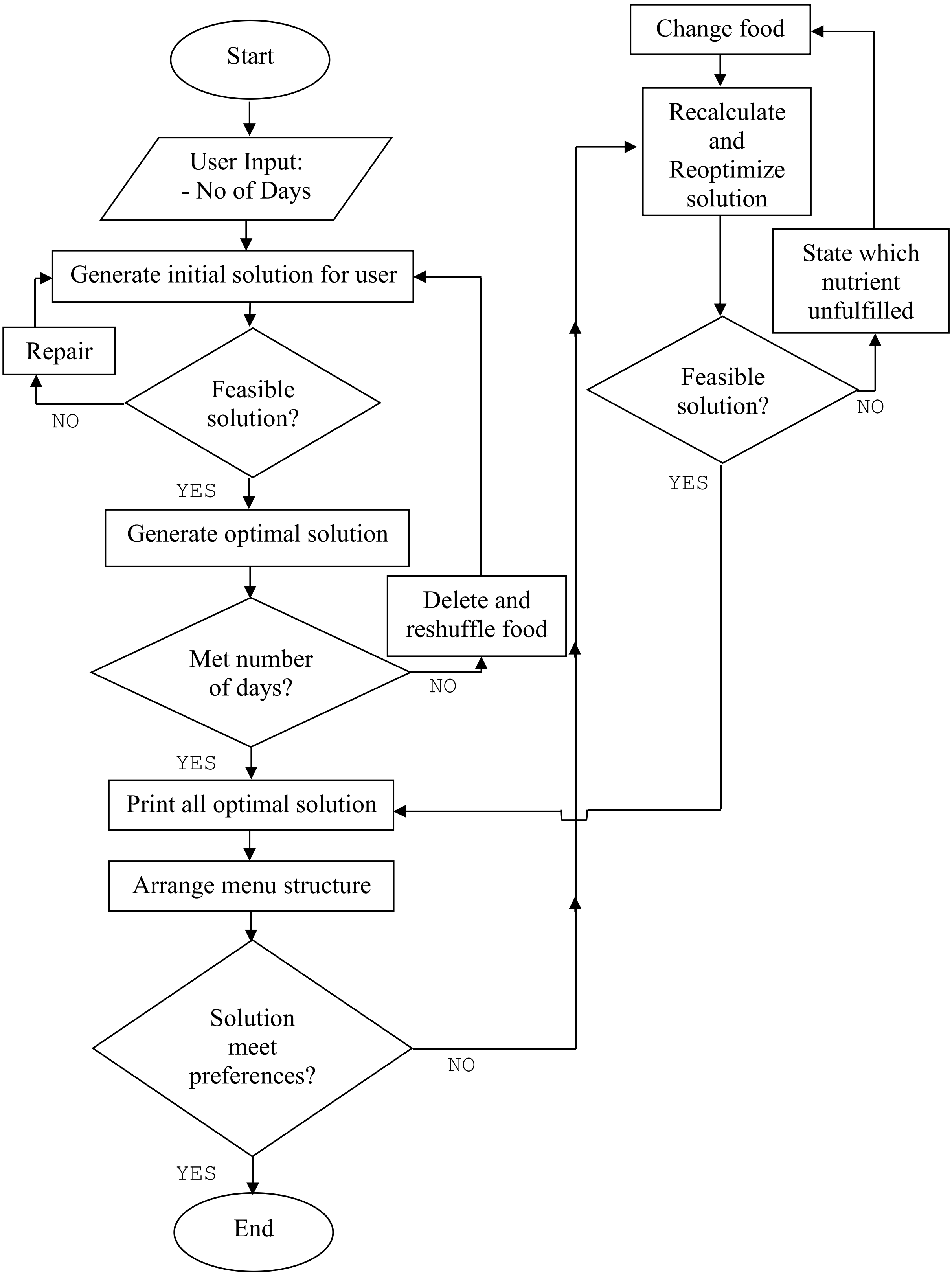


**Figure 1.** DRRA flow charts.

## 4. Result and Discussion

The outcomes are exhibited in Table 3 and Table 4. It indicates meal for one day to be given by the administration of the school to the boarding school children. In Table 4.1, we can see that there are an assortment of beverages and sustenance displayed in the primary ideal arrangement which incorporates six sorts of meals from breakfast to dinner. At that point we chose to replace one each in Beverages and Fruits from the primary ideal arrangement in light of our best menu. A recalculation procedure was done and second ideal arrangement demonstrates the outcomes. Table 4.2 demonstrates the diverse supplement allowance between the two ideal arrangements. Both outcomes meet the daily nutritious prerequisite for the boarding school children at the minimum cost. Thusly, it can be reasoned that each one of the chosen meals are nutritious and is prudent to serve to the boarding school children. The estimation of the aggregate cost is less than the monetary allowance given by the legislature (government). It implies that the administration of the school will spend under RM15.00 per individual every day. The aggregate cost for each day getting increasingly elevated in light of the fact that the program pick the least expensive sustenance however yet fulfill the RDA prerequisite to be serve first.

**Table 3.** Optimal and re-optimal result for Day 1.

| Day 1: Optimal Result | Type of nourishment | Day 1: Re-Optimal Result |
|---|---|---|
| Rice, chicken [L]; Rice, cooked [D] | **CMB** | Rice, chicken [L]; Rice, cooked [D] |
| Kuih kasui [B] | **RFB** | Kuih kasui [B] |
| Biscuit soda/plain [S] | **CFB** | Biscuit soda/plain [S] |
| Doughnut [E] | **WFB** | Doughnut [E] |
| Fish unspecified, dried, salt [D] | **SF** | Fish unspecified, dried, salt [D] |
| Chicken satay [L] | **MT** | Chicken satay [L] |
| Guava [L]; Nangka [D] | **FR** | Guava [L]; Lychee [D] |
| Celery(daun seladeri) [L]; Mengkudu [D] | **VG** | Celery(daun seladeri) [L]; Mengkudu [D] |
| Orange flavoured drink, powder [B]; Plain water (2 times) [T,L]; Coconut water [E]; Sugar cane juice D]; Milo [S] | **BV** | Milk powder, skim [B]; Plain water (2 times) [T,L]; Orange flavoured drink, powder [E]; Sugar cane juice D]; Milo [S] |
| Candy coconut [M] | **MS** | Candy coconut [M] |
| **RM6.05** | **COST** | **RM6.61** |

**Table 4.** Optimal and re-optimal supplement intake for Day 1.

| LB | Day 1: Optimal Result | Type of supplements | Day 1: Re-Optimal Result | UB |
|---|---|---|---|---|
| 600mg | 1010mg | **A** | 978mg | 2800mg |
| 1.1mg | 1.53mg | **B1** | 1.47mg | - |
| 1mg | 2.03mg | **B2** | 2.24mg | - |
| 65mg | 270.1mg | **C** | 255.6mg | 1800mg |
| 1000g | 1037g | **Cal** | 1021g | 2500g |
| 2050kcal | 2399kcal | **E** | 2359kcal | 2840kcal |
| 16mg | 23.5mg | **Ni** | 22.9mg | 30mg |
| 54g | 91g | **Pr** | 90.3g | - |
| 180g | 318.5g | **Car** | 320g | 330g |
| 15mg | 20.3mg | **I** | 17mg | 45mg |
| 46g | 55.5g | **F** | 55.8g | 86g |
| | **RM6.05** | | **RM6.61** | |

## 5. Conclusion

The specialists have delivered a reasonable menu arrange for that can be utilized as a guide for the administration of the school. The model was explained utilizing Matlab with LPSolve. It satisfied every one of the imperatives set by the specialists and gives a superior arrangement contrast with other heuristic strategies, for example, Genetic Algorithms. This exploration concentrated on 13 to 18 years of age for boarding school children. The nutritious prerequisites required for children beneath 12 years of age and grown-ups will not be quite the same as the one utilized here and it will influence the menu choice and the cost of setting up the meals. The aggregate cost for every day is under RM15.00. In this manner we can serve somewhat costly and better nature of nourishments for the boarding school children. An approach utilizing post-optimality and affectability examination was created in this study in the view of adjustments in the coefficient esteem ($w_i$).

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