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VEGETARIAN MENU PLANNING THROUGH OPTIMIZATION METHOD: AN OVERVIEW

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ABSTRACT

Diet is important for human body development, restoration and growth. It is essential to consume an appropriate amount of nutrients for a person to stay healthy and live longer. Recently, people who practice vegetarian or vegan diet are increasing significantly from year to year. However, restriction on taking meat-based or even dairy product might result in malnutrition. Vegetarians have to substitute their nutrition source via vegetable-based product instead from meat-based products. This study aimed to review the effect of practicing vegetarian diet and identify various types of optimization techniques used to perform menu planning for vegetarian. In future, this review will provide a deeper insight for nutritionist or person who want to have a good look into vegetarian dietary.

1.0 INTRODUCTION

In 2018, all types of vegetarianism were estimated to make up about 8% of the world population (Bailey, 2018). Vegetarianism is a belief in and practice diet with plant food that excludes any forms of animal food in their meals. Vegan, ovo vegetarian, lacto vegetarian and lacto-ovo vegetarian are the types of vegetarian that quite common around the world. A belief in animals' rights, religions especially Buddha and Hindu, health issues, concern on global warming and environmental protection are the common reasons behind people to become vegetarians (Thed & Toh, 2012).

Since vegetarians are unable to obtain nutrients from animal based product especially meat and seafood, people who practice vegetarian diets might having the problem of deficiency in some nutrients especially protein, vitamin B12, vitamin D, calcium, iron and zinc which may lead to some health problem such as emaciation, anaemia and rickets (Thed & Toh, 2012). It is essential for our body cells to obtain the required nourishments or energy in order to function normally through gaining sufficient nutrients. Besides, nutrition also plays an important role in growing, developing and functioning correctly based on template defined in our genetic code of DNA (WCRF/AICR, 2018). Therefore, there is the case whether ones will face malnutrition that lead to abnormal homeostasis and cancer development.

Diet may play an important role in both promoting and inhibiting human breast cancer development (Kotepui, 2016). A well-planned vegetarian diet is healthful and nutritionally adequate where it provides health benefits for the prevention and treatment of certain critical diseases in which majority are cancer-based diseases. Therefore, healthy eating may be best achieved with plant-based diet (Tuso *et al.*, 2013). A balanced diet is very important to be practiced by everyone daily. A continuous practicing of a balanced diet would ensure one to obtain the sufficient nutrients required by their body. This will prevent a person from getting illness and help a person to maintain a healthy body simultaneously.

A menu planning with optimal nutrients could be designed using optimization approaches such as Linear Programming (LP), Integer Programming (IP), Binary Programming (BP) and etc. A diet planning using optimization approaches has the purpose of finding the optimal combination of foods for a population, a subpopulation or even an individual that could satisfy a set of constraints while minimizing or maximizing an objective function (Gazan *et al.*, 2018).

2.0 LITERATURE REVIEW

2.1 Effects of vegetarian diet towards children

Numerous researchers investigated the effect of consuming vegetarian diet on children health. Hackett, Nathan & Burgess (1998) investigated the adequacy of vegetarian diet for children. Based on their study, they found that children who practiced vegan diets are more likely to be associated with malnutrition. However, lacto-ovo vegetarian children have pre-pubertal growth in a good state. According to a research, results showed that vegan children have lower adjusted median intakes of protein, fats and added sugars (Weder *et al.*, 2019). Overall, the result showed that vegan diet is less suitable for children compared to vegetarian diet because of vegan diet the strict restriction of food intake.

However, vegan children have higher adjusted median intake of carbohydrates and fibre, but which still insufficient in promoting growth for a growing child.

Ambroszkiewicz *et al.* (2019) investigated 106 children where half of them were vegetarian and the rest were omnivorous with the median age of 7 years old. According to the investigation, vegetarian children have lower total and lumber spine bone mineral density than omnivorous children during pre-pubertal state. Furthermore, there is another research also said that vegetarianism is not suitable for children's growth (Cofnas, 2019). They also found out that there are still many unknowns about the health effects of meatless diets in children. Based on the literature reviewed, most of the researches mentioned that vegetarian or vegan diet is less suitable for children.

2.2 Effects of vegetarian diet towards adolescents / adults

Although vegetarian diet shows negative results in childhood intakes, the intake of vegetarian diet during adolescents was shown to have a positive effect. A study was carried out by Gonçalves *et al*. (2019) which involved 107 university students where 58 students follows vegetarian diet while 49 students follow non-vegetarian diet for a period of at least 1 year. The results were obtained through TXRF spectroscopy to determine the trace element in whole blood which give a conclusion that both student groups that took vegetarian and omnivorous diet showed adequate intakes for some macronutrients while deficiencies for some micronutrients.

Another study also conducted a comparison of dietary intakes of vegetarian and non-vegetarian adolescents (Segovia-Siapco *et al*., 2019). The study was conducted by inspecting 534 adolescents and measure 151 items self-administered web-based food frequency, weight and height. Throughout the study, most of the students follow strictly to the diet that they being assigned. According to the result obtained, vegetarian adolescents consumed more fruits, vegetables, dairy and protein foods. Thus, more micronutrients but fewer macronutrients by vegetarian adolescents as compared to non-vegetarians. Overall, vegetarian adolescents have more favourable dietary intake profile than non-vegetarian adolescents.

Movassagh *et al*. (2018) carried out a study on the effect of bone density from adolescents to young adulthood. At a total of 125 participants which includes 72 males and 53 females adolescents from Saskatchewan Pediatric Bone Mineral Accrual Study were recruited to measure 5 different dietary patterns by scanning their Bone Mineral Content (BMC), areal Bone Mineral Density (aBMD) of total body (TB), femoral neck (FN) and lumbar spine (LS) using dual-energy X-ray absorptiometry. Based on statistics, dietary pattern of "Vegetarian-style" had a positive relationship with adolescents' TBBMC.

However, some researches showed negative effects of vegetarian diet on adolescents. There was a research said that vegetarian diet has lower mean intakes of some nutrients such as omega-3 fatty acid Docosahexaenoic Acid (DHA), iron and zinc due to the bioavailability from vegetable foodstuff (Rudloff, 2018). Despite the high intake of vitamin C, the risk of iron deficiency can be high as well. The research also stated that the intake of vitamin B12 would be a difficulty for strict vegan diet.

Based on the literature reviewed, adolescents should follow a strict diet where they have to consume a sufficient amount of food according to the recommended daily nutrients intake to obtain positive impact from vegetarian diet towards adolescents. Eating without planning would result in deficiency in particular nutrients.

2.3 Effects of vegetarian diet towards elders

As an individual reaches a certain age, the ability of nutrient absorption would slowly drop from age to age. According to a study done by Russell (2001), the older the person, the higher the chance of changing in gastrointestinal physiology which leads to atrophic gastritis. Atrophic gastritis will reduce the absorption of vitamin B12, calcium and iron. Besides, the lower absorption ability of calcium is due to the age-related changes in vitamin D metabolism that caused by reduced skin synthesis. Therefore, elders that practice vegetarian diet would be advised to take some food supplement to achieve their daily required nutrients.

Furthermore, elders that practice vegetarian diet may have a higher risk factor for depression as compared to meat-based diet (Li *et al*., 2019). This statement was concluded after analyzing data from 1051 elderly persons using Cohort Elderly Health Environmental Controllable Factors. This statement was supported by several evidences such as lower intake of omega-3 HUFAs, vitamin B12 and folate which associated with greater risk of depression. On the other hand, the research said that vegetable consumption and depression have an inverse relationship (Wolniczak, 2017). However, the positive impact from vegetable consumption yet outperforms the negative impact from the lacking of nutrients of omega-3 HUFAs, vitamin B12 and folate.

Although most of the literature said that vegetarian diet will lead to malnutrition toward elders, nutritionists suggested that malnutrition issues can be overcome by following strict diet planning (Johnston & Dahl, 2018). In their report, well planned and balanced vegetarian or vegan diet were found to be beneficial to health issues such as obesity, heart disease, and other chronic diseases.

2.4 Importance of Menu Planning

It is very important for everyone to obtain sufficient nutrition from their diet daily where the problem of malnutrition could be avoided and the risk of having diseases could be reduced as well. Therefore, an individual should follow the menu planning strictly to achieve a balanced diet where their eating menu should be well-planned and scheduled. A menu planning through diet optimization aims to obtain the optimal or the best combination of food for a population, a subpopulation or even an individual which

could satisfy a set of constraints while minimizing or maximizing an objective function (Gazan *et al*., 2018).

In medical field, it is common that menu planning is widely used by the hospital catering department in order to ensure the quality of catering could meet the nutritional needs of the patients. Besides, menu planning and scheduling could ease the process for the doctors to monitor their patients' health status since following a scheduled menu could reduce the risk of worsening the patients' health condition or even aid them to recover more easily. Therefore, it is very important to consider the management perspective where the cooking staff should know a planned menu in advance such as for n-number of days and for preparing cooking ingredients to serve a massive number of inpatients in a hospital (Choosri & Anprasertphon, 2015). Patients suffer from many diseases such as heart disease, cancer, hypertension, diabetes and etc. are most encouraged to practice a suitable menu planning daily for their benefits.

In the field of nutrition, a diet optimization model aims to find the unique combination of foods that maximizes an objective such as total diet cost, the content of a given nutrient, total deviation from the observed diet, while satisfying the nutritional recommendations and or amounts of foods, food groups at the same time. Other constraints could be considered in the optimization model based on the researchers' preference (Gazan *et al*., 2018).

Ducrot *et al*. (2017) assessed the meal planning practices on 40,554 participants via an optional questionnaire launched in the web-based observational NutriNet-Santé cohort study in April 2014. The results obtained showed that meal planning was associated with lower possibility of being overweight and obese among women. Besides, meal planning was associated with a healthier diet and less obesity. Moreover, meal planning could potentially be relevant for obesity prevention. It showed us the importance and the impact of a menu planning towards an individual.

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2.5 Recommended Nutrition

There are 30 essential nutrients required by a normal person suggested by Ministry of Health Malaysia (2017) and are tabulated in Table 1. Nutrient-poor, energy-dense food and drinks are replaced with a large amount of vegetables, fruits and wholegrain cereals which will help prevent chronic disease. The public was also be advised to consume natural food sources rather than commercially available dietary supplements

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Table 1. 30 Essential nutrients required by a person

Energy / Micronutrients	Vitamins		Minerals & Trace Elements.	
Energy	Vit B1	Vit B12	Calcium	Potassium
Protein	Vit B2	Vit C	Iron	Magnesium
Fat	Vit B3	Vit A	Iodine	Chromium
Carbohydrate	Vit B5	Vit D	Zinc	Copper
	Vit B6	Vit E	Selenium	Manganese
	Vit B9	Vit K	Phosphorus	Molybdenum
			Sodium	Fluride

2.6 Menu planning through optimization

There are various types of menu planning methods, the most commonly used is optimization method. Optimization methods such as Linear Programming, Integer programming, Binary programming, Goal Programming and etc. could be adopted to make up a menu with optimal nutrients. In the optimization problem, the parameters such as decision variables, the constraints, and the objective function are included in the modelling. Mathematically, an optimization model aims to find the unique combination of values for decision variables that generate the optimal value for one objective function, while fulfilling a set of equalities or inequalities, called constraints (Gazan *et al*., 2018).

Using the list of locally available food in Malawi, linear programming was adopted by Darmon, Ferguson & Briend (2002) for the season of harvest and non-harvest to select food that satisfies nutritional and food-habit constraints at a minimal amount of energy. The findings showed that it was possible to satisfy nutritional recommendations with little departure from the local diet during the harvest season. However, nutritional inadequate happened during non-harvest season where it was found to have low availability of riboflavin- and zinc-rich animal or vegetable foods and by the high phytate content of other foods. Next, a linear programming model was constructed by Okubo *et al*. (2015) to minimize the differences between observed and optimized food intake patterns. The diets optimized with the 28 studied nutrients were developed successfully using linear programming for different age and sex groups, deviating as little as possible from the average observed diet of each subpopulation.

Linear programming was applied by both of these researches in their study which involved the optimization of a linear objective function, subjected to the linear equality or inequality constraints of decision variables (Hreţcanu & Hreţcanu, 2010). The general form of linear programming is shown as follows (Geomans, 2015):

$$\text{Maximize or Minimize} \quad z = c_0 + c_1 x_1 + \ldots + c_n x_n \tag{1}$$

$$\text{Subject to} \quad \begin{aligned} a_{i1} x_1 + a_{i2} x_2 + \ldots + a_{in} x_n &\le b_i \\ a_{i1} x_1 + a_{i2} x_2 + \ldots + a_{in} x_n &\ge b_i \\ a_{i1} x_1 + a_{i2} x_2 + \ldots + a_{in} x_n &= b_i \end{aligned} \qquad i = 1, \ldots, \text{m} \tag{2}$$

$$x_j \geq 0 \qquad j = 1, \ldots, n \quad (3)$$

where a_{mn} and c_n are the objective coefficient, m is the number of constraint and n is the number of objective variables.

There are several researchers adopted integer programming to solve the menu planning problem. Sapri *et al*. (2019) proposed an integer programming model for meal planning of diabetic patients which meets their nutritional requirement at minimum cost. Besides, a study proved that integer programming techniques can be used to optimize the nutrients intake and costs for the eczema patients (Sheng & Sufahani, 2018). Moreover, Su Hui & Sufahani (2019) adopted linear and integer programming to generate the one-day meal plan for the high blood pressure patients of 80 years old male and 54 years old female. Based on the results, the cost of the one-day menu for the integer programming (IP) approach was higher than linear programming (LP) approach.

Integer programming had been used by Sapri *et al*. (2019) and Su Hui & Sufahani (2019). Similar with linear programming which is also optimizing linear equality or inequality constraints of the decision variables with additional constraints that the decision variables must be in integer form. The general form of integer programming is shown as follows:

$$\text{Maximize or Minimize} \quad z = c_0 + c_1 x_1 + \ldots + c_n x_n \quad (1)$$

$$\text{Subject to} \quad \begin{matrix} a_{i1}x_1 + a_{i2}x_2 + \ldots + a_{in}x_n \leq b_i \\ a_{i1}x_1 + a_{i2}x_2 + \ldots + a_{in}x_n \geq b_i \\ a_{i1}x_1 + a_{i2}x_2 + \ldots + a_{in}x_n = b_i \end{matrix} \qquad i = 1, \ldots, m \quad (2)$$

$$x_j \geq 0, \; x_j \in \mathbb{Z}^n \qquad j = 1, \ldots, n \quad (4)$$

where a_{mn} and c_n are the objective coefficient, m is the number of constraint and n is the number of objective variables.

There were 11 nutrients such as energy, fats, carbohydrate, protein, niacin, vitamin A, vitamin B1, vitamin B2, vitamin C, calcium and iron considered by Ali, Sufahani & Ismail (2016) during formulating a menu planning using Binary Programming. The model proposed was able to minimize the budget provided by the government for boarding school caterers and maximize the variety of food intake. It also managed to achieve the maximum nutritional requirement based on the Malaysian RDA requirements. Binary Programming was adopted by Sufahani, Ismail & Kek (2018) with the aid of Matlab and LPSolve programming language in order to produce optimal solutions focused on school children aged from 13 to 18 years old. The menu planned to cost less than USD 3.92 for one day.

Binary programming contains stricter constraints than linear programming and integer programming. Aside from basic decision variables, it also requires the decision variables to be an integer with the value of 0 or 1. The general form of binary programming is shown as follows:

$$\text{Maximize or Minimize} \quad z = c_0 + c_1 x_1 + \ldots + c_n x_n \quad (1)$$

$$\text{Subject to} \quad \begin{matrix} a_{i1}x_1 + a_{i2}x_2 + \ldots + a_{in}x_n \leq b_i \\ a_{i1}x_1 + a_{i2}x_2 + \ldots + a_{in}x_n \geq b_i \\ a_{i1}x_1 + a_{i2}x_2 + \ldots + a_{in}x_n = b_i \end{matrix} \qquad i = 1, \ldots, m \quad (2)$$

$$x_j = \{ 0 , 1 \} \qquad j = 1, \ldots, n \quad (5)$$

where a_{mn} and c_n are the objective coefficient, m is the number of constraint and n is the number of objective variables.

Furthermore, goal programming can also be applied for menu planning. A study was conducted with the aims to determine the optimal dietary menu variations for diabetes mellitus patients and minimize the expenses (Pasic *et al.*, 2012). The study was carried out by analyzing the data obtained from hospital in Yogyakarta and completed using LINGO computer program. Dhoruri, Lestari & Ratnasari (2017) also developed a goal programming nutrition optimization model for regular person according to World Health Organization (WHO) standards. This research consisted of 55 most frequently used food items as decision variables which were selected based on 50 households in Bosnia and Herzegovina.

Goal programming contains different constraints compared to linear programming, integer programming and binary programming. It is used to optimize multiple objectives for a problem. The general form of goal programming is shown as follows:

$$\text{Maximize or Minimize} \quad z = \sum_{i=1}^{n} c_i x_i (d_i^- + d_i^+) \quad (6)$$

$$\text{Subject to} \quad \sum_{i=1}^{n} a_{ij} x_j + d_i^- - d_i^+ = b_i \qquad i = 1, \ldots, m \quad (7)$$

$$x_j, d_i^-, d_i^+ \geq 0 \qquad j = 1, \ldots, n \quad (8)$$

$$d_i^- \times d_i^+ = 0$$

where a_{mn} and c_n are the objective coefficient, d is the deviational variable, m is the number of constraint and n is the number of objective variable.

However, studies on specific menu planning of vegetarian diet is relatively low in number since only 8% of the people in this world are vegetarian or vegan (Bailey, 2018). Only little attention was given to investigate the menu planning for vegetarian consumers. Orešković, Kljusurić & Šatalić (2015) applied menu planning based on computer-generated menus. The research was done by evaluating weekly vegan menu using three different food composition databases. The menus quantities were optimized using Linear Programming method. The result showed the generated menus provide adequate quantity of essential nutrients and were able to minimize the differences due to different data in the database. The researchers also concluded that Linear Programming method proved to be an effective optimization tool in planning vegetarian diet and especially vegan diet.

Apart from that, a study was carried out to identify the feasibility of urban agriculture making a substantial contribution to the food security by exploring different dietary preferences (Ward *et al*., 2014). Linear Programming optimization method was applied in the study to optimize the

diet decision of high meat intake and vegetarian diet. Based on their results, it was shown that Linear Programming as an effective method to produce the menu for both non-vegetarian and vegetarian diet.

Tyszler Kramer & Blonk (2016) also applied Linear Programming to study the environmental impact based on three different diet restrictions for woman with age 31 to 50 which includes no restriction (omnivorous), meat-based restriction (vegetarian) and restriction of meat, fish, dairy or eggs (vegan). Based on their study, planned vegan diet able to achieve a 30% environmental impact reduction as well as 21% of environmental impact reduction from planned vegetarian diet.

Apart from programming optimization methods, artificial intelligence optimization method is suitable to plan the menu for vegetarian diet. Gaál, Vassányi & Kozmann (2007) applied automated menu generator (MenuGene) of web-based lifestyle counselling system to provide personalized diet advices. This menu generator generates the diet by adopting Genetic Algorithm method. Based on the results, Genetic Algorithm showed a success in planning dietary menus that satisfy strict numeral constrict for different item restrictions.

Genetic Algorithm is a machine learning method where the machine will optimize the solution according to the constraints provided by learning through patterns and evolve from generation to generation. The Genetic Algorithm optimize the decision variables by following these steps:

1. Generate a fixed amount and size of the chromosome population.
2. The genes of the chromosome are randomly generated based on binary number.
3. For every generation, each of the chromosomes are evaluated based on their fitness.
4. Two random chromosomes are chosen to breed a chromosome to be included in the next generation population through crossing techniques. The chromosomes with higher fitness are most probability to be chosen.
5. Some genes in some chromosomes will be mutated where 0 will turn into 1 or vice versa.
6. The population iterates the above steps until it reached a stopping criteria.

The summary of the optimization approaches are tabulated in Table 2.

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Table 2. Summary of the optimization approaches

Citation	Technique	Diet	Research Objectives
Darmon *et al.* (2002)	Linear Programming	Omnivorous	- To design the nutrient adequate diets of optimal nutrient density - To identify the most stringent constraints in nutritional recommendations and food consumption
Okubo *et al.* (2015)	Linear Programming	Omnivorous	To explore optimal food intake patterns that meet the nutrient recommendations of Dietary Reference Intakes.
Sapri *et al.* (2019)	Integer Programming	Omnivorous	To provide a combination of food menu that satisfies the daily nutrient requirements of a diabetic person at a minimum cost.
Sheng & Sufahani (2018)	Integer Programming	Omnivorous	To optimize the nutrients intake and costs for the eczema patients
Su Hui & Sufahani (2019)	Integer Programming & Linear Programming	Omnivorous	To construct a diet menu that meet the nutritional requirement of high blood pressure patient as well as lower the food cost.
Ali *et al.* (2016)	Binary Programming	Omnivorous	To develop a mathematical model for diet planning that meets the necessary nutrients intake for the secondary school students as well as minimizing a budget.
Sufahani *et al.* (2018)	Binary Programming	Omnivorous	To develop a mathematical method for menu scheduling that satisfy the entire nutrient requirement for school children.
Pasic *et al.* (2012)	Goal Programming	Omnivorous	To determine the optimal dietary menu variations for diabetes mellitus patients and minimize the expenses
Dhoruri *et al.* (2017)	Goal Programming	Omnivorous	To develop goal programming nutrition optimization for regular person according to WHO standards
Orešković *et al.* (2015)	Linear Programming	Vegetarian	To propose a menu planning based on computer-generated menus.
Ward *et al.* (2014)	Linear Programming	Vegetarian	To apply Linear Programming optimization method to optimize the diet decision of high met intake and vegetarian diet.
Tyszler *et al.* (2016)	Linear Programming	Vegetarian	To demonstrate a method that is able to identify diets with reduced environmental impact and are more similar to current diet than predetermined scenario.
Gaál *et al.* (2007)	Genetic Algorithm	Vegetarian	To propose an automated menu generator (MenuGene) of web-based lifestyle counselling system to provide personalized diet advised by adopting Genetic Algorithm

3.0 CONCLUSION

Practicing vegetarian diet is beneficial which it enables vegetarianism to stay a healthy lifestyle with a longer lifespan. However, people who practice vegetarian diet might have a high risk of malnutrition if their diet do not fulfill the recommended dietary intake. Hence, a vegetarian diet should be developed properly in order to overcome the problem of malnutrition where vegetarian menu planning and scheduling could be done using optimization approaches. Linear programming, Integer Programming, Binary Programming, Goal Programming and Genetic Algorithm are the several optimization approaches adopted by the researchers for dealing with the issue of menu planning and scheduling. Based on the literature reviewed, Linear Programming was found to be the most familiar approach by

the researchers for vegetarian menu planning and scheduling. Overall, this study provides a better insight which give readers an overview about the effects of vegetarian diet for all ages and also the application of optimization techniques in vegetarian diet menu planning. Although there were only limited literature about vegetarian menu planning available for now, perhaps more attention could be focused on planning and scheduling a vegetarian diet by other researchers in the future.

Reference

Ali, M., Sufahani, S., & Ismail, Z. 2016. A New Diet Scheduling Model for Malaysian School Children Using Zero-One Optimization Approach. *Global Journal of Pure and Applied Mathematics* 12(1), 413–419.

Ambroszkiewicz, J., Chełchowska, M., Szamotulska, K., Rowicka, G., Klemarczyk, W., Strucińska, M., & Gajewska, J. 2019. Bone Status and Adipokine Levels in Children on Vegetarian and Omnivorous Diets. *Clinical Nutrition* 38(2), 730–737.

Bailey, P. 2018. *What Does It Mean to Consumers? An Exploration into Diets around the World*. Retrieved 28 September 2020, from https://www.ipsos.com/sites/default/files/ct/news/documents/2018-09/an_exploration_into_diets_around_the_world.pdf

Choosri, N., & Anprasertphon, S. 2015. Hospital Dietary Planning System Using Constraint Programming. *5th International Conference on Innovative Computing Technology, INTECH 2015*, 17–22.

Cofnas, N. 2019. Is Vegetarianism Healthy for Children? *Critical Reviews in Food Science and Nutrition* 59(13), 2052–2060.

Darmon, N., Ferguson, E., & Briend, A. 2002. Linear and nonlinear programming to optimize the nutrient density of a population's diet: an example based on diets of preschool children in rural Malawi. The American journal of clinical nutrition 75(2), 245-253.

Dhoruri, A., Lestari, D., & Ratnasari, E. 2017. Menu Variations for Diabetes Mellitus Patients Using Goal Programming Model. *AIP Conference Proceedings* 1867, 1–13.

Ducrot, P., Méjean, C., Aroumougame, V., Ibanez, G., Allès, B., Kesse-Guyot, E., Hercberg, S., & Péneau, S. 2017. Meal Planning Is Associated with Food Variety, Diet Quality and Body Weight Status in a Large Sample of French Adults. *International Journal of Behavioral Nutrition and Physical Activity* 14(1), 12–14.

Gaál, B., Vassányi, I., & Kozmann, G. 2007. *Application of Artificial Intelligence for Weekly Dietary Menu Planning*. Springer Berlin Heidelberg.

Gazan, R., Brouzes, C. M. C., Vieux, F., Maillot, M., Lluch, A., & Darmon, N. 2018. Mathematical Optimization to Explore Tomorrow's Sustainable Diets: A Narrative Review. *Advances in Nutrition* 9(5), 602–616.

Goemans, M. 2015. Linear Programming, Retrieved 28 September 2020, from http://www-math.mit.edu/~goemans/notes-lp.ps

Gonçalves, A. V., Pereira, R. C., Bissoli, M. C., Sanson, A. L., Afonso, R. J. de C. F., & de Angelis-Pereira, M. C. 2019. Nutrition Status and Quantification of Blood Minerals by TXRF Spectroscopy in Vegetarian and Non-Vegetarian University Students. *Acta Scientiarum - Health Sciences* 41(1), 1–11.

Hackett, A., Nathan, I., & Burgess, L. 1998. Is a Vegetarian Diet Adequate for Children? *Nutrition and Health* 12(3), 189–195.

Hreţcanu, C., & Hreţcanu, C. 2010. A Linear Programming Model for a Diet Problem. *Journal Food and Environment Safety of the Suceava University*, 56–63.

Johnston, K., & Dahl, W. J. 2018. *Vegetarianism and the Older Adult*.

Kotepui, M. 2016. Diet and Risk of Breast Cancer. *Wspolczesna Onkologia* 20(1), 13–19.

Li, X. de, Cao, H. juan, Xie, S. yu, Li, K. chun, Tao, F. biao, Yang, L. sheng, Zhang, J. qing, & Bao, Y. song. 2019. Adhering to a Vegetarian Diet May Create a Greater Risk of Depressive Symptoms in the Elderly Male Chinese Population. *Journal of Affective Disorders* 243(May 2018), 182–187

Ministry of Health Malaysia. 2017. *Recommended Nutrient Intakes for Malaysia 2017*. *Ministry of Health Malaysia*.

Movassagh, E. Z., Baxter-Jones, A. D. G., Kontulainen, S., Whiting, S., Szafron, M., & Vatanparast, H. 2018. Vegetarian-Style Dietary Pattern during Adolescence Has Long-Term Positive Impact on Bone from Adolescence to Young Adulthood: A Longitudinal Study. *Nutrition Journal* 17(1), 1–10.

Okubo, H., Sasaki, S., Murakami, K., Yokoyama, T., Hirota, N., Notsu, A., Fukui, M., & Date, C. 2015. Designing Optimal Food Intake Patterns to Achieve Nutritional Goals for Japanese Adults through the Use of Linear Programming Optimization Models. *Nutrition Journal* 14(1), 1–10.

Orešković, P., Kljusurić, J. G., & Šatalić, Z. 2015. Computer-Generated Vegan Menus: The Importance of Food Composition Database Choice. *Journal of Food Composition and Analysis* 37, 112–118.

Pasic, M., Catovic, A., Bijelonja, I., & Bahtanovic, A. 2012. Goal programming nutrition optimization model. In *23rd DAAAM International Symposium on Intelligent Manufacturing and Automation 2012* 23(1), 243–246.

Rudloff, S., Bührer, C., Jochum, F., Kauth, T., Kersting, M., Körner, A., Koletzko, B., Mihatsch, W., Prell, C., Reinehr, T., Zimmer, K. P., Rudloff, S., Bührer, C., Jochum, F., Kauth, T., Körner, A., Koletzko, B., Mihatsch, W., Prell, C., Reinehr, T., & Zimmer, K. P. 2018. Vegetarian Diets in Childhood and Adolescence: Statement of the Nutrition Committee of the German Society for Pediatric and Adolescent Medicine (DGKJ). *Monatsschrift Fur Kinderheilkunde* 166(11), 999–1005.

Russell, R. M. 2001. Factors in Aging That Effect the

Bioavailabiity of Nutrients. *The Journal of Nutrition* 131(4), 1376–1382

Sapri, N. S. M., Bedi, M. R. B. D. S., Abdul-Rahman, S., & Benjamin, A. M. 2019. A diet recommendation for diabetic patients using integer programming. In *AIP Conference Proceedings* 2138, 1–6.

Segovia-Siapco, G., Burkholder-Cooley, N., Haddad Tabrizi, S., & Sabaté, J. 2019. Beyond Meat: A Comparison of the Dietary Intakes of Vegetarian and Non-Vegetarian Adolescents. *Frontiers in Nutrition* 6(June), 1–11.

Sheng, L. Z., & Sufahani, S. 2018. Optimal Diet Planning for Eczema Patient Using Integer Programming. *Journal of Physics: Conference Series* 995(1), 1–9.

Su Hui, L., & Sufahani, S. 2019. Healthy Menu Scheduling for High Blood Pressure Patient with Optimization Method through Integer Programming. *Advances in Computing and Intelligent System* 1(1), 1–5.

Sufahani, S. F., Ismail, Z., & Kek, S. L. 2018. A Binary Programming Mathematical Approach for Serving Healthy and Palatable Secondary School Menu, *In: A letter on applications of mathematics and statistics*. 1–6.

Thed, S. T., & Toh, J. X. 2012. Vegetarianism Among Young Adults in Klang Valley. *4th Asia-Euro Conference 2012 in Tourism, Hospitality & Gastronomy* 9(1), 1–6.

Tuso, P. J., Ismail, M. H., Ha, B. P., & Bartolotto, C. 2013. Nutritional Update for Physicians: Plant-Based Diets. *The Permanente Journal* 17(2), 61–66.

Tyszler, M., Kramer, G., & Blonk, H. 2016. Just Eating Healthier Is Not Enough: Studying the Environmental Impact of Different Diet Scenarios for Dutch Women (31–50 Years Old) by Linear Programming. *International Journal of Life Cycle Assessment* 21(5), 701–709.

Ward, J. D., Ward, P. J., Mantzioris, E., & Saint, C. 2014. Optimising Diet Decisions and Urban Agriculture Using Linear Programming. *Food Security* 6(5), 701–718.

WCRF/AICR. 2018. *Diet, Nutrition, Physical Activity and Cancer: A Global Perspective*. *Continuous Update Project Expert Report 2018*.

Weder, S., Hoffmann, M., Becker, K., Alexy, U., & Keller, M. 2019. Energy, Macronutrient Intake, and Anthropometrics of Vegetarian, Vegan, and Omnivorous Children (1-3 Years) in Germany (VeChi Diet Study). *Nutrients* 11(4), 1–18.

Wolniczak, I., Cáceres-DelAguila, J. A., Maguiña, J. L., & Bernabe-Ortiz, A. 2017. Fruits and Vegetables Consumption and Depressive Symptoms: A Population-Based Study in Peru. *PLoS ONE* 12(10), 1–12.