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Faculty of Administrative Science and Policy Studies

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MALAYSIAN SECONDARY BOARDING SCHOOL MENU PLANNING SYSTEM

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ABSTRACT

Boarding school students need to eat well balanced nutritious food which include proper calorie, 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. Arranging a nutritious and adjusted menu physically is confounded, wasteful and tedious. This study intends to build up a scientific mathematical model and decision support system for menu planning that improves and meets the vital supplement consumption for boarding school students aged 13-18 and in addition, saving the financial cost. It gives the adaptability and flexibility for the cook to change any favoured menu even after the ideal arrangement has been produced. A recalculation procedure was performed in view of the ideal arrangement. The data were gathered from the Ministry of Education and boarding schools' authorities. Menu arranging is a notable enhancement issue and one of the well-established problems in optimisation. A well-balanced menu scheduling is produced which meets all the constraints. The model was fathomed by utilising Binary Programming and "Sufahani-Ismail Algorithm" and a system was developed to comply with the problem. The Malaysian Secondary Boarding School Menu Planning System is the first system in Malaysia and in the world. It can also be used for other problems such as military, hospitals and others.

Keywords: mathematical modeling, decision support system, menu scheduling, integer programming, information systems.

INTRODUCTION

Planning adequate menus faces many economic and psychological constraints. It involves simultaneous consideration of several types of constraints: the desired nutritional content, the likes, and dislikes of the person that it is being planned for, the amount (volume or weight) of food to be consumed, and the expected form and content of different kinds of meals. The menu or diet problem model was first formulated by Stigler in 1945. This model, as in most operation research models, has been set up on the traditional fundamental assumption that the decision maker seeks to optimise a single objective function. The problem has continued to be investigated by scientists and nutritionists. Therefore, in this paper, we expand the current knowledge in menu planning focusing on Malaysian recipes, minimising the cost, fulfilling the nutritional requirements, serving variety of food serve each day and optimising the user's preference. We use zero-one programming to determine the most nutritious and palatable meal for Malaysian children aged 13 to 18 years old. The menu lists are given to caterers in boarding schools who provide six meals per day, breakfast [B], morning tea [M], lunch [L], evening tea [E], dinner [D] and supper [S]. The menu provided is a nonselective menu where the school children do not have the choice to choose their preferred foods. Planning adequate and palatable menus is important to prevent the school children from suffering any undesirable diseases. Hence, research on menu planning by developing mathematical models using operational research and decision science techniques is important in order to help caterers provide nutritious meals over extended time periods within the limited budget allocation.

DATA COLLECTION

There are several types of data needed to build a menu planning model. These include the standardised price of each Malaysian menu, the nutritional contents for each menu, recommended nutritional daily allowance (RDA) which include upper and lower bound of each nutrient for Malaysian school children aged between 13-18 years old, and the government budget for caterers. The information on current monthly caterers' budget and cost per serving for each meal was collected from the nutritionists of the Ministry of Education, the boarding schools' authorities through interview sessions and caterers. The budget is RM15.00 per student per day.

MODEL FORMULATION

The main aim of this research is to formulate a menu planning model that minimises the budget provided by the government to the school caterers, maximises the variety of food intake and maximises the nutritional requirement based on the Malaysian RDA requirements. There are 11 nutrients considered; energy, fats, carbohydrate, protein, niacin, vitamin A, vitamin B1, vitamin B2, vitamin C, calcium, and iron (refer Table 1). Furthermore, we will consider 10 types of foods; beverage, cereal flour based, rice flour based, cereal based meal, meat dishes, seafood, vegetable, fruit, wheat flour based and miscellaneous (re-fer Table 2). There are 426 of foods and drinks to be considered. Based on the data, a zero-one programming model is developed and discussed. We have 426 of foods and drinks, therefore we have 426 variables (xi) where i=1,2,..,426. Each type of food has its own available range of selection as presented in Table 2. For example, Bever-age dishes (x1 - x37). We need 18 dishes from 10 types of food per day. Therefore, in a week we need 126 dishes that will be suitably selected from the 426 dishes that are available.

Table 1. Values of upper bound and lower bound of the 11 nutrients

Nutrients	Lower Bound (LB)	Upper Bound (UB)
Energy (kcal)	2050	2840
Fat (g)	46	86
Carbohydrate (g)	180	330
Protein (g)	54	-
Calcium (g)	1000	2500
Vitamin A (mg)	600	2800
Vitamin B1 (mg)	1.1	-
Vitamin B2 (mg)	1.0	-
Vitamin C (mg)	65	1800

Niacin (mg)	16	30
Iron (mg)	15	45

Table 2. Food requirement per day

Type of food	No. of requirement per day (n)
Beverage (x_1 - x_{37})	6 [including 2 Plain Water]
Cereal Flour Based (x_{38} - x_{85})	1
Rice Flour Based (x_{86} - x_{113})	1
Cereal Based Meal (x_{114} - x_{126})	2 [including 1 Plain Rice]
Meat Dishes (x_{127} - x_{158})	1
Seafood (x_{287} - x_{324})	1
Vegetable (x_{159} - x_{212})	2
Fruits (x_{213} - x_{261})	2
Wheat Flour Based (x_{262} - x_{286})	1
Miscellaneous (x_{325} - x_{426})	1
Total Dishes Per Day	**18**

For the objective function, we minimise the total cost Z,

$$Z = \sum_{i=1}^{426} \text{Cost}(x_i) = \sum_{i=1}^{426} c_i x_i \quad (1)$$

by selecting the dish and providing a palatable daily menu. The maximum budget provided per day by the government is MYR15.00. Therefore, we try to minimise the cost. The daily constraints,

$$LB \le \sum_{i=1}^{426} \text{Nutrient}(x_i) \le UB \quad i = 1,2,..,11 \quad (2)$$

where LB and UB is the vector and give a different value for each nutrient. This is to ensure that we meet the nutrients requirements. We have 11 constraints of nutrients with lower and upper bound values except for protein, vitamin B1 and B2 as stated in Table 2. Based on Table 1 we then specify the 10 food requirements,

$$\sum_{i=1}^{10} \text{Type of foods } (x_i) = n \quad i = 1,2,...,10 \quad (3)$$

so that we can serve 18 dishes per day. All 426 variables are in binary values $x_i = \{0,1\}$. Each food can only be served once (1 chosen and 0 otherwise) in a week except for Plain water and Plain Rice. Each time running, the programme will consider different available variables. For example, 18 variables are selected from the 426 variables that are available to be served on Day 1. The selected variables will be denoted as 1 (except for plain water which is 2) and the rest are zeros. As mentioned earlier all variables are binary except for plain water and plain rice. Binary means that the lower bound value for the variable is 0 and the upper bound value is 1. Before running for Day 2, each variable that is selected in Day 1 will be eliminated except for plain water and plain rice. It means that all the foods that are served on day *1* will be deleted from the model and will not be served again on day (i + 1) except for the two compulsory foods. We will use a looping process in running the programme for 7 days; deleting the selected variables from the existing model and reshuffle all the optimal variables into a proper serving schedule. The selected variables in Day 1 will be rewritten as $x_i = \{0,0\}$, where the lower bound value is 0 and the upper bound value is 0 except for plain water and plain rice. Then the selected food will be arranged into proper serving schedule (Breakfast, Morning Tea, Lunch, Evening Tea, Dinner and Supper). Even though an optimal solution has been obtained, the users are still being given the flexibility to change any food from the optimal results. As mentioned earlier, for Day 1, 18 foods are being selected from each food group. If the user is keen to have another food on that day, the selected food can be replaced with any other food that are still available, and a recalculation process will be done based on the optimal result. As mentioned in Table 2, a daily meal consists of 6 beverages (BEV), 1 cereal flour based (CFB), 1 rice flour based (RFB), 2 cereal meals based (CMB), 1 meat (MEAT), 1 seafood (SEA), 2 vegetables (VEG), 2 fruits (FRU), 1 wheat flour based (WFB) and 1 miscellaneous (MIS). These foods are rearranged accordingly into a complete 1-day menu schedule by applying Algorithm 4.2. This present study involves many decision variables, constraints, and parameters. The coding was programmed using Matlab with LPSolve and optimal results were obtained through 2.26GHz PC. By eliminating the selected variables and reducing the size of variables, it will help the programme run faster.

RESULTS AND DISCUSSION

The results are presented in Table 3. It shows meals for one day to be provided by the management of the school to the children aged 13 to 18 years old. In Table 3, we can see that there are a variety of drinks and foods presented in the first optimal solution which includes six types of meals from breakfast to supper. Then we decided to change one item each in Beverages and Fruits from the first optimal solution based on our preferable menu. A recalculation process was done, and second optimal solution shows the results. Both results meet the daily nutritional requirement for the school children at a minimum cost. Therefore, it can be concluded that all the meals chosen are nutritious and is advisable to serve to the school children aged 13 to 18 years old. The value of the total cost is less than the budget provided by the government. It means that the management of the school will spend less than RM15.00 per person per day. The total cost for each day increases because the programme chooses the cheapest food but the RDA requirement need also to be satisfied.

Table 3. First and second optimal solution for Day 1

	Day 1: First Optimal	**Day 1: Second Optimal**
Beverages	Orange flavoured drink, powder [B]; Plain water (2 times) [T,L]; Coconut water [E]; Sugar cane juice D]; Milo [S]	Milk powder, skim [B]; Plain water (2 times) [T,L]; Orange flavoured drink, powder [E]; Sugar cane juice D]; Milo [S]
Cereal Flour Based	Biscuit soda/plain [S]	Biscuit soda/plain [S]
Rice Flour Based	Kuih kasui [B]	Kuih kasui [B]
Cereal Meal Based	Rice, chicken [L]; Rice, cooked [D]	Rice, chicken [L]; Rice, cooked [D]
Meat	Chicken satay [L]	Chicken satay [L]
Seafood	Fish unspecified, dried, salt [D]	Fish unspecified, dried, salt [D]
Vegetables	Celery [L]; Mengkudu [D]	Celery [L]; Mengkudu [D]
Fruits	Guava [L]; Nangka [D]	Guava [L]; Lychee [D]
Wheat Flour Based	Doughnut [E]	Doughnut [E]
Miscellaneous	Candy coconut [M]	Candy coconut [M]
COST	RM5.90	RM6.50

CONCLUSION

The researchers have produced a suitable menu plan that can be used as a guide for the management of the school. The model was solved using Matlab with LPSolve. It fulfilled all the constraints set by the researchers and gives a better solution compared to other heuristic methods such as Genetic Algorithms. This research focused on 13 to 18 years old school children at secondary boarding schools. The nutritional requirements required for children below 12 years old and adults will be different from the ones used here, and it will affect the menu selection and the cost of preparing the meals. The total cost for each day is less than RM15.00. Therefore, we can serve slightly expensive and better quality of foods for the children. An approach using post-optimality and sensitivity analysis will be developed in the future based on the changes in the coefficient value (ci).

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REFERENCES

Armstrong, R.D. & Sinha P. (1974). Application of Quasi-Integer Programming To The Solution Of Menu Planning Problems With Variable Portion Size, *Management Science*, Vol. 21, No. 4, pp. 474.

Balintfy, J.L. (1975). A Mathematical Programming System for Food Management Applications, *INTERFACES*, Vol. 6, No. 1, pp. 2.

Bassi, L.J. (1976). The Diet Problem Revisited The American Economist, Vol. 20, No. 2, pp. 35-39.

Benson, H.P. & Morin, T.I. (1987). A Bicriteria Mathematical Programming Model for Nutrition Planning In Developing Nations, *Management Science*, Vol. 33, No. 12, pp. 1593.

Dantzig, G.B. (2002). Linear Programming, *Operation Research*, Vol. 50, No. 1, pp. 42-47.

Endres, J.M., McCann-Rugg, M., & White, G.P. (1983). Using Goal Programming to Improve the Calculation of Diabetic Diets, *Computer & Operation Re-search*, Vol. 10, No. 4, pp. 365-373.

Foytik, J. (1981). Devising and Using a Computerized Diet: An Exploratory Study, The *Journal of Consumer Affairs*, Vol. 15, No. 1, pp. 158.

Gallenti, G. (1997). The Use of Computer for the Analysis of Input Demand in Farm Management: A Multicriteria Approach to the Diet Problem, First European Conference for Information Technology in Agriculture.

Garille, S.G. & Gass, S.I. (2001). Stigler's Diet Problem Revisited, *Operation Research*, Vol. 49, No. 1, pp. 1-13.

Lancaster, L.M. (1992). The Evolution of The Diet Model In Managing Food Systems, *INTERFACES*, Vol. 22, No. 5, pp. 59-68.

Leung, P.S., Wanitprapha, K., & Quinn, L.A. (1995). A Recipe-Based, Diet-Planning Modelling System, *British Journal of Nutrition*, Vol. 74, pp. 151-162.

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