INDIAN JOURNAL OF SCIENCE AND TECHNOLOGY

RESEARCH ARTICLE

A Decision Support System for Optimizing Nutrient in Daily Lunch Intake among College Students in Cagayan de Oro City, Philippines using Linear Programming

Rhoda A Namoco[1]*, Aristeo L Abecia[1], Raymond O Pailagao[1]

1 Department of Applied Mathematics, College of Science and Mathematics, University of Science and Technology of Southern Philippines - Cagayan de Oro, C.M. Recto Avenue, Lapasan, 9000, Cagayan de Oro, Philippines

OPEN ACCESS

Received: 30.08.2021

Accepted: 09.12.2021

Published: 22.12.2021

Citation: Namoco RA, Abecia AL, Pailagao RO (2021) A Decision Support System for Optimizing Nutrient in Daily Lunch Intake among College Students in Cagayan de Oro City, Philippines using Linear Programming. Indian Journal of Science and Technology 14(45): 3304-3317. https://doi.org/10.17485/IJST/v14i45.1457

* **Corresponding author**.

rhoda.namoco@ustp.edu.ph

Funding: None

Competing Interests: None

Copyright: © 2021 Namoco et al. This is an open access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Published By Indian Society for Education and Environment (iSee)

ISSN
Print: 0974-6846
Electronic: 0974-5645

Abstract

Objectives: This study aims to develop a decision support system to find food choices that will optimize nutrient intake among college students given their food choices and budget by formulating and solving linear programming models. **Methods:** Survey interviews among college students in various colleges and universities around Cagayan de Oro City were conducted to determine the foods which they usually eat as well as their usual budget for lunch. Moreover, cafeterias and fast-food chains located near school areas were also visited to ascertain the kind of foods they serve to students as well as the corresponding prices per serving of these foods. Using this information such as costs per food serving, nutrient content, student meal budget and their food preferences, linear programming models are then formulated and solved while making sure that individual nutrient requirements are met. The models are then incorporated into an excel-based program to present a user-friendly decision support system (DSS) for determining lunch menu options. **Findings:** Results of the study show various lunch food combinations for male and female college students. Recommended food menu costs vary according to sex, age, BMI classification and level of daily activity. For example, the lowest for normal BMI male between 14-18 years old is PhP 40 while the lowest food menu cost for 14-18 years old female with normal BMI is PhP 45. In particular, the DSS developed in this study allow students to input their preferences such as choice of drink, viand, number of servings preferred and budget allotted for a particular meal, as well key-in their personal attributes (such as height, weight, physical activities engaged in) which are then used as basis for computing the recommended lunch menu options. **Novelty.** This study provides students the guide for a more nutritionally-filled lunch menu that is within their budget.

Keywords: Nutrition; Food choices; Linear Programming; Optimization; Decision Support System

1 Introduction

With the transition from secondary school to college or university, as independency increases, students are constantly challenged to make healthy food selections[1]. Such transition into young adulthood is frequently a period of unhealthy lifestyle where young people could assume long-lasting health behavior habits. In particular, college students are exposed to unhealthy eating habits leading to body weight gain, and make their independent food choices, sometimes based on cost of food and availability of fast food. Diet formulation among humans generally requires, first and foremost, defining the food to be considered in the formulation and consequently, analyzing their corresponding nutrient composition[2].

Varying age groups have different energy requirements[3]. In the Philippines, college students are usually composed of individuals whose ages are between 16–21 years old. The 8th National Nutrition Survey conducted by Philippines' Department of Science and Technology in 2013 reports that in every 100 adolescents (aged 11–19 years old), about 17 were found to be underweight and about 5 were overweight[4]. The survey report also pointed out a significant increase in the prevalence of underweight among adolescents as compared to the 2008 Nutrition survey. Overweight adolescents, on the other hand, significantly decreased in the 2013 survey results.

The World Health Organization (WHO) Food and Nutrition Security Profiles mentioned that although the Philippines has experienced growth in per-capita gross domestic product (GDP) and dietary energy supply (DES), the dietary quality among Filipinos has remained poor and based on cereals. The poor quality of diet has contributed to high levels of stunting and underweight among young children. In addition, socioeconomic inequalities have been highly associated with malnutrition, and inadequate access to improved sanitation and high levels of food inflation have also contributed to malnutrition. Moreover, WHO reported that one-third of adults are overweight, and obesity represents an emerging issue because of unbalanced and calorie-dense diets. The reduction of physical activities among adolescents and adults have further contributed to the increase in overweight Filipinos[5].

A healthy diet is basically one that includes the appropriate number of servings in essential food groups. College students spend a large part of their time at school, where they may consume one or more meals or snacks. An adequate diet that meets nutritional requirements is crucial for healthy physical growth and cognitive development during adolescence and can also have an influence on health and work capacity later in these students' life[5]. College or University populations are vulnerable in their eating habits for various reasons. Students might be deficient in their knowledge of healthy food selections that could negatively influence their eating habits. Financial aspects might also play a role, as fats and sweets cost less, whereas many healthy foods cost more, and increased financial concerns are associated with worse health. Planning for a nutritious meal at school may provide opportunities to students to improve their dietary intake, and in turn, help them achieve their full developmental potential.

Only 31.7 percent of Filipino households met 100 percent of the energy recommendation. The Estimated Average Requirements (EAR) for niacin and protein was met by 86.4 and 62.7 percent of households, respectively. The proportion of households meeting the EAR for the rest of the nutrient ranged from 25 to 35 percent except calcium (15.2%) and iron (8.8%). In rural areas, the proportion of households meeting the energy intake was slightly higher than in urban areas. However, the proportion of households meeting the EAR for all nutrients was higher in urban areas, except for calcium and vitamin C. Among regions, the proportion of households meeting 100 percent of the recommended energy intake was highest in CAR (40.8%) and lowest in SOCCSKSARGEN (25.8%). Regions with the highest proportion of households meeting the EAR for nutrients were NCR for protein (72.4%), CAR for iron (19.4%), vitamin A (35.4%), thiamin (49%) and riboflavin (34.8%) and Cagayan Valley for calcium (26.5%) and vitamin C (44.5%)[6].

The main goal of nutrition plans is to obtain the appropriate and necessary nutrition to remain healthy, to be physically prepared and to lead a healthy life. For this reason, to promote the health level of a society, and the attitudes of its people, must be taken into account. Given that one of the main goals of colleges and universities is to broaden the knowledge of the society, the enhancement of the nutrition attitudes, knowledge and practices of the students is of high importance, as this will subsequently lead to a more food-conscious society and healthier people. Some studies have shown that most students are not familiar with the healthy foods needed for their body in different conditions[1,4]. Research showed that the majority of students (83.6%) eat three meals during the day regularly and no difference was found between men and women[6].

According to the 8th National Nutrition Survey Report[2], energy inadequacy is greatly observed among adolescents. Based on their study, over a period of 20 years, the mean daily energy intake increase can only be observed among preschool children. Tanchoco[4] reviewed the formulation of positive, practical and culturally sensitive food-based dietary guidelines (FBDGs) to help Filipinos choose an adequate diet and foster wholesome food and nutrition practices to promote good health. She pointed out that there is a need to come up with a comprehensive plan that includes implementation, assessment, monitoring and reformulation of dietary patterns for Filipinos. The paper provided guidelines on how food for Filipinos must be prepared in order to meet the required nutrients.

Angeles-Agdeppa, et al.[1] investigated the dietary intakes and acceptance of nutritionally balanced school meals (or nutri-meals) as compared with regular (or baseline) school meals among high school students. They found out that nutritionally balanced nutri-meals may be a healthier and acceptable alternative to regular Filipino school meals. The focus of the study was on assessing the acceptability of new school meals among Filipino students. Results of the study may be used as basis for improving dietary intakes among students.

Magbuhat, et al.[5] examined differences in food preferences and dietary intake among male and female Filipino adolescents of different nutritional status as measure by body mass index (BMI). Results of their study suggest that food preferences should be considered in the nutritional care management of malnourished adolescents. It should be noted that this study only focused on the food preferences of Filipino adolescents, considering both its effect on the nutrient intake and its effect on the nutritional status of each respondent.

Linear programming has seen real-world applications in health[7] also been applied to providing diet recommendations to human. Namoco[8], Agdeppa-Namoco and Gican[9] and Namoco, et. al[10] conducted studies on the use of linear programming for animal feed formulation. The study presented various possible animal feed rations using ingredients which are locally available. Another interesting aspect of the study is that they used ingredients which are not necessarily commercially available, and hence do not have direct cost. However, the focus of the study is to find feeds at a minimum cost so that the authors made use of the labor cost for the feed cost. Saxena and Parasher[11], on the other hand, developed mathematical models for animal diet formulation using artificial neural network (ANN).

Alaini, et. al[12] used linear programming method to develop low-cost cancer prevention food plans based on existing cancer dietary guidelines in order to help cancer patients achieve healthy eating style. Fletcher, et al.[13] provided a mathematical model on the relationship between acceptable diets and satisfactory nutrition. The study emphasized that the classical minimum-cost diet problem is not generally suited to most purposes in human dietetics since the objective of providing least-cost diets may lead to unpalatable diets. Linear integer programming was also used to solve a diet problem for McDonald's set menu in the work of Mohamed, et. al[14].

There have been studies on human diet formulation using mathematical programming techniques. Similar studies on diet formulation have also been conducted for animal feeds. While mathematical programming techniques help obtain optimal diet formulation either for humans or animals, it can be seen from these existing studies that they normally deal with fairly databases of food choices and their corresponding nutritional analysis. Consequently, users may find solving these mathematical models complex and tedious.

With the advent of computer technology, computer-based solvers have been made available. These computer-based systems help make the decision-making process easier and convenient. A decision support system (DSS) provides an alternative way to reduce uncertainties that may result when solving large optimization problems. A DSS normally consists of databases, modelling functionality and a user-friendly interface.

In this study, a DSS is developed to provide for daily diet planning to optimize nutrients in daily lunch intake among college students. The study is aimed to aid students in choosing lunch that are more nutritious yet are within the current budget normally spent by these students. The study shall be limited to the food available within the school area. Furthermore, an excel-based DSS is developed in this study to provide students with a user-friendly platform for deciding which food choices for lunch to take.

2 Methodology

To achieve the objectives of this study, surveys and interviews were conducted among college students in various colleges and universities around Cagayan de Oro City, Philippines to determine the food that these students usually consume for lunch, including the serving sizes as well as the budget that they usually allot for their lunch. Actual visits to four universities in Cagayan de Oro, namely, the University of Science and Technology of Southern Philippines (a state university) and Xavier University, Liceo de Cagayan University and Capitol Universities (which are private universities) were made to conduct the survey. Randomly selected college students, with ages between 18-30, from these universities were asked to provide their usual food choices when eating lunch using the survey questionnaire developed and prepared by the researchers. The questionnaire also asked the student-respondents to specify their usual food budget, the activities that they are usually engaged in every day and other personal information.

Eateries and fast-food chains around these universities were also surveyed to ascertain the kind of foods they serve to students (including the ingredients used in these foods and the costs per servings). All eateries situated within a 100-meter radius from the universities were included in this study.

It is interesting to note that the food choices mentioned by students in the survey are the same food that are being served in the eateries and fast-food restaurants around the universities. Correspondingly, all these food choices are included in the

database designed for the decision support system developed in this study.

After all these foods have been determined, the nutrient contents of these foods as well the corresponding nutrient requirements of males and females (of varying ages) were determined through the help of published literature as well a nutrition-dietetics specialist. Table 1 shows the usual food that college students eat during lunch. On the other hand, Table 2 shows the food available from fast-food chains as well as their nutrient contents and price per serving. The corresponding nutrient content and cost per serving are also shown in these tables. The nutrient analyses are based from the Philippine food composition tables 1997[15].

Table 1. Food that are usually consumed by College students at lunchavailable from local eateries.

Food		Calorie Content	CARBS	PROTEIN	FAT	Cost per Serving
		Energy (KCAL)	grams	grams	grams	PhP
1	Adobong Baboy	277	3.1	10.3	24.8	25
2	Afritada	123	6.3	6.3	8.1	25
3	Ampalaya	156	13.9	6.5	9.6	15
4	Ampalaya With Egg	169	8	14	4	20
5	Bacon	287	0.1	23.2	21.6	25
6	Bagoong	45	3	2	3	10
7	Beans	239	54	12	0.9	25
8	Beef	247	0	22	17	25
9	Beef loaf	80	10	3	3	10
10	Bicol Express	605	24	29	44	25
11	Bihon	426	54	28	11	15
12	Boiled Egg	78	0.6	6.3	5.3	10
13	Bulalo	158	9.6	21	4.1	35
14	Canton	304	27	3	24	20
15	Chicken Adobo	189	0	14.5	14.6	25
16	Chicken Curry	243	7.5	28	11	25
17	Chicken Fillet	145.8	0.1	24.8	4.6	25
18	Chicken With Brocolli	220	11	37	4.4	25
19	Chopsuey	220	9.1	16	7.8	15
20	Corned beef	213	0.4	15	16	25
21	Crispy Pata	427	0.9	32	32	30
22	Marinated milkfish	410	0.6	43	25	25
23	Dried Fish	82	0	18	0.7	10
24	Egg & Hotdog	307.3	3.7	14.3	25.9	25
25	Eggplant Salad	156	16	1.8	11	20
26	Embotido	303	13	23	18	25
27	Fish Fillet	199	7	16	12	25
28	Fish Soup	100	6.2	14	1.3	25
29	Fish Tinapa	25	0	3	1.4	25
30	Fried Chicken	377	4.4	40	21	25
31	Fried Egg	90	0.4	6.3	6.8	15
32	Fried Eggplant	88	12	2.9	3.4	15
33	Fried Fish	218	0	44	4.5	25
34	Fried Fish	199	7	16	12	20
35	Fried Pork	280	0	26	19	25
36	Grilled Milkfish	162	0	7	22	25
37	Mixed veggies	45	9.7	2.4	0.5	20
38	Hotdog	155	1.3	5.6	14	10
39	Humba	127	14	7.1	4.7	25
40	Pork Adobo	277	3.1	10.3	24.8	25
41	Pork Barbecue	418	47	33	11	25
42	Pork Steak	438	0	43	28	25
43	Pork with Beans	130	23	7	1.6	25

Table 2. Food that are usually consumed by College students at lunch available from local eateries.

FOOD	CALORIES	CARBOHYDRATES	FATS	PROTEINS	COST PER SERVING
Chicken Meal Solo (thigh)	983	126	34	41	89.00
Chicken Meal Solo (leg)	823	124	6	14	89.00
Chicken Meal Solo (breast)	923	127	21	35	89.00
Chicken Meal Solo (wing)	793	121	6	14	89.00
Chicken Meal (thigh) with double rice	1187	171	34	93	99.00
Chicken Meal (leg) with double rice	1027	169	6	18	99.00
Chicken Meal (breast) with double rice	1127	172	21	39	99.00
Chicken Meal (wing) with double rice	997	166	6	18	99.00
Chicken Meal (thigh) with Spaghetti	1153	148.5	40	46	120.00
Chicken Meal (leg) with Spaghetti	993	146.5	12	19	120.00
Chicken Meal (breast) with Spaghetti	1093	149.5	27	40	120.00
Chicken Meal (wings) with Spaghetti	963	143.5	12	19	120.00
Chicken Meal (thigh) palabok (Filipino noodle)	1135.5	145.5	38.5	49.5	159.00
Chicken Meal (leg) palabok	975.5	143.5	10.5	22.5	159.00
Chicken Meal (breast) palabok	1075.5	146.5	25.5	43.5	159.00
Chicken Meal (wing) palabok	945.5	140.5	10.5	22.5	159.00
Double Chicken Meal (thigh)	1363	131	62	68	164.00
Double Chicken Meal (leg)	1043	127	6	14	164.00
Double Chicken Meal (breast)	1243	133	36	56	164.00
Double Chicken Meal (wing)	983	121	6	14	164.00
Chicken Meal (thigh) with fries	1213	155	45	44	105.00
Chicken Meal (leg) with fries	1053	153	17	17	105.00
Chicken Meal (breast) with fries	1153	156	32	38	105.00
Chicken Meal (wing) with fries	1023	150	17	17	105.00
Chicken Meal (thigh) with macaroni soup	1333	175	49	45	110.00
Chicken Meal (leg) with macaroni soup	1173	173	21	18	110.00
Chicken Meal (breast) with macaroni soup	1273	176	36	39	110.00
Chicken Meal (wing) with macaroni soup	1143	170	21	18	110.00
Chicken Meal (thigh) with burger steak	1133	147	40	45	130.00
Chicken Meal (leg) with burger steak	973	145	12	20	130.00
Chicken Meal (breast) with burger steak	1073	148	27	39	130.00
Chicken Meal (wing) with burger steak	943	142	12	18	130.00

Table 3. Commonly eaten lunch by college students available from fast-food chains.

FOOD	CALORIES	CARBOHYDRATES	FATS	PROTEINS	COST PER SERVING
Supermeal A with Chicken Thigh	1303	169.5	46	50	150.00
Supermeal A with Chicken Leg	1143	167.5	18	23	150.00
Supermeal A with Chicken Breast	1243	170.5	33	44	150.00
Supermeal A with Chicken Wing	1113	164.5	18	23	150.00
Supermeal B with Chicken Thigh	1361	158	40	46	130.00
Supermeal B with Chicken Leg	1201	156	12	19	130.00
Supermeal B with Chicken Breast	1301	159	27	40	130.00
Supermeal B with Chicken Wing	1171	153	12	19	130.00
Super Meal C	1024	155.5	32	28	100.00

Continued on next page

Table 3 continued

Regular Burger Value Meal	854	117	18	14	79.00
Cheese Burger Value Meal	683	117	18	14	89.00
TLC Burger Value Meal	934	137	24	27	115.00
Aloha Burger Value Meal	1394	154	68	43	130.00
Champ Burger Value Meal	935	110	32	52	175.00
Regular Hotdog Value Meal	454	71	28	10	70.00
Regular Hotdog with fries meal	684	100	39	13	100.00
Spaghetti Value Meal	714	116	18	20	55.00
Spaghetti with Fries Meal	944	145	29	23	89.00
Spaghetti with Regular Burger Meal	1568	233	36	34	89.00
Spaghetti with Cheese Burger Meal	1397	233	36	34	99.00
Spaghetti with Burger Steak Meal	864	137	24	24	99.00
Burger Steak Value Meal	728	137	12	18	59.00
Double Burger Steak Meal	470	40	58	30	89.00
Burger Steak Lumpiang Shanghai Meal	936	146.5	12	18	89.00
Burger Steak with Fries Meal	958	166	23	21	89.00
Ultimate Burger Steak with Lumpiang Shanghai Meal	1068	88.5	14	42	140.00
Regular Fries	230	29	11	3	30.00
Macaroni Soup	350	49	15	4	35.00
Lumpiang Shanghai	416	19	0	0	50.00
Palabok	305	39	9	17	50.00
Halo-Halo	490	0	0	0	69.00
Sundae	360	44	7	5	35.00
Regular Drinks	374	71	6	10	30.00
Garlic Pepper Beef	404	38	15	31	79.00
Tuna Pie	200	0	0	0	39.00
Rice	204	45	0	4	30.00
Regular Burger	250	33	9	10	39.00
Cheese Burger	79	17	1	1	55.00
Cheese Burger with TLC	330	37	7	14	75.00

Continued on next page

Table 3 continued

Aloha Burger	790	54	51	30	85.00
Champ Burger	331	10	15	39	99.00

Commonly eaten lunch by college students available from fast-food chains.

It should be noted that as of this writing, 1 USD ($) is approximately equal to 50 Philippine Peso (PhP).

Tables 3 and 4 show the needed energy and nutrient intake of male and female college students for different age brackets [16]. The body mass index (BMI) categories for both male and female of varying ages are also shown in the tables. The values reflected are for lunch, which is computed as one-thirds of the daily requirement for each individual.

Using the information from Tables 1 and 4, a linear programming (LP) model that will determine the right food combination which meets the required nutrient intake for college students based on their preferred food and allotted budget is then formulated. The main objective of the linear programming model is to maximize the buying power of each student's allotted budget for lunch given their preferred food choices and specified daily activities. Constraints of this LP model include the daily nutrient requirements among college students based on age group and the amount of money they allocate for a meal (daily budget for lunch).

Let $x_i = \begin{cases} 1, & if\ food\ choice\ i \in I\ is\ chosen\ to\ be\ part\ of\ a\ meal \\ 0 & otherwise \end{cases}$

where I is the set of all available food choices from Table 1 and Table 2.

Then, for each j=1, 2, …, 12 (corresponding to the different age intervals for males and females), we have the following LP model.

$MaximizeZ = \sum_{i \in F} c_i x_i$

subject to

$\sum_{i \in I} a_i x_i \leq A_u$, maximum energy requirement

$\sum_{i \in I} a_i x_i \geq A_L$, minimum energy requirement

$\sum_{i \in I} b_i x_i \leq B_u,\ j = 2,\ j \in N$, maximum carbohydrate requirement

$\sum_{i \in I} b_i x_i \geq B_L,\ j = 2,\ j \in N$, minimum carbohydrate requirement

$\sum_{i \in I} d_i x_i \leq D_u,\ j = 3,\ j \in N$, maximum protein requirement

$\sum_{i \in I} d x_i \geq D_L,\ j = 3,\ j \in N$, minimum protein requirement

$\sum_{i \in I} f_i x_i \leq F_u,\ j = 4,\ j \in N$, maximum fat requirement

$\sum_{i \in I} f_i x_i \geq F_L,\ j = 4,\ j \in N$, minimum fat requirement

$$\sum_{i \in F} c_i x_i \leq P\ (where\ P\ is\ the\ budget\ alloted\ for\ a\ meal)$$

$$x_i\ is\ Binary$$

where A_U, A_L, B_U, B_L, D_U, D_L, F_U, F_L correspond to the maximum and minimum energy, carbohydrates, protein and fat requirements for males and females of the different age intervals and varying BMI descriptions, as shown in Tables 3 and 4.

Table 4. Energy and nutrient requirements for Female College students. (Source:Philippine Dietary ReferenceIntakes (2015). Food and Nutrition Research institute, Department of Scienceand Technology (FNRI - DOST). Taguig, Philippines.)

Gender	Age Interval	BMI	Energy (Kcal)		Carbs (g)		Protein (g)		Fat (g)	
			Max	Min	Max	Min	Max	Min	Max	Min
Male	14-18	Normal	900	740	200	70	150	5.5	50	1.5
Male	19-30	Normal	723	563	200	70	150	5.5	50	1.5
Male	14-18	Underweight	980	820	200	70	150	5.5	50	1.5
Male	19-30	Underweight	803	643	200	70	150	5.5	50	1.5
Male	14-18	Overweight/Obese	820	660	200	70	150	5.5	50	1.5
Male	19-30	Overweight/Obese	643	483	200	70	150	5.5	50	1.5

To better put the results of this study into good use, a decision support system (DSS) is then designed and developed to provide an easier lunch planning guide to college students.

Table 5. Energy and nutrient requirements for Male College students. (Source: Philippine Dietary Reference Intakes (2015). Food and Nutrition Research institute, Department of Science and Technology (FNRI - DOST). Taguig, Philippines.)

Gender	Age Interval	BMI	Energy (Kcal)		Carbs (g)		Protein (g)		Fat (g)	
			Max	Min	Max	Min	Max	Min	Max	Min
Female	14-18	Normal	1003	843	200	70	150	5.5	50	1.5
Female	19-30	Normal	760	600	200	70	150	5.5	50	1.5
Female	14-18	Underweight	1083	1003	200	70	150	5.5	50	1.5
Female	19-30	Underweight	840	680	200	70	150	5.5	50	1.5
Female	14-18	Overweight/Obese	1003	763	100	70	150	5.5	50	1.5
Female	19-30	Overweight/Obese	680	520	200	70	150	5.5	50	1.5

3 Results and Discussion

The DSS developed in this study provides suggestions on what a student may eat at lunch given his/her food preference and budget. This is attained by solving the LP model mentioned above.

Table 5 shows a sample lunch menu for a male, between 14-18 years old and with normal BMI. Based on our computations, it was found out that the smallest possible cost to satisfy the minimum requirements for energy, carbohydrates,protein, and fat, is PhP 40, for food bought at the cafeteria. This food menu includes rice, chopsuey and bihon. It can be observed that as the budget is increased, the food included in the menu also changed, and correspondingly, the nutrient contents of these food choices vary. It is also interesting to note that as the budget increases, the number of food choices included in the menu also increase. For example, at PhP 40 only two (2) viands are included while at PhP 80, the menu has three (3) viands. Moreover, since all-meat viands are more expensive that those with vegetables, it can also be observed that the cheaper recommended menus are mostly vegetable-based while the more expensive ones have a combination of all-meat and vegetable viands. Additionally, rice has always been a part of the recommended food menu. Similar observations can also be made from Tables 6-8 for the suggested food compositions for both 14-18 years old male and female who are overweight.

The main goal of this study is to develop an automated system that will help college students decide which food to eat for lunch given their food preferences and budget. Hence, we have prepared a decision support system that captures the linear programming model as presented in the previous section and demonstrated by the sample suggested menus in Tables 5, 6, 7 and 8.

Table 6. Suggested food menufor 14-18 years old male under normal BMI.

Menu	Food Inclusion	Cost	Nutrient content			
			Energy	Carbohydrates	Protein	Fat
1	Rice	10	130	28	2.7	0.3
	Chopsuey	15	220	9.1	16	7.8
	Bihon	15	426	54	28	11
Total		**40**	**776**	**91.1**	**46.7**	**19.1**
2	Rice	10	130	28	2.7	0.3
	Bihon	15	426	54	28	11
	Canton	20	304	27	3	24
Total		**45**	**860**	**109**	**33.7**	**35.3**
3	Rice	10	130	28	2.7	0.3
	Chopsuey	15	220	9.1	16	7.8
	Pork BBQ	25	418	47	33	11
Total		**50**	**768**	**84.1**	**51.7**	**19.1**
4	Humba	25	127	14	7.1	4.7
	Rice	10	130	28	2.7	0.3
	Canton	20	304	27	3	24
	Chicken curry	25	243	7.5	28	11

Continued on next page

Table 6 continued

Total		**80**	**804**	**76.5**	**40.8**	**40**
5	Rice	10	130	28	2.7	0.3
	Canton	20	304	27	3	24
	Fried egg	15	90	0.4	6.3	6.8
	Fried eggplant	15	88	12	2.9	3.4
	Pork with beans	25	130	23	7	1.6
Total		**85**	**742**	**90.4**	**21.9**	**36.1**
6	Rice	10	130	28	2.7	0.3
	Canton	20	304	27	3	24
	Chicken fillet	25	145.8	0.1	24.8	4.6
	Eggplant salad	20	156	16	1.8	11
	Fish tinapa	25	25	0	3	1.4
Total		**100**	**760.8**	**71.1**	**35.3**	**41.3**

Table 7. Suggested food menu for 14-18 years old male under normal BMI.

Menu	**Food Inclusion**	**Cost**	**Nutrient content**			
			Energy	**Carbohydrates**	**Protein**	**Fat**
1	Rice	10	130	28	2.7	0.3
	Bihon	15	426	54	28	11
	Hotdog	10	155	1.3	5.6	14
Total		**35**	**711**	**83.3**	**36.3**	**25.3**
2	Rice	10	130	28	2.7	0.3
	Bihon	15	426	54	28	11
	Chopsuey	15	220	9.1	16	7.8
Total		**40**	**776**	**91.1**	**46.7**	**19.1**
3	Rice	10	130	28	2.7	0.3
	Hotdog	10	155	1.3	5.6	14
	Pork BBQ	25	418	47	33	11
Total		**45**	**703**	**76.3**	**41.3**	**25.3**
4	Rice	10	130	28	2.7	0.3
	Canton	20	304	27	3	24
	Hotdog	10	155	1.3	5.6	14
	Pork with beans	25	130	23	7	1.6
Total		**65**	**719**	**79.3**	**18.3**	**39.9**
5	Rice	10	130	28	2.7	0.3
	Dried fish	10	82	0	18	0.7
	Pork BBQ	25	418	47	33	11
	Pork with beans	25	130	23	7	1.6
Total		**70**	**760**	**98**	**60.7**	**13.6**
6	Rice	10	130	28	2.7	0.3
	Bagoong	10	45	3	2	3
	Canton	20	304	27	3	24
	Eggplant salad	20	156	16	1.8	11
	Fried egg	15	90	0.4	6.3	6.8
Total		**75**	**725**	**74.4**	**15.8**	**45.1**

Table 8. Suggested food menu for 14-18 years old male under overweight/obese category.

Menu	Food Inclusion	Cost	Nutrient content			
			Energy	Carbohydrates	Protein	Fat
1	Rice	10	130	28	2.7	0.3
	Bihon	15	426	54	28	11
	Canton	20	304	27	3	24
Total		**45**	**860**	**109**	**33.7**	**35.3**
2	Rice	10	130	28	2.7	0.3
	Bagoong	10	45	3	2	3
	Bihon	15	426	54	28	11
	Canton	20	304	27	3	24
Total		**55**	**905**	**112**	**35.7**	**38.3**
3	Rice	10	130	28	2.7	0.3
	Boiled egg	10	78	0.6	6.3	5.3
	Eggplant salad	20	156	16	1.8	11
	Hotdog	10	155	1.3	5.6	14
	Pork BBQ	25	418	47	33	11
Total		**75**	**937**	**92.9**	**49.4**	**41.6**
4	Rice	10	130	28	2.7	0.3
	Beans	25	239	54	12	0.9
	Canton	20	304	27	3	24
	Eggplant salad	20	156	16	1.8	11
	Fish tinapa	25	25	0	3	1.4
Total		**100**	**854**	**125**	**22.5**	**37.6**

Table 9. Suggested food menu for 14-18 years old female under normal BMI.

Menu	Food Inclusion	Cost	Nutrient content			
			Energy	Carbohydrates	Protein	Fat
1	Rice	10	130	28	2.7	0.3
	Bihon	15	426	54	28	11
	Hotdog	10	155	1.3	5.6	14
Total		**35**	**711**	**83.3**	**36.3**	**25.3**
2	Rice	10	130	28	2.7	0.3
	Bihon	15	426	54	28	11
	Chopsuey	15	220	9.1	16	7.8
Total		**40**	**776**	**91.1**	**46.7**	**19.1**
3	Rice	10	130	28	2.7	0.3
	Boiled egg	10	78	0.6	6.3	5.3
	Dried fish	10	82	0	18	0.7
	Pork BBQ	25	418	47	33	11
Total		**55**	**708**	**75.6**	**60**	**17.3**
4	Rice	10	130	28	2.7	0.3
	Canton	20	304	27	3	24
	Chicken fillet	25	145.8	0.1	24.8	4.6
	Eggplant salad	20	156	16	1.8	11
	Fish tinapa	25	25	0	3	1.4
Total		**100**	**760.8**	**71.1**	**35.3**	**41.3**

Suggested food menu for 14-18 years old female under overweight/obese category.

The following figures provide information on how the DSS can be used. Figure 1 shows the landing page of the DSS developed in this study. Here, users are required to input their details. This information is then processed and results are shown in Figure 2. The system is developed in a very user-friendly manner. Figure 3 shows how the system informs the user that it is ready to release results based on the information given by the user. On the other hand, the system prompts a warning message when the information supplied by the user is incomplete. This is shown in Figure 4. Once complete information is entered in the system, results are then displayed based on the supplied preferences. As can be seen in the following figures, various considerations were included in the setup. These include meal recommendations for male and female of various ages and activities. Similarly, the mathematical model used in the DSS developed in this study also considers different budget constraints. Sample outputs from the DSS developed in this study are shown inFigures 5, 6, 7, 8 and 9. It is worth noting that the DSS developed in this study allows users to specify their food preferences while considering their body figure and budget.

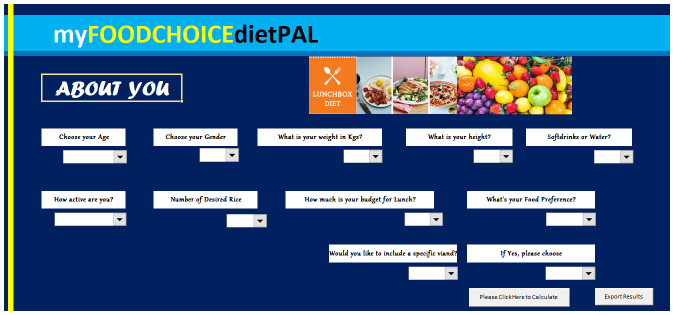

Fig 1. DSS landing page.

Fig 2. DSS results page

Fig 3. Food Platform withcomplete data

Fig 4. Food Platform with incomplete data

Fig 5. Female, (14-18), OBESE, Light Activity, 80Php

Fig 6. Female, (14-18), OBESE, Light Activity, 80Php

Fig 7. Female, (14-18), OBESE, Moderate Activity, 80Php

Fig 8. Female, (14-18), OBESE, Very Active, 80Php

Fig 9. Female, (14-18), OBESE, Very Active, 80Php, with SpecificFood Choice

4 Conclusion

The linear programming models formulated and solved which were then incorporated in the DSS developed in this study provide college students a better way to choose the food they want to consume for lunch by ensuring that the required nutrients are satisfied while keeping the cost at a minimum. Moreover, students are given better insights on how these foods contribute to their wellness. The results of the study further show that these food choices vary according to their daily activities and meal budget. The introduction of the DSS enables users to have a more dynamic way of customizing their food menu, taking into consideration their food choices, individual characteristics and other personal preferences and circumstances. In particular, food costs vary according to age, sex, body figure and kind of activity of the individuals. We have seen that the lowest cost for food menu for 14-18 years old male with normal BMI is PhP 40 while for female, the cost is P45.

While results of the study provide a better way to plan meals among college students, it would be more interesting to come up with a more comprehensive system for meal planning to include people of different age brackets.

References

1) Angeles-Agdeppa I, Neufingerl N, Magsadia C, Hiemstra H, Patalen C, Eilander A. Energy and Nutrient Intake and Acceptability of Nutritionally Balanced School Meals in Filipino Students. *Food and Nutrition Bulletin*. 2014;35(3):361–371. Available from: https://dx.doi.org/10.1177/156482651403500308.
2) The 8th National Nutrition Survey (2013). Food and nutrition research institute. Department of Science and Technology, Taguig, Philippines. . Available from: http://enutrition.fnri.dost.gov.ph/assets/uploads/publications/Overview_8thNNS_050416.pdf.
3) Human Energy requirements. Report of a joint Food and Agriculture Organization (FAO), World Health Organization (WHO) and United Nations University (UNU) Expert Consultation. FAO Food and Nutrition Technical Report Series No. 1. Rome, Italy . 2001. Available from: https://www.fao.org/3/y5686e/y5686e00.htm.
4) Tanchoco CC. Food-based dietary guidelines for Filipinos: Retrospects and prospects. *Asia Pacific Journal of Clinical Nutrition*. 2011;20(3):462–471. Available from: https://pubmed.ncbi.nlm.nih.gov/21859668/.
5) Magbuhat RMT, Borazon EQ, Villarino BJ. Food preferences and dietary intakes of Filipino adolescents in Metro Manila, the Philippines. *Malaysian Journal of Nutrition*. 2011;17(1):31–41. Available from: https://pubmed.ncbi.nlm.nih.gov/22135863/.
6) Food security and nutrition security profile. World Health Organization.. 2014. Available from: https://www.fao.org/3/i4030e/i4030e.pdf.
7) Namoco RA. Solving the Nurse Scheduling Problem of Private Hospitals in the Philippines using Various Operators for Genetic Algorithm. *Indian Journal of Science and Technology*. 2016;9(1):1–17. Available from: https://dx.doi.org/10.17485/ijst/2016/v9i47/102641.
8) Namoco RA. Linear Programming Approach for Feed Ration Formulation of Pre-Starter Swine using Locally- Available Feed Ingredients in the Philippines. *Indian Journal of Science and Technology*. 2017;9(48):1–6. Available from: https://dx.doi.org/10.17485/ijst/2016/v9i48/106120.

9) Agdeppa-Namoco RP, Gican KCP. Alternative Feed rations for grower stage backyard swine. *Mindanao Journal of Science and Technology*. 2012;10:93–106. Available from: https://mjst.ustp.edu.ph/index.php/mjst/article/view/31.
10) Namoco RA, Mendoza KC, Pailagao RO, Vallar JB. Optimizing Nutrient Intake of Holstein Dairy Cattle during Early Lactation using Locally-available By-products. *Indian Journal of Science and Technology*. 2018;11(27):1–7. doi:10.17485/ijst/2018/v11i27/129327.
11) Saxena P, Parasher Y. Application of Artificial Neural Network (ANN) for Animal Diet Formulation Modeling. *Procedia Computer Science*. 2019;152:261–266. Available from: https://dx.doi.org/10.1016/j.procs.2019.05.018.
12) Alaini R, Rajikan R, Elias SM. Diet optimization using linear programming to develop low cost cancer prevention food plan for selected adults in Kuala Lumpur, Malaysia. *BMC Public Health*. 2019;19(S4):1–8. Available from: https://dx.doi.org/10.1186/s12889-019-6872-4.
13) Fletcher LR, Soden PM, Zinober ASI. Linear Programming Techniques for the Construction of Palatable Human Diets. *Journal of the Operational Research Society*. 1994;45(5):489–496. Available from: https://dx.doi.org/10.1057/jors.1994.76.
14) Mohamed NF, Mohamed NA, Mohamed NH, Mohamed A. An integer linear programming model for a diet problem of McDonald's set menu in Malaysia. *European Journal of Molecular and Clinical Medicine*. 2021;8(2):60–67. Available from: https://ejmcm.com/article_6980_0d339a73490d644d75780e09a868cbf6.pdf.
15) The Philippine food composition tables. Food and Nutrition Research institute, Department of Science and Technology (FNRI - DOST). Taguig, Philippines.. 1997.
16) Philippine Dietary Reference Intakes. Food and Nutrition Research institute, Department of Science and Technology (FNRI - DOST). Taguig, Philippines. . 2015.