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Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

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Research Article
Development and Acceptance of Healthy and Balanced Diet for Diabetes Mellitus Patients among UKM Staff Using Linear Programming

Shirin Khashim and Roslee Rajikan

School of Healthcare Sciences, Faculty of Health Sciences, National University of Malaysia, 50300 Jalan Raja Muda Aziz, Kuala Lumpur, Malaysia

Abstract
Background and Objective: It is established that nutrition and diet management is a significant aspect of managing diabetes. The aim of this study was to construct a balanced, palatable and affordable diet that helps diabetics in Malaysia to manage their disease. Linear programming techniques were employed to develop a menu plan that takes into account not only nutritional guidelines but also palatability and budget constraints. **Materials and Methods:** A cross-sectional study involving 120 UKM staff aged 30-59 years old diagnosed with Type 2 Diabetes Mellitus (T2DM) was conducted. Socio-demographic, anthropometry, dietary intake and food security and the subjects' glucose level (HbA1c) were taken in the first phase. Three diet models were produced: Model 1 is 1391.419 kcal day^{-1} costing RM 9.94; Model 2 is 1523.500 kcal day^{-1} at RM9.23 and Model 3 is 1713.500 kcal day^{-1} at the lowest cost of RM 9.17. These three diabetes diet management models were tried out among ten randomly selected subjects. All data collected were analysed using the Statistical Package for Social Sciences (SPSS) program version 22.0. **Results:** No significant difference was found between groups within each socio-demographic characteristic, comparing HbA1c levels among the subjects but significant differences were found in the nutrient intakes between male and female subjects in the mean daily intakes of energy, carbohydrates, fat and sucrose but not in crude fibre and protein. These data were needed to develop a healthy and balanced menu at a minimum cost via linear programming for the second phase. Results showed a significant improvement in both weight loss ($p = 0.029$) and HbA1c control ($p = 0.028$) as evidenced by data collected pre and post-diet implementation. **Conclusion:** Linear programming can be an effective tool in helping to produce an optimised healthy and balanced diet at minimal cost by interpreting and translating dietary recommendations into a nutritional model, based on local market prices.

Key words: Balanced diet, diet management, healthy diet, linear programming, Type 2 Diabetes Mellitus

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Corresponding Author: Shirin Khashim, School of Healthcare Sciences, Faculty of Health Sciences, National University of Malaysia, 50300 Jalan Raja Muda Aziz, Kuala Lumpur, Malaysia

Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Nearly 285 million people worldwide are known to be suffering from Type 2 Diabetes Mellitus (T2DM), and this figure is expected to increase to 439 million people by the year 2030[1]. In Malaysia the prevalence of T2DM keeps increasing mainly due to an unhealthy lifestyle, poor eating habits and lack of exercise among many Malaysians[2]. Recently, the International Diabetes Federation (IDF)[3] reported that there were over 3.4 million cases of diabetes in Malaysia in 2017.

Evidence from prospective observational studies and clinical trials has converged to mark the significance of individual nutrients, foods and dietary patterns in the prevention and management of Type 2 diabetes in the past couple of decades[4]. Increased intakes of refined carbohydrates (including sugars), greater saturated and less monounsaturated fat intake, low-quality protein and decreased fruit and vegetable intake combined with increased sedentariness and reductions in voluntary physical activity[5], are believed to have contributed to T2DM. While diet is meant to be individualiseddepending on age, weight, gender, health condition and occupation etc[6], a set of dietary guidelines should be determined for the general population. The diabetes care team generally refers to nutritional recommendations for diabetes prevention and management under Medical Nutrition Therapy (MNT) version 2013[7], advocated by both American Diabetes Association (ADA) and Malaysia Dietitians' Association (MDA).

Socio-economic factors and budget constraints have always been a concern for patients adhering to a specific diet. Food prices and food purchasing ability are important indicators in food choices and food safety, particularly for individuals with obesity and non-communicable diseases such as diabetes. In general, a person will purchase less food when food prices rise and more when the food prices decline[8]. The cost per calorie of lower-quality diets or food with lower nutritional value is usually less and tends to be purchased by those in the lower income group[9]. Linear programming (LP) techniques have been used to solve diet problems by producing a model that contains optimal nutrition, dietary cost and diet quality and to establish nutrition recommendations in developing countries[10]. LP is used to measure the diet problem, in optimising the price and nutrients in food and in estimating the portion size in individuals[11]. Although, LP has been used actively by researchers since the past decade, it has not been used to produce a diet plan for the subgroup of diabetics in Malaysia. Hence, the aim of this study was to construct, using LP, a balanced, palatable and affordable diet that helps in better self-management of diabetes.

MATERIALS AND METHOD

Ethical approval for conducting this study was obtained from the National University of Malaysia Medical Research Ethics Committee (UKMREC). A total of 120 UKM staff aged between 30-59 years, diagnosed with Type 2 Diabetes Mellitus, were selected to participate in this study via convenience sampling. Dietary patterns, anthropometric and socio-demographic data and blood glucose (HbA1c) levels of the subjects were collected throughout the study.

Data collection: A questionnaire was distributed to the subjects to assess their socio-demographic profiles based onage, gender, marital status, occupation, education level and household income. Anthropometric measurements including weight, height and body mass index (BMI) were recorded. BMI was calculated by using weight and height and classified based on the WHO BMI classification into underweight, normal, pre-obese/overweight and obese (class I, II and III) in adults. The subjects' diabetes status was assessed through blood glucose (HbA1c) percentage, T2DM duration and any family history of the disease. HbAlc level $<7\%$ is categorised as controlled DM while $>7\%$ is uncontrolled DM. Dietary patterns of the subjects were recorded and assessed by three-day food records, where the subjects had to document their food intake for two days during weekdays and one over the weekends. Based on the subjects' diet history information, a food list was prepared, and the price for each food item was obtained from the Ministry of Domestic Trade, Cooperatives and Consumerism (KPDNHEP). The food prices were set in terms of price per serving size.

Data analysis: All data collected (socio-demographic, anthropometric, HbA1c level and dietary recall) were analysed using Statistical Package for Social Sciences version 22.0 software (SPSS Inc., Chicago, IL, USA). Descriptive analysis was presented on baseline characteristics of subjects involved such as sex, age, marital status, educational level, occupation and monthly incomes and BMI. Independent t-test and one way ANOVA were used to test the differences among different categories within each characteristic when compared with HbA1c level among DM patients. Paired t-test was done to gauge acceptance of the healthy and balanced menu among DM patients, by assessing the pre- and post-results of weight and HbA1c level, after the subjects adhered to the diet models produced. Dietary recall recorded was initially analysed using Nutritionist Pro software to determine subjects' dietary nutritional status including total energy intake, macronutrient and micronutrient of subjects' average daily food consumption, compared with NCCFN[12] based on age before SPSS analysis. A food list was prepared and all food items were analysed using Nutritionist Pro software, market survey and Malaysian Food Composition Database (MyFCD) to determine the nutrient content. Microsoft Excel Solver was used to produce a balanced optimum nutritional model through linear and integer programming that meets all the dietary and nutrient recommendations of MDA[7], NCCFN[12] and MoH[13]. A balanced menu was finally planned with the food items that had been chosen from the model.

Linear programming model development: Diabetes management diet models with the lowest cost were planned. The formulation for Linear Programming is as follows[14]:

Minimize : $z = \sum c_j x_j$
Subject to : $b_i \leq \sum a_{ij} x_j \leq b_i$

The quantity of food item, j (in kg) is represented by x_j; a_{ij} denotes the amount of nutrient, i in 1 kilogram of the food item, j, c_j is the cost of 1 kilogram of the food item, j; b_i denotes the largest or smallest acceptable quantity of nutrient, i. The constraints in the model for this study were MDA[7], NCCFN[12] and MoH[13], as used to set the minimum and maximum values of macronutrient and micronutrient. Palatability constraints were also included to ensure that the suggested menus were suited to the subjects' common food pattern. In this study, the cost of food items, *z* (measured in RM) is the objective function that we want to minimise. Choosing food items from the dietary recall of the subjects and avoiding the repetition or large portions of certain foods were also considered to ensure the palatability of the menu.

RESULTS AND DISCUSSION

Socio-demographic data: A total of 120 subjects, all UKM staff participated in this study, with males constituting the majority (n = 81) and females (n = 39) . Most subjects were from the older age group, 51-59 years (n = 77, 64.2%), with the rest from the younger age group, 30-50 years (n = 43, 35.8%). 90% of the subjects were married (n = 108) and the remaining 10% were either single (n = 9, 7.5%) or divorced (n = 3, 2.5%). More than half of the subjects had received tertiary education, holding a Masters/PhD (n = 30, 25.0%), first degree (n = 15, 12.5%) and Certificate/Diploma (n = 16, 13.3%). The rest of the respondents had completed secondary schooling (n = 52, 43.3%) while 5.8% (n = 7) of them had attended only primary school. The subjects worked in various occupations such as Assistant/Clerk (n = 49, 40.8%); professional positions such as Lecturer/Teacher/Dentist (n = 35, 29.2%); Technician (n = 13, 10.8%); Security (n = 11, 9.2%); Driver (n = 7, 5.8%) and Supervisor/Officer (n = 5, 4.2%). The middle-income group earning RM2,300-5,600 per month formed the majority of respondents (n = 55, 45.8%). Nearly one third (n = 37, 30.8%) had a monthly income of more than RM5,600 and the rest were low-income earners (n = 24, 20.0%) with monthly incomes of RM 1,500 to RM 2,300 and those in poverty (n = 4, 3.3%), earning less than RM 1,500 per month. There were no significant difference in HbA1c level among the subjects between groups or categories within each socio-demographic characteristic .

Anthropometric measurements and health status: Anthropometric measurements were recorded from the subjects. After the weight and height of the subjects were obtained, the BMI was calculated for each subject. Most of the subjects were found to fall into the category of Pre-Obese/Overweight (n = 53, 44.2%) followed by Normal (n = 24, 20.0%). The remaining 35.8% were classified as Obese class I (n = 29, 24.2%), Obese class II (n = 10, 8.3%) and Obese class III (n = 4, 3.3%).

With regard to HbA1c level, most of the respondents were non-controlled DM (n = 94, 78.3%), followed by respondents who were controlled DM (n = 26, 21.7%). From the interview session, it was concluded that most of the patients had diabetes for less than five years (n = 62, 51.7%). Even though most of them had diabetes for less than five years, the HbA1c level was still uncontrolled. This may be due to non-compliance with medication, improper diet and unhealthy lifestyle. The percentage of having uncontrolled HbA1c is slightly higher in men (n = 65, 80.2 %) than in women (n = 29, 74.4%). Most of the respondents reported having a family history of T2DM (n = 93, 77.5%).

Dietary intake: A comparison of average macronutrient intakes between male and female subjects was produced as shown in Table 1. A significant difference was observed in the mean daily intakes of energy, CHO, sucrose and fat but not on crude fibre and protein. Conventionally within a healthy, balanced diet, a male with more muscle mass in general would require more calories to maintain his weight as muscle burns more calories per hour than fat[15], which is clearly shown in the study where males have significantly higher energy intake per day (1993$\pm$282 kcal) than the females (1710$\pm$275 kcal). However, the results might have indicated that it would be harder for male diabetics to lose weight and control BMI since being overweight or obese is strongly

Table 1: Nutrient Intake data of 120 subjects (Mean±SD)

	Male (n = 81)				Female (n = 39)					
	Mean±SD	Range	Ref. value	MNT (%)	Mean±SD	Range	Ref. value	MNT (%)	t	Significance
Energy (kcal)	1993.0±282***	1135.0-2545	2460	81.0	1710.0±275	1030.0-2331	2180	78.4	5.195	0.000
CHO (g)	252.5±44.0***	128.3-392.9	45-60%	100.0	203.5±35.2	94.3-276.4	45-60%	100.0	5.875	0.000
Sucrose (%)	7.3±5.4*	0.1-24.8	10-20%	73.0	10.6±8.8*	0.1-36.7	10-20%	100.0	-2.217	0.031
Crude fiber (g)	5.1±3.3	1.0-19.3	-		6.9±6.6	1.7-32.0	-		-1.580	0.121
Protein (g)	78.4±18.2	36.7-129.4	15-20%	100.0	72.4±19.8	36.8-147.3	15-20%	100.0	1.651	0.101
Total fat (g)	74.4±17.3*	27.0-112.9	25-35%	100.0	67.0±17.5	27.9-130.6	25-35%	100.8	2.186	0.031

*Significantly different (p<0.05) between male and female subjects according to independent T-test. ***Significantly different (p<0.001) between male and female subjects according to independent T-test

associated with diabetes[16]. It would be more challenging if male subjects also have significantly higher daily intakes of CHO (252.5±44.0 g) and fats (74.4±17.3 g) than the females with intakes of CHO (203.5±35.2 g) and fats (67.0±17.5 g). This might suggest that males tend to eat more high-carbohydrate food such as rice, noodles or roti canai and food that is cooked in a way that uses greater amounts of oil, such as frying. Interestingly, in this study, while females take in 10.6±8.8% sucrose in their daily consumption (100% MNT) that is significantly higher than males, at only 7.3±5.4% sucrose per day (73% MNT), males remain as the ones with more diagnosed diabetes cases.

While over 75% of the subjects tested to be non-controlled DM, all nutrient intakes assessed fall within the recommended ranges by MNT, thus the credibility of the subjects during diet recall becomes questionable. Most patients were detected to be not reporting the right amount of food consumed in a day or trying to hide some of their dietary habits. One possible reason for such behaviour is that most diabetic patients are reluctant to expose every single detail of their current lifestyle and dietary habits which they are comfortable with and are also trying to avoid excessive interference from the diabetes care team.

Development of diabetes management diet model and menu at minimum cost: Linear Programming can be utilised to formulate minimum cost menus which meet all the criteria of all macronutrients and micronutrients set by dietary guidelines or nutritional recommendations. While in Malaysia, Rajikan *et al.*[17] succeeded in developing healthy and palatable diet plans at the minimum cost that meet recommendations of NCCFN[12] and MoH[13] via linear programming, the result is restricted to only a female adult with a total energy intake of 2000 kcal day^{-1}. Therefore, this study aimed to determine a set of dietary guidelines that are achievable by Malaysian population subgroups, in particular, people with diabetes, with the help of optimisation models based on an individual's energy intake requirement at all stages, regardless of sex and age.

Three categories of energy levels within the lower and the upper limit of different kcal per day was established in the study: 1200-1400 kcal day^{-1}, 1400-1600 kcal day^{-1}, 1600-1800 kcal day^{-1} which are more applicable for all, especially those in weight loss or management programs. While budget constraints to maintain such balanced diets with the increased food prices remain part of the concerns, linear programming techniques were therefore used and applied in producing a model that holds within a certain minimum cost range, which in this study, is below RM 10 each day and comprising three main meals. Table 2 shows three models produced using LP, including all food materials/choices with respective portions according to different caloric intakes. The palatability factor was considered by including servings from olein palm oil and margarine and also evaporated milk commonly used in Malaysian cooking or drinks for individuals of all caloric intake categories.

The food list selected comprises mainly vegetables that are low-energy density and high in fibre, which provides sufficient fibre to meet the recommendations of 20-30 g fibre per day by MDA[7] and MoH[13]. It is also understood from the menus produced that each model consists of at least one to three servings of whole and unprocessed grains such as brown rice, oats and lentils (dhal), in promoting adequate CHO intake with lower GI and higher fibre content. Using brown rice either incorporated with or to fully replace white rice in each meal is supported by Sun *et al.*[18] who reported that substituting brown rice for white rice decreased risk of T2DM independently of other lifestyle factors when examining the role of whole grains for the prevention of T2DM. The food list for each model also provides at least two servings of fish and more than nine servings of vegetables, although it resulted in a slight variation of the existing diets. Consequently, an optimal diabetes management menu was developed based on a model produced by using a linear programming method which meets the requirements of constraints based on the dietary guidelines of MDA[7], NCCFN[12] and MoH[13].

Table 2: Comparison of the three models produced based on different caloric intake and palatability

Energy upper limit		1400	1600	1800
Price		RM9.94	RM9.23	RM9.16
Basmati rice (long, parboiled rice)	2 scoops	2	0	0
Brown rice	2 scoops	1	3	3
Rolled oats (Oat digelek)	½ cup	0	0	1
Kuey-teow noodles	1 cup	0	1	0
Wholemeal wheat flour (Tepung atta)	½ cup	0	0	1
Wheat flour (Tepung gandum)	½ cup	1	1	1
Cauliflower (Bunga kobis)	1 cup chopped	1	0	0
Long beans (Kacang panjang)	1 cup diced	2	2	2
Spinach (bayam)	1 cup (chopped)	1	3	3
Cabbage (kobis)	1 cup shredded	0	0	1
Swamp cabbage or water spinach (kangkung)	1 cup chopped	3	1	1
Chinese kale(Kailan)	1 cup chopped	0	2	2
Bean sprout	1 cup	3	2	0
Evaporated Milk (Susu sejat)	2/3 cup	1	1	1
Catfish (ikan keli)	1 piece	1	1	1
Silver catfish (Ikan patin)	1 piece	0	0	1
Yellow trevally fish (Selar kuning)	1 piece medium	0	1	0
Sardine, raw (Pucuk tamban)	1 whole	1	0	0
Yellow dhal, dry (Dal kuning)	1/4 cup	2	2	2
Olein palm oil (Minyak sawit Olein)	1 tbsp	1	1	1
Margarine (Marjerin)	1 tbsp	1	1	1
Butter (Mentega)	1 slice	0	0	1
Oyster, sauce (Sos tiram)	1 tbsp	1	0	0

Three different menus were produced using LP following the list of food ingredients selected according to each model, set at different energy levels within the lower and the upper limits of different kcal categories. Model 1 is 1391.419 kcal day^{-1} at the highest cost of RM 9.94; Model 2 is 1523.500 kcal day^{-1} at RM9.23 and Model 3 is 1713.500 kcal day^{-1} at the lowest cost of RM 9.17 (Table 3). A slight difference can be made in the list of ingredients in each model by removing the food or placing limits on the same food from a model to the next model to ensure different quantities, or not to be selected by the next model.

Findings from previous research prove that higher consumption level of fibre from green leafy vegetables, yellow vegetables and cruciferous vegetables is associated with a lower risk of T2DM[19]. The menu created also emphasizes the intake of high dietary fibre. The food list selected comprises mainly vegetables as the largest serving, as high fibre intake may result in reduced blood glucose level[20-22]. The menu created restricts the use of added sugar except for sugar naturally found in vegetables. Interestingly, in this study, fruits are excluded from the menu, even though certain specific whole fruits, blueberries, grapes and apples, for instance, have been found to be significantly associated with lower diabetes risk[23].

Moreover, this diet model does not include processed meat, or fast food where lean proteins are the only protein source. Besides that, all three models emphasise using less saturated fat that is achievable by different cooking methods. Only one tablespoon of oil and margarine is used. Hence, the menus created incorporate many healthier ways of cooking such as steaming, grilling or roasting. The use of healthy cooking methods such as steaming can reduce fat content in food[24]. Choi *et al*.[25] have found the effects of five different cooking methods, namely boiling, steaming, grilling, microwaving and superheated steaming. These methods have effects on proximate composition, pH, colour, cooking loss, textural properties and sensory characteristics of chicken steak. It was proven in the study that superheated steam can improve cooked chicken steak[25].

The three models produced fulfil the upper and the lower limits of the constraints including macronutrient and micronutrient recommendations set by MDA[7], NCCFN[12] and MoH[13]. Looking at the three LP models as shown in Table 4, mono-saturated fat, dietary fibre, iron and calcium only reached the lower limit of the constraint values. However, other nutrients such as sugar, saturated fat and poly-saturated fat nearly reached the upper limit of the maximum acceptable value of constraints.

Acceptance of a healthy and balanced diet: Weight and HbA1c level of 10 UKM staff were taken as pre- and post-study. The acceptance of healthy and balanced diet is accessed when the sample adopts and adheres to the diabetes management menu created via LP, resulting in a significant improvement in

Table 3: Development of three diabetic management menus according to caloric intake with minimum cost

Caloric Intake	1400	1600	1800
Meal	Model 1	Model 2	Model 3
Breakfast	Lempeng Dhal gravy with cauliflower	Fried Kuey-Teow with bean sprouts	Rolled oats
Morning snack	-	-	Chapatti dhal gravy
Lunch	Steamed basmati rice (2 scoops) mixed with steamed brown rice (1 scoop) Grilled catfish (1 medium piece) Sayur Masak Lemak (Bean sprouts and long beans)	Steamed brown rice (3 scoops) Fried Kailan Steamed Kangkung Asam Rebus Selar Kuning with long beans	Steamed brown rice (3 scoops) Fried Ikan Patin Stir Fried Kailan Masak Lemak with cabbage
Afternoon snack	-	Lempeng Dhal gravy	Lempeng Dhal gravy
Dinner	Steamed basmati rice (2 scoops) mixed with steamed brown rice (1 scoop) Grilled sardine with roasted cauliflower Kangkung with oyster sauce Spinach soup	Steamed brown rice (3 scoops) Stir-fried spinach Catfish Masak Lemak (1 cup)	Steamed brown rice (3 scoops) Steamed Kailan Grilled catfish Spinach soup
Total consumption	1391.419 kcal day^{-1}	1523.500 kcal day^{-1}	1713.500 kcal day^{-1}
Food cost per day (RM)	RM 9.94	RM 9.23	RM 9.17

Table 4: Nutritional information of three menus based on different caloric intake

	1400			1600			1800		
	Consumption	Lower limit	Upper limit	Consumption	Lower limit	Upper limit	Consumption	Lower limit	Upper limit
Energy kcal^{-1}	1391.42	1200.00	1400.00	1523.50	1400.00	1600.00	1713.50	1600.00	1800.0
Protein g^{-1}	64.50	45.00	70.00	68.00	52.50	80.00	72.00	60.00	90.0
Carb g^{-1}	178.57	135.00	192.50	206.00	157.50	220.00	236.00	180.00	247.5
Fat g^{-1}	46.58	33.33	54.44	47.50	38.89	62.23	53.50	44.44	70.0
Chol mg^{-1}	175.94	60.00	200.00	99.30	60.00	200.00	154.36	60.00	200.0
Sat fat g^{-1}	15.06	9.33	15.56	16.15	10.89	17.78	19.88	12.44	20.0
Mono fat g^{-1}	16.69	16.00	23.33	18.78	18.67	26.67	21.66	21.33	30.0
Poly fat g^{-1}	10.77	6.67	10.89	12.20	7.78	12.44	13.46	8.89	14.0
Sodium mg^{-1}	1253.55	500.00	2300.00	629.01	500.00	2300.00	675.61	500.00	2300.0
Diet fiber g^{-1}	20.01	20.00	30.00	20.19	20.00	30.00	20.30	20.00	30.0
Potas mg^{-1}	2294.55	2000.00	5000.00	3123.39	2000.00	5000.00	3221.91	2000.00	5000.0
Vit A (RE)	2678.93	600.00	3000.00	2802.67	600.00	3000.00	2838.41	600.00	3000.0
Vit C mg^{-1}	298.78	70.00	1000.00	375.51	70.00	1000.00	390.21	70.00	1000.0
Calcium mg^{-1}	1200.09	1200.00	2000.00	1203.78	1200.00	2000.00	1201.48	1200.00	2000.0
Iron mg^{-1}	30.96	29.00	45.00	30.89	29.00	45.00	30.19	29.00	45.0
Thiamin mg^{-1}	4.97	1.10	500.00	10.05	1.10	500.00	10.47	1.10	500.0
Ribo mg^{-1}	3.85	1.10	25.00	3.73	1.10	25.00	3.59	1.10	25.0
Niacin mg^{-1}	26.43	14.00	35.00	24.56	14.00	35.00	25.80	14.00	35.0
Phosphorus mg^{-1}	1471.02	700.00	3000.00	1087.10	700.00	3000.00	1288.49	700.00	3000.0
Sugar g^{-1}	16.59	0.00	17.50	18.34	0.00	20.00	21.43	0.00	22.5

weight loss ($p = 0.029$) and HbA1c control ($p = 0.028$). A diet problem among diabetes patients could therefore be solved with an optimal combination of proposed foods that satisfy their daily nutritional requirements[26]. Hence, the T2DM patients not only have the choice of creating varieties of the healthier menu with lower energy consumption but also have better control of their DM status.

CONCLUSION

This study findings suggest that linear programming is an effective tool inplanning a healthy and balanced diet. It has the capability of interpreting dietary recommendations into an optimized nutritional model at minimal cost according to local market prices. Also, it could serve as an ideal menu for an individual who would like to maintain a healthy lifestyle at lower cost.

One of the limitations to the study is that the sample in the study cannot be considered representative of the general population as it was limited to the university staff rather than randomly sampled from the wider Malaysian population. Also, when creating healthy menus, the program resorted mostly to the cheapest types of food materials, getting the same menu for a day in the result. A larger number of subjects were from different social and economic backgrounds and therefore, more lists of food items should be included in the model to improve the results from future studies.

SIGNIFICANCE STATEMENT

This study has produced a healthy and balanced diet menu plan especially for T2DM at a minimal cost, using linear programming. This will certainly contribute to efforts at better individual management of diabetics.

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