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A LINEAR PROGRAMMING OPTIMIZATION MODEL FOR A DIET PROGRAM

Ahmed Bakr Khoshaim, King AbdulAziz University, Jeddah, Saudi Arabia

ABSTRACT

The global obesity problem has increased over the years. Weight control is a concern for the third decade generation as social media and commercials play major role in demonstrating beauty standards. This study proposes a diet program, subject to the calories needed for daily consumption, the budget for the diet, and the healthiest distribution for meals in a day. A Linear Programming modelling is used to identify the optimal diet program with defined standard limits. These standards are translated to become the constraints of the Linear Programming model and QM software program to find the solution. The solution provides a diet choice for consumers under study. The diet provides a tool for businesses to help their employees remain healthy and productive.

JEL: C60, C61

KEYWORDS: Optimal, Diet, Linear Programming

INTRODUCTION

The third decade of life is among the busiest times of the human life. Life demands energy at work and taking care of the family. It can be hard to keep up with the demands. Thus, people tend to take the easiest option with their food choices, whether eating fast food, consuming more food than needed, or eating extra snacks between meals. These choices often lead to a serious problem with weight gain that implies a whole new set of health problems including diabetes, high blood pressure and cardiac problems. Several researchers indicate that both overweight and obesity are common in Saudi Arabia in both genders.

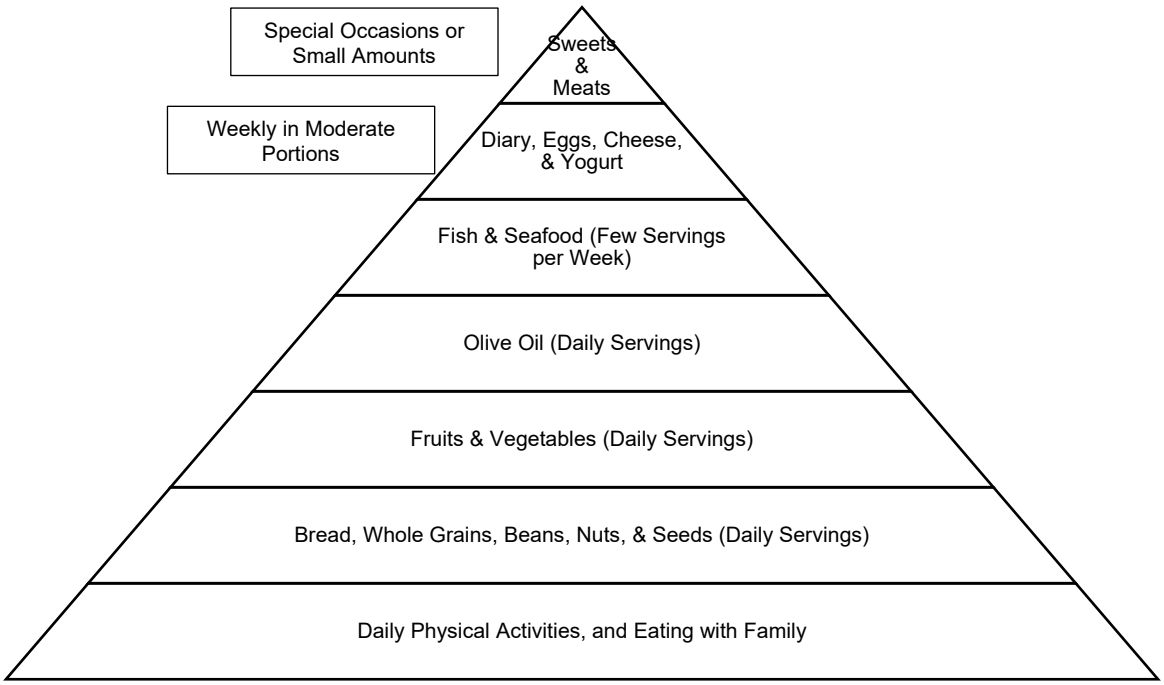
Overweight individuals tend to be males while obesity is more common in women. One of researcher found that 36.9% of the population is overweight and 35.5% are obese (Alqarni, 2016). In some areas of the country, female obesity reached 71% male obesity was 56.2% (Ahmed, Ginawi, Elasbali, Ashankyty, Al-hazimi, 2014). In Jeddah, Saudi Arabia, the overweight and obesity percentages are 29.8% and 18.6%, respectively (Baig, Gazzaz, Gari, Attallah, Al Jedaani, Mesawa, Al Hazmi, 2015) This research analyzes the problem and makes recommendations people in their third decade of age in Jeddah city, Saudi Arabia. The research started with the literature review and then gathers additional information about the problem. Next, I provide a list of possible food choices with their calories and prices. After that, the constraints for the equation are identified leading to formulating a linear programming model based on the data. Finally, optimal solution is provided by solving the equation using the QM program, which will gives the minimum price for breakfast, lunch, and dinner individually for the suggested food types. The optimization model is suggested for business level strategy that pushes business owners in food industry to obtain more market shares.

LITERATURE REVIEW

A good diet is essential for people to keep fit and healthy. Bottled or fast food is possible reason for early ageing and may affect the immune system of human beings. Choosing a balanced diet might be challenging as it constitutes numerous ingredients, which are needed for human growth. Therefore, the diet decision is complex if it is related to cost constraints.

The constituents considered are Protein, Vitamin E, Iron and Calcium, which can be facilely available in eggs, wheat, black and brown beans, and milk (Patil, Kasturi, 2016). A number of diets have been proposed. Thee include Sea food diets, the macrobiotic diet, and the Mediterranean diet. The Mediterranean diet in particular can improve the life of Crohn's disease (CD) patient or reduce the activity of the Crohn's disease. (Papada, Amerikanou, Forbes, Kaliora, 2019). The Mediterranean diet depends on old habits of eating since the 1960s. The diet is common among people from countries that surround the Mediterranean Sea. It is motivated b consuming of fresh, seasonal, and local foods. The Mediterranean diet is not a single specific diet, but is a general, expansive and food-based diet that is characterized by local and cultural differences throughout the Mediterranean Sea area (Willett, Sacks, Trichopoulou, Drescher, Ferro-Luzzi, Helsing, Trichopoulos, 1995). Studies show the guidelines of this diet are only catching up to individuals and their actual behavior (Willett, 2006). The Mediterranean diet has been studied and shows a reduction in mortality rates (Trichopoulou, Costacou, Bamia, Trichopoulos, 2003). Other research demonstrates a significant reduction on mortality risks by reducing the incidence of cardiovascular, cancer, Parkinson's, and Alzheimer's diseases (Sofi, Cesari, Abbate, Gensini, Casini, 2008). Figure 1 shows the tringle of Mediterranean diet, which gives an idea of the wide choices that can be consumed.

Figure 1: Mediterranean Diet



The Mediterranean diet tringle provides a nutrition guide. This diet includes a wide choice of food that can be consumed. The figure summarizes the Mediterranean Diet pattern of eating, suggesting the types and frequency of foods that should be consumed every day.

One study shows the Mediterranean diet can protect against Hepatocellular carcinoma. The results also stated that adhering to the Mediterranean diet could help the conditions of patients with hepatitis viruses. (Turati, Trichopoulos, Polesel, Bravi, Rossi, Talamini, Franceschi, Montella, Trichopoulou, Vecchia,

Lagiou, 2014). Another study displays that, in an insulin-resistant population with non-alcoholic fatty liver disease, the Mediterranean diet can reduce liver steatosis and improves insulin sensitivity. This occurs even without weight loss (Ryan, Itsiopoulos, Thodis, Ward, Trost, Hofferberth, O'Dea, Desmond, Johnson, Wilson, 2013). In addition, The Mediterranean diet can reduce both coronary atherosclerosis and thrombosis (Lorgeril, Salen, 2011).

A common way to lose fat and improve mood and sleeping habits is through exercise (Mgordon, Heath, Holmes, Christy, 2000). A recommended way to burn fat is to do cardio exercises that increases the heart rate such as running, swimming or any other cardio exercises. However, physical exercise alone could result in worse body shape for some women (Prichard, Tiggemann, 2008). "According to the American College of Sports Medicine (ACSM)" the recommended exercise time is 150 to 250 minutes per week to burn fat (Donnelly, Blair, Jakicic, Manore, Rankin, Smith, 2009). The suggested heart rate for burning fat for third decade is between 126-150 beats per minutes (Carey, 2009).

Many applications can be used to optimize solutions such as Delivery and Storage system, or Queuing theory, which reduces cost, or reduces waiting time and increase the speed of customer service, respectively. Other applications are also available such as Scheduling and Facility location (Fathi, Khakifirooz, 2019). In this research, an optimal solution of choices is obtained through operational research methods of using a linear programming equation solved by QM program. QM software provides solutions based on Quantitative methods, mathematical analysis for Operations Management, or Management Science. It features calculations for a number of methods including Linear Programming, which reduces cost and saves time and effort (Richardson, 2019, Singla, 2016). Linear programming is a mathematical equation that helps the user identify the best solution possible from a range of solutions by identifying variables, data, target setting of the study and constraints, and by setting the maximizing or minimizing target (Júnior, Yanasse, Morabito, Junqueira, 2019).

Operations research problems contain two main objective functions which are to maximize or minimize an objective function in the presence of constraints. For example, as a minimization problem the objective function might be a desire to minimize the time spent. At the same time a constraint might be that no negative time is spent. Similarly, most people want to minimize spending money on food. But at the same time, maintaining a certain level of nutrition. For instance, the US national institute for health advises certain consumption of some minimum daily nutrition for males between the age of 19-30 years, such as 3.7 liters of water, 90 milligrams of vitamin C, and 1 gram of calcium per day. Operations research has been used to find the optimum solution that minimize the cost with maintaining the required nutrition constraints. (J2kun, 2014a). Applying operations research for finding a suitable weight loss diet in third decade of life and identifying an optimal weight loss solution is desirable.

We keep in mind that following extreme diets which contains a limited number of calories, could lead to a lack of energy and strength, missing some essential nutrition and vitamins, as well as a lot of mood changes. In addition, when the body faces a lack of calories and energy declines, metabolism will naturally slow to save energy. Moreover, a extreme diet may lack the appropriate digestive needs of water and fiber, which come from several kinds of foods like grains, vegetables, and fruits. Thus, a diet lacking certain food groups could lead to decelerated digestion (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2010).

THE METHODOLOGY

To lose weight during a diet, the number of the consumed calories should be monitored. The type of food and the consumed amount should be balanced. Moreover, sometime healthy food can be expensive. As a result, cost was considered a constraint. Therefore, a variation of food was chosen with multiple flavors to

eliminate the consumer's bored feeling and assure a more enjoyable continuation with the diet (Schumacher, 2018). Table 1 shows a list of food choices the consumer can choose from is provided.

Table 1: Ingredients List

Ingredients List	1	2	3	4	5	6	7	8	9
#	Oats	Yogurt	Chicken breast	Tuna	Cheese slice	Brown bread	Mix vegetables	Milk	Peanut butter

The table shows a list of food choices the consumer can choose from. These meals have been chosen based on availability and that they can be easily found. In the study, the amount and frequency will be calculated. Ingredients 1,2,3 are for the breakfast, Ingredients 4,5,6 are for the lunch, and ingredients 7,8,9 are for the dinner.

The information in Table 2 is based on a nutritional expert's view about the best amount of protein, carbohydrate, and fat for males between 20-30 years old planning to losing weight. Consumer's must intake 1500 calories daily divided between three main categories of food (Binks, 2019).

Table 2: The Diet Meals

Meals	Carbohydrate (g)	Protein (g)	Fat (g)	Calories
Breakfast	56.25	56.25	5.5	500
Lunch	78.75	70	11.6	700
Dinner	18.75	48.75	3.3	300
Daily/ Grams	153.75	175	20.4	1500

This table shows the natural carbohydrate, protein, fat, and calories for all three different meals. These are based on a nutrition experts view of the best amount of protein, carbohydrate, and fat for males between 20-30 years old planning to losing weight with a total consumption of 1500 calories daily divided between three mails.

Table 3 shows the list of food choices divided into meal categories: breakfast, lunch and dinner. It also shows the nutrition values and the price for each kind of food. This table shows a list of healthy food that helps in losing weight with lower cost. The prices are in Saudi Riyals (SAR1 = US$ 0.27 approximately) and were taken from Al-Danube supermarket in October/2019 (Al Danube, 2019). Each meal should contain three items. For instance, breakfast will include brown bread, peanut butter, and milk. Lunch will include Oats, Yogurt, and Chicken breast. Finally, dinner includes tuna, cheese slice and mixed vegetables.

Table 3 Meals and Price

#		Food/100g	Carbohydrate	Protein	Fat	Calories	Price (SAR)
1	X_1	Brown bread	40.1	9.8	2.5	222.1	1/100g
2	X_2	Peanut butter	8	7	8	132	3/100g
3	X_3	Milk	4.4	3.2	1.1	41.5	1/100ml
4	X_4	Oats	58.1	12.1	8.4	356.4	1.5/100g
5	X_5	Yogurt	7	4.6	1.1	56.3	0.70/100g
6	X_6	Chicken breast	0	33	1.5	145.5	2/100g
7	X_7	Tuna	0	29	6.5	174.5	3/100g
8	X_8	Cheese slice	9	21	1.5	133.5	4.5/100g
9	X_9	Mix vegetables	11.9	9.46	0.1	86.34	0.8/100g
Totals			138.8	129.16	30.7	1348.14	

Table 3 shows the list of food choices divided in the meal categories: breakfast, lunch, and dinner, and includes nutrition values and the price for each kind of food. The prices are in Saudi Riyals and are taken from Al-Danub supermarket. The three meals are breakfast (brown bread, peanut butter, milk), Lunch (Oats, Yogurt, Chicken breast), and dinner (tuna, cheese slice, mix vegetables)

RESULTS

In this step, the meals have been divided into breakfast, lunch and dinner. To determine the best way or the optimal way to lose weight, linear programming was used to find the optimal solution. There are many methods to solve this problem such as graphical and simplex methods. The simplex method was used here. Finally, the optimal diet solutions will be found by using QM software program.

Formulation and Optimal Solution

1) Formulation of Breakfast:

Objective Function

$$Minimize\ Z = X_1 + 3X_2 + X_3 \quad (1)$$

Subject To

$$40.1X_1 + 8X_2 + 4.4X_3 \geq 56.25 \quad (2)$$

$$9.8X_1 + 7X_2 + 3.2X_3 \geq 56.25 \quad (3)$$

$$2.5X_1 + 8X_2 + 1.1X_3 \geq 5.5 \quad (4)$$

$$X_1,\ X_2,\ X_3 \geq 0 \quad (5)$$

Table 4 shows, the process of solving the minimization equation for the breakfast meal with the considered constraint by the QM program, and the optimal solution for each 100g in breakfast is SAR 5.74, when eating brown bread, peanut butter, and milk.

Table 4: Solutions of Breakfast

Solution	X_1	X_2	X_3		RHS	Dual
Minimize	1	3	1			
Constraint 1	40.1	8	4.4	>=	56.25	0
Constraint 2	9.8	7	3.2	>=	56.25	-1
Constraint 3	2.5	8	1.1	>=	5.5	0
Solution	5.74	0	0		5.74	

Table 4 shows the process of solving the minimization equation for the breakfast meal with the considered constraint by the QM program. It shows that the minimum price for the breakfast is SAR5.74 when eating brown bread, peanut butter, and milk. These meal items have been chosen for the breakfast for their availability and price in the region of the test (Saudi Arabia). Constraint 1 contains carbohydrates, constrain 2 contains protein, and constrain 3 contains fat.

2) Formulation of Lunch:

Objective Function

$$Minimize\ Z = 1.5X_4 + 0.7X_5 + 2X_6 \quad (6)$$

Subject To

$$58.1X_4 + 7X_5 + 0X_6 \geq 78.75 \quad (7)$$

$$12.1X_4 + 4.6X_5 + 33X_6 \geq 70 \quad (8)$$

$$8.4X_4 + 1.1X_5 + 1.5X_6 \geq 11.1 \quad (9)$$

$$X_4,\ X_5,\ X_6 \geq 0 \quad (10)$$

As shown in Table 5 below, the minimization equation for the lunch meal with the given constraints indicate an optimal solution for lunch when eating 100g of oats, yogurt and chicken breast equals SAR 5.28.

Table 5: Solutions of Lunch

SOLUTION	X_4	X_5	X_6		RHS	DUAL
Minimize	1.5	0.7	2			
Constraint 1	58.1	7	0	>=	78.75	-0.01
Constraint 2	12.1	4.6	33	>=	70	-0.06
Constraint 3	8.4	1.1	1.5	>=	11.1	0
Solution	1.36	0	1.62		5.28	

Table 5 shows, the minimization equation for the lunch meal with the given constraints indicate an optimal solution for lunch when eating 100g of oats, yogurt and chicken breast equal to SAR 5.28. These meal items have been chosen for lunch because of their availability and price in the region of the test (Saudi Arabia). Constraint 1 contains carbohydrates, constrain 2 contains protein, and constrain 3 contains fat.

3) Formulation of Dinner:

Objective Function

$$Minimize\ Z = 3X_7 + 4.5X_8 + 0.8X_9 \quad (11)$$

Subject To

$$0X_7 + 9X_8 + 11.9X_9 \geq 18.75 \quad (12)$$
$$29X_7 + 21X_8 + 9.46X_9 \geq 48.75 \quad (13)$$

$$6.5X_7 + 1.5X_8 + 0.1X_9 \geq 3.3 \quad (14)$$

$$X_7,\ X_8,\ X_9 \geq 0 \quad (15)$$

Finally, Table 6 shows the optimal solution after the data was processed by the QM program for the minimization equation for the dinner meal when eating 100g of tuna, cheese slice and mix vegetables. The optimal solution is SAR 4.37.

Table 6: Solutions of Dinner

SOLUTION	X_7	X_8	X_9		RHS	DUAL
Minimize	3	4.5	0.8			
Constraint 1	0	9	11.9	>=	18.75	0
Constraint 2	29	21	9.46	>=	48.75	-0.08
Constraint 3	6.5	1.5	0.1	>=	3.3	-0.09
Solution	0.45	0	3.77		4.37	

Table 6 shows the optimal solution after data was processed by the QM program. I use a minimization equation for the dinner meal when eating 100g of tuna, cheese slice and mix vegetables. The optimal solution equals SAR 4.37. These meal items have been chosen for dinner for their availability and price in the test region (Saudi Arabia). Constraint 1 contains carbohydrates, constrain 2 contains protein, and constrain 3 contains fat.

CONCLUSION

This study proposes a weight loss diet plan. Setting a diet plan is essential to help consumers following the diet plan to be aware of the concept of the diet as well as being realistic, serious, and enthusiastic. People follow a diet plan to either loose or gain weight. This study sets up a plan for the essential daily calories needed for losing weight with the consideration of lower food cost with targeting people in their third decade of life in Jeddah, Saudi Arabia. To the best of the author's knowledge, there is no study that has been published with the targeted consumers stated. The approach used in this study was applying linear programming method on the data to find the optimal solution for the process, the optimal solution was found using QM software. The optimal solution for breakfast is SAR 5.74 for every 100g. Whereas the optimal solution for lunch is SAR 5.28 for every 100g, and optimal solution for the dinner is SAR 4.37 for every 100g. The recommendations are for consumers living in Jeddah, Saudi Arabia in their third decade of age and want to follow a diet plan for losing weight. Farther research could include other age groups as well as other areas of the country. Further research might also examine the effectiveness of the diet on the individual's health and weight loss achievement. The suggested optimization model is highly recommended for businesses (e.g., food market) to customize diet meals for customers with respect to cost. As a business level strategy, this optimization tool fetched worthy repetition for the market store. However, I recommend that any diet plan be initiated only in consultation with an appropriate medical doctor and should consider any special health circumstances of the individual.

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BIOGRAPHY

Dr. Ahmed B. Khoshaim is an Assistant Professor at the Mechanical Engineering Department at King AbdulAziz University in Jeddah, Saudi Arabia. He received his B.S. in Mechanical Engineering from King AbdulAziz University (KAU), M.S. in Mechanical Engineering from the University of Dayton (UD), Dayton, USA. He also received his Ph.D. from the MIME (Mechanical, Industrial, and Manufacturing Engineering) department at the University of Toledo, USA. His research and teaching interests include conventional and non-conventional manufacturing processes, additive manufacturing, and optimization. He is a member of Saudi Consul of Engineers (SCE) since 2014.